



## ENGINEER - WP6

### 6.5 - EVALUATION AND ANALYSIS OF THE PROJECT IMPACT

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## EXECUTIVE SUMMARY

This report draws on data from all stages of the project to evaluate the implementation and impact of the project. It evaluates the organisation of the project within different WPs and comments on the effective management of the project.

The evaluation is based on the key objectives outlined in the DOW.

- Adapt for European usage EIE's EDP which has been shown to increase children's technology literacy and raise their interest in science;
- Develop new engineering design challenges suited to European contexts;
- Adapt teacher training materials that will increase primary school educators' ability to teach engineering and technology to their students using IBSE methods;
- Undertake an extensive outreach program that will target science teachers, teacher trainers and schools in at least 10 EU member states and associated countries;
- Strengthen the cooperation between schools and informal science learning institutions and enrich formal science education with informal experiences in the science museums;
- Undertake advocacy activities for promoting the long term goal of integrating engineering into science teaching in primary schools throughout Europe.

The report evaluates the processes contributing to the distinctive ENGINEER materials based on the EDP which have been developed.

It considers the effect of the materials on teachers' attitudes and practices drawing on data from piloting activities which suggest that the materials may have a European wide impact on teachers' practices. This view is further supported by data from evaluations of training during the outreach activities, which indicate that the majority of those trained, intended to use the materials in their classrooms.

The report discusses the impact of the materials on pupils' views of science and engineering and ways of working is evaluated through analysis of pupils' reported changes in attitudes pre and post piloting of the materials.

The report evaluates the productive relationships which were established between museums and schools and draws some conclusions concerning the value of linking informal and formal learning contexts. It also considers factors which were important in the development of strong working relationships between museums and schools and also in the development of a strong network of European science museums interested in Engineering.

It evaluates important features of successful outreach activities and dissemination. Also included are examples of successful advocacy activities.

The report's conclusions evaluate the strengths of the project and indicate directions for sustaining the project and future developments.

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# 1 INTRODUCTION

## 1.1 REMINDER OF THE CONTEXT

The ENGINEER project has supported the widespread adoption in Europe of innovative methods of science teaching and extensive training on inquiry based methods (IBSE). The project team has created ten engineering design challenges suited to European environments. These challenges have been piloted in schools across Europe. Each challenge has focused on one engineering field and uses inexpensive materials for pupil-led design problem solving.

Science museums have led the outreach effort to train teachers, teacher trainers and museum educators in the use of the materials. Museums have offered programmes for student groups as well as the general public based on the ENGINEER materials.

Dissemination activities have helped to increase awareness of ENGINEER and helped to promote participation. Advocacy strategies have been implemented to ensure the sustainability of the project and to maximise its impact after the project formally ends.

This final report of the evaluation team (WP6) seeks to evaluate the impact of the project in relation to the key aims which are set out in the DOW. It draws data from WP reports, interim reports and its own evaluation tools to present a report which draws together all elements of the evaluation and arrives at an independent view of its strengths and weaknesses, both against the original project objectives and in terms of criteria derived from a critical appraisal of the cultural and policy context and the research based knowledge relevant to the project.

UWE has applied a democratic approach to evaluation which has sought to assess the experiences, impacts and effects of the project at all levels. We have been interested in collecting the views of all those who have participated in the project; teachers and museum educators, WP leaders; pupils and families and BMOS. The team has developed and utilised evaluation tools such as questionnaires, monitoring forms, structured observations and interviews. It also draws on field notes, informal conversations and discussions.

In addition, this evaluation also draws on evaluation reports submitted by the evaluation team earlier in the project and the reports from WP leaders on different milestones within the project.

The central role of the evaluation team in supporting the project is evidenced in Figure 1.3 Work Plan Overview in the Description of Work (page 31). Members of the team have acted as critical friends throughout the project providing evaluations which fed into future developments of the project (for example the development of materials from the piloting phase) and also providing ongoing advice on the outreach activities, advocacy and dissemination.

Members of the UWE team have attended whole consortium meetings in Brussels (M1), Amsterdam (M4 and M13) Jerusalem (M6) and Milan (M21). The UWE team draws on field notes and informal conversations from these meetings in this report.

The UWE team has been present at all management meetings and noted how the project has developed; the challenges which have been met and plans to mediate them.

The evaluation thus draws on a range of data sets to evaluate the different stages of the project. It provides an analysis of different opportunities and challenges met by participants as the project was implemented and draws conclusions for future consideration.

## **1.2 RELATIONSHIP WITH OTHER TASKS**

The 6.5 report evaluates and draws on data presented in reports from other WPs and the internal periodic reports.

## **1.3 STRUCTURE OF THE DOCUMENT**

The report is structured within the following sections.

2.1 The organisation of the project.

2.2 The creation of new engineering design challenges suited to European contexts which draw on the principles of EiE's EDP.

2.3 The outreach campaign

2.4 Strengthening the cooperation between school and informal science learning institutions and enriching formal science education with informal experiences in the science museum.

2.5 Dissemination and Advocacy activities for promoting the long term goal of integrating engineering into science teaching in primary schools throughout Europe.

3.0 Conclusions

## **1.4 IMPACTS OF THE DELIVERABLE**

The report identifies key findings from the project to evaluate the success of the project. Findings will inform the sustainability of the project and future developments to promote the take up of engineering and inquiry based methods in European primary schools.

## 2 REPORT

### 2.1 ORGANISATION OF THE PROJECT.

The DOW has eight individual WPs designed to ensure the successful implementation of the project. Each WP has an allocation of specific tasks and deliverables to be completed by specified dates. WPs were led by university and museum partners and ECSITE.

These partners have all presented their deliverables on time and where there have been delays, they have been minor. Justifications for delays have been well founded and have not affected the successful completion of other tasks.

The design of the WPs required different WP leaders to work closely together to ensure there was consistency in approaches. This was achieved well and has facilitated the development of a strong spirit of co-operation which led to successful completion of tasks.

The WP reports provide detailed information about the progress of the project and the different stages in its implementation. Clear templates have ensured that WP leaders address important features concerning progress in their reports.

The project has been managed very effectively. Project expectations have been clearly explained and partners provided with appropriate templates to enable them to report on their work. Well-structured agendas have ensured that meetings have clear aims and outcomes and ensured that the project followed its stated timeline. The central website has provided a useful repository for reports and resources for all partners, keeping them up to date with the progress of the project. Comments from project partners indicate the central website has been well used and has been an important resource connecting different sites of learning across the European partners.

In the sections which follow we evaluate the project against the project's key aims stated in the DOW.

### 2.2 THE CREATION OF NEW ENGINEERING DESIGN CHALLENGES SUITED TO EUROPEAN CONTEXTS WHICH DRAW ON THE PRINCIPLES OF EiE'S EDP.

#### 2.2.1 Background context

Based on the experience and proven success in the US of the Engineering is Elementary (EiE) programme developed by Boston's Museum of Science (BMOS), the ENGINEER project aimed to introduce into European primary schools engineering as a new approach for using IBSE pedagogical methods in science education. The project aimed to adopt the 'engineering design challenge', the core feature of the EiE programme, in which students follow a five-step engineering design process to develop and build a model solution to a specific practical problem. The ENGINEER project intended to use the five-step process applying it to new engineering challenges chosen for their suitability to the European environment.

ENGINEER has adopted the EDP but also has several distinctive features which distinguish it from EiE. The focus of design challenges have been chosen as those relevant to the life of European children and which may be locally adjusted to grade 4-6 curriculum needs in various European countries. Unlike EiE ENGINEER offers free access to its materials which have been created for use both in schools and in museums.

The evaluation team draw attention to some key features in the project organisation which have ensured the successful creation and piloting of these new European materials.

From the outset the project has focused on the development of understanding of EiE's EDP in the development of all its materials (ENGINEER units, teacher training materials, dissemination materials and advocacy) through consortia meetings, workshops and tailored support for individual partners.

Initial survey data from WP2 and interviews with project partners indicate that whilst there were common pedagogic aims in science teaching across the consortium which valued discovery, discussion and questioning, there was variability in the extent to which these were developed in the classroom. These features (discovery, discussion and questioning) are central to the EDP and were taken into account in the development of the ENGINEER units (WP2).

Museum and school partners' understanding of the EDP has been deepened through engagement in specific activities and through guidance and support provided by MMU. In particular, in Jerusalem (M6) MMU provided examples of how to include different features of the EDP within a prototype unit. Importantly too, MMU described the narrative illustrating the process of developing a prototype unit which enabled school and museum partners to see the thinking and rationale underpinning the unit. This guidance was fundamental to support partner schools and museums, (who were not all experienced in curriculum development), to think about how the EDP would relate to the development of their own units.

Thus the project has provided more than an adaptation of EiE's EDP; it has also provided guidance on how to structure teaching and classroom learning around the EDP which teachers and museums have successfully drawn on in the development of the ENGINEER units. This guidance included the exemplification of the distinct processes (unit planning process; engineering design process and scientific investigation process) in developing a unit which has the potential to support further curriculum development in science and engineering across Europe beyond that of the ENGINEER project.

Ten engineering challenges suited to European environments which span a range of engineering disciplines including marine, structural, electrical, biomedical and aeronautical have been created. Each unit includes a resources kit and a teacher's guide. The science topics were selected because of their alignment with national curricula across the ten participating countries, and provide pupils with a wide range of engineering themes leading pupils towards projects they might well not otherwise engage with. The challenges also have been relevant to pupils' lives and in particular have taken into account research indicating that girls gravitate towards science disciplines that have an evident benefit to society (FP6 GAPP and FP7 ROSE).

Unit development and piloting was undertaken by all partners in the project. Strength of this process was that each unit was tested both by the team who developed it and by a partner team who were not involved in its development and who therefore approached the piloting with a greater degree of objectivity.

This process provided opportunities for the voices of different European partners to be heard. Interview data during the piloting indicate that communication between country partners/museums was generally good and most partners benefitted from the iterative mutual feedback process during the pilot phase. Feedback between country partners, particularly at consortium workshops, also resulted in successful adaptation and improvement of the units.

The units have taken into account the different curricula and pedagogical approaches across Europe which were identified in the WP2 survey of partner countries' different provision. Thematic and cross curricular approaches to learning across European schools have also been taken into account. Teachers' involvement in the development and piloting of the design challenges has ensured that the units are relevant for European pupils and also of interest to the specified age ranges.

Discussion at consortium meetings has also strengthened partners' awareness of different European contexts. For example, there was some discussion during the unit development meetings concerning how the terms 'experiment' and 'inquiry' have different connotations in different countries. In the finished units the term 'experiment' is used to describe all pupil activities.

There were also wide variations in partners' approach to tool use. Observations during the piloting phase revealed that in some countries, tools were largely absent from the design and make process, with materials pre-prepared and cut to size by the teacher. In other countries pupils were required to use cutting and joining tools during the EDP. In some countries tool skills were explicitly taught and in others, pupil tool competence was assumed. This variation across partners indicates one of the challenges of designing materials to suit different European contexts.

A further challenge was the issue of health and safety which was viewed differently in partner countries, with some schools not able to use tools that others use regularly (e.g. glue guns, hand saws etc.). This made it challenging to develop a protocol for all units and the issue has been left to the discretion of individual teachers/schools that use the ENGINEER units.

The provision of resource kits to accompany the materials has been an important factor in resolving some of these issues and in ensuring the successful implementation of the units during the outreach activities. Following their outreach training teachers reported how helpful the kits had been and how they had motivated them to use the units.

A clear strength of the ENGINEER materials is their potential to integrate curriculum subjects (science, mathematics and design & technology – engineering). Our observations in classrooms and reports from outreach activities indicate pupils' enthusiasm to engage with the cross curricular activities provided in the units. Such data are supported by research (see Gresnigt et al. 2014 for example) which suggests that pupils' attitudes towards science and mathematics can be enhanced through cross-curricular integrated approaches.

In addition, teachers reported in the outreach activities their enjoyment in engaging with the units. Appleton (2002) found that teachers see science activities as more appealing when they are part of an integrated, thematic approach with a perspective that encompasses more than just science; this suggests that the ENGINEER materials could play an important role in motivating teachers who will subsequently motivate and enthuse their pupils.

One of the unique features of the project is its bottom-up design process. Often education innovation occurs through a top-down approach from policy makers and curriculum developers to schools and teachers. BMOS EiE materials were developed following extensive trialling by professional curriculum developers. In contrast, on the ENGINEER project every aspect of the materials was designed by teachers and museum educators with the European context in mind.

Evaluation observations and data from WP2 reports during the development and piloting phases revealed that creating learning and teaching materials of this sort is a highly complex task and that the teachers and museum educators received intensive support and guidance from MMU.

Brundrett and Duncan, 2011 suggest that when teachers have a voice in the design process, curriculum becomes more contextually relevant, more accessible and more motivational for children. Given the nature and aims of the ENGINEER project, the decision to involve those with current experience of teaching in school and museum contexts in the design process was important, since fellow teachers in each of the participating countries who use the ENGINEER materials will benefit from the knowledgeable input of those involved in the design process.

### **2.2.2 Summary**

ENGINEER has created distinctive materials based on the EDP. It has also produced guidance on the processes involved in developing Engineering units which will be of value for those interested in creating further units. The involvement of museum and schools in the creation and piloting of the



materials has ensured their relevance for European contexts. Topics included in the materials have been designed to appeal to both boys and girls.

### 2.2.3 The impact of partners' teachers' involvement in the project on their knowledge and understanding of science and engineering and their classroom practices.

Given the important role which partner teachers had in the development and piloting of the units, we wanted to know more about how their involvement in the project affected their own knowledge and classroom practices. We wanted to know if there were common experiences amongst European partners.

We administered a Project Questionnaire at three separate points (Sweeps 1, 2 and 3) during the project: M6 (beginning of the project), M21 (following the piloting) and M33 (during the outreach phase) which provided data on partner teachers' knowledge, attitudes and practices.

There are 22 responses included in the data from those who completed Project Questionnaires for Sweeps 1 and 2. In Sweep 3 there were a total of six responses of which only three had completed the data in previous sweeps. This does not give any statistically valid data and does not allow for any reliable conclusions to be drawn and so these responses have been left out of the data for this report.

In terms of the level of their study roughly a third of the teachers had studied science or mathematics beyond secondary school (36% and 32% respectively). Notably, this percentage was reduced to only 24% for the level of study of technology. Only three teachers (13.5%) had studied any engineering.

Such experience is useful to explain some of teachers' reported levels of confidence in knowledge and understanding and in teaching such subjects. Teachers were asked to report on their level of confidence on a 4 point scale ranging from very low to very high. Teachers expressed least confidence in their knowledge and understanding of technology and in teaching engineering in the pre-pilot questionnaires.

From the responses to the Project Questionnaires completed by teachers in M6 and M21 (n22) following the pilots there is an indication of some increase in confidence in knowledge and understanding of maths and technology (both 14%) it is however interesting to note that for some teachers their confidence levels dropped after piloting the units.

Confidence Level	No response n (%)	Very Low n (%)	Low n (%)	High n (%)	Very High n (%)
<b>Maths</b>					
Sweep 1 (%)	2 (9%)	0 (0%)	4 (18%)	5 (23%)	11 (50%)
Sweep 2 (%)	0 (0%)	2 (9%)	2 (9%)	8 (37%)	10 (45%)
Change (%)	-2 (9%)	(-) +2 (9%)	-2 (9%)	(-) +3 (14%)	-1 (-5%)
<b>Science</b>					
Sweep 1 (%)	0 (0%)	1 (5%)	7 (32%)	9 (41%)	5 (23%)
Sweep 2 (%)	1 (5%)	1 (5%)	2 (9%)	10 (45%)	8 (37%)
Change (%)	+1 (5%)	0 (0%)	-5 (23%)	(-) +1 (5%)	+3 (14%)
<b>Technology</b>					
Sweep 1 (%)	4 (18%)	5 (23%)	4 (18%)	5 (23%)	4 (18%)

<b>Sweep 2 (%)</b>	1 (5%)	4 (18%)	3 (14%)	7 (32)	7 (32%)
<b>Change (%)</b>	-3 (14%)	-1 (5%)	-1 (5%)	+2 (9%)	+3 (14%)
<b>Teaching science</b>					
<b>Sweep 1 (%)</b>	0 (0%)	1 (5%)	3 (14%)	7 (32%)	11 (50%)
<b>Sweep 2 (%)</b>	1 (5%)	1 (5%)	2 (9%)	9 (41%)	9 (41%)
<b>Change (%)</b>	+1 (5%)	0 (0%)	-1 (-5%)	+2 (9%)	-2 (-9%)
<b>Teaching engineering</b>					
<b>Sweep 1 (%)</b>	0 (0%)	2 (9%)	9 (41%)	5 (23%)	6 (27%)
<b>Sweep 2 (%)</b>	0 (0%)	1 (5%)	4 (18%)	11 (50%)	6 (27%)
<b>Change (%)</b>	0 (0%)	-1 (5%)	-5 (23%)	+6 (27%)	0 (0%)
<b>Teaching technology</b>					
<b>Sweep 1 (%)</b>	0 (0%)	3 (14%)	3 (14%)	9 (41%)	7 (32%)
<b>Sweep 2 (%)</b>	4 (18%)	1 (5%)	3 (14%)	12 (55%)	6 (27%)
<b>Change (%)</b>	+4 (18%)	-2 (-9%)	0 (0%)	+3 (14%)	-1 (-5%)

Note: For the three teachers that completed sweep 3 their confidence levels had not changed

In terms of the classroom where teachers rated their practices when using the ENGINEER materials along a continuum of almost always to never, (using a Likert Scale where never is 1 and almost always is 4) there were changes in **all** their practices following the piloting.

The greatest reported changes were in teachers reporting pupils had opportunities: 'to work on projects in science', and 'to ask 'scientific' questions'. The next greatest changes were in providing opportunities for: 'pupils to do practical activities to learn science'; 'to try out ideas for solving problems' and 'to discuss what they have found out and how to improve next time'.

Teacher Practice	Sweep 1	Sweep 2	Difference
ask 'scientific' questions	2.52	3.62	1.10
work on 'projects' in science	2.14	3.57	1.43
do practical activities to learn science	2.68	3.57	0.89
discuss what they know that relates to the topic being covered	3.00	3.48	0.48
use everyday objects and materials when solving problems	3.09	3.71	0.62
imagine different ways of solving problems	3.23	3.80	0.57
choose equipment	2.73	3.29	0.56
Play with materials	2.82	3.40	0.58
Try out their ideas for solving problems	3.05	3.76	0.72
plan investigations	2.73	3.33	0.61
work together in pairs or small groups	3.73	3.90	0.18
discuss their work with each other	3.68	3.81	0.13
try lots of different ways of solving problems	3.32	3.76	0.44
explain their problem solving strategies orally	3.18	3.52	0.34
explain their problem solving strategies in writing	2.91	3.10	0.19
collect data or information to analyze	2.91	3.37	0.46
Decide for yourself how to collect data or information	2.86	3.15	0.29
record what they find out in an investigation	3.00	3.52	0.52
discuss what they have found out and how to improve next time	2.90	3.76	0.86

Teachers were also asked about their classroom organisation. Data indicate an increase in teachers reporting using examples from everyday life to introduce science and technology (0.29 point scale difference) and a decrease in the use of science textbooks (1.39 point scale difference).

In terms of concerns about teaching ENGINEER units (pupil behaviour, resourcing, time, physical space, adult support, confidence, pupil numbers and assessment) teachers' responses all indicate a reduction. The only concern where there was a slight increase was in curriculum priorities. It might be that teachers who value and want to undertake ENGINEER activities in the classrooms are worried that about the availability of time to do this with their commitments to other curriculum areas.

Data below indicate teachers viewed the ENGINEER materials positively following the piloting and the majority were aiming to use the materials again with their class and with other classes.

Data from M21	Yes	No	Unsure
Were ENGINEER materials effective for learning science in your class?	18	0	1
Did the children learn the science concepts and engineering process successfully?	16	0	3
Will you use Engineer in your class again?	17	1	1
Will you use Engineer Problem solving approaches with other classes?	16	0	3

Teachers reported different ways in which ENGINEER materials helped them.

	Teachers' responses (n/22) M21
Plan Lessons	18
Answer pupils' questions	18
Teach using enquiry based approaches	18
Encourage pupils to talk about the engineering design process	17
Teach engineering knowledge and skills	16
Teach science knowledge and skills	14
Organise pupils	11
Find resources	10

For these teachers, the ENGINEER materials were playing a role in enabling them to teach IBSE approaches and Engineering in their classrooms. This questionnaire was completed before the resource kits were developed and made available to teachers which could explain the low response to finding resources. (Data collected subsequently following the piloting from outreach evaluations indicate that teachers found the resource kits very useful.)

Qualitative data from the Project Questionnaire indicate that teachers were adapting ENGINEER materials for their own classrooms. In terms of worksheets teachers commented:

'It depends on the age of the pupils as to how often I used them';

'I would need to adapt them to suit the age of my pupils'.

In Sweeps 1 and 2, there were mixed views on how helpful the teachers' guides were which indicate the challenges in creating a text which can support teachers across Europe with a variety of experiences, science knowledge or confidence. The following comments were taken from Sweep 2, which was following changes made during the pilot but before the outreach:

'The teacher guide could have been written more clearly; too much text'

'It took time to find the bits I needed; I had to search out other sources of information especially for technical term'.

There were no comments on the teacher guides in Sweep 3. Interestingly, however outreach data indicate that the teachers who were trained did find the teachers' guides very helpful which could suggest that the 'sweep' teachers who had created the units, required less information from the teacher guides.

Teachers acknowledged the effectiveness of teaching the design challenge for learning science and engineering concepts.

'The EDP plan is very easy to follow and makes the steps clear to the pupils and teachers';

'The pupils remember more things doing the activities';

'The pupils got a lot more information through the practical activities';

'They still remember what they learned'.

Teachers also commented that they would use the ENGINEER project units in their classes again;

'The pupils loved it;

'Open solution task was very exciting';

'Makes the children think before doing';

'It was inspiring'

'Technology and engineering seem to be easier and more understandable'.

However, teachers did recognise some difficulties in incorporating these materials within their curriculum.

'Yes, but it is sometimes difficult to incorporate in the curriculum';

'It depends on how easy I can interface it with the curriculum'.

Several teachers were also enthusiastic to use ENGINEER problem solving approaches with other classes.

'I found it worked very well and the pupils seemed to understand and identify with it';

'The hands on experience is good';

'It's challenging and motivating for pupils';

'Problem solving is important';

'I will use it as soon as the curriculum allows me to do so';

'I think it encourages pupils to work in teams'.

### **2.2.4 Summary**

Following the piloting of materials teachers from ten European countries reported changes in all their practices. This suggests that the materials may have a European wide impact on practice. Teachers also reported how useful they had found the materials to teach IBSE methods.

### **2.2.5 The impact of the project on children's technology literacy and raising their interest in science**

Experience in the US from BMOS indicates that EiE engages all pupils in hands-on, real-world engineering experiences and EiE evaluation reports show that engineering has the potential to reach ALL students. Engineering projects have been shown to support the study of science and maths concepts and to promote problem solving and inquiry based learning. There is some evidence that engineering can foster girls' engagement with science disciplines which have an evident benefit to society (FP6 GAPP and FP7 Rose projects).

Consequently evaluators were interested in how the materials affected pupils' views of science and engineering.

Pupils were asked to complete questionnaires administered by classroom teachers in the ten European partner primary schools pre and post piloting the ENGINEER units with their classes (M15 – 22).

The questionnaires were developed with the help of ideas and examples from: Pollen: Seed cities for science, a community approach for a sustainable growth of science education in Europe, funded by the European Commission under the FP6 Programme Science in Society and Boston Museum of Science (BMOS) Engineering is Elementary Project Surveys.

The pre-pilot questionnaires asked pupils to choose their own 'detective code' to ensure anonymity in responding to statements concerning:

1. What they liked doing at school (on a 5 point scale - a lot, a bit, not sure, not much, not at all);
2. The frequency of doing different activities in science and technology lessons ( on a 4 point scale - Almost always, often, now and then, never);
3. What they liked doing in science and technology lessons in schools (on a 5 point scale – a lot, a bit, not sure, not much. Not at all);
4. Their opinions on science and technology in school (on a 5 point scale – a lot, a bit, not sure, not much. Not at all.);
5. Their knowledge about the work of Engineers (on a 3 point scale – agree, not sure, disagree).

The questionnaire was administered again following the piloting of ENGINEER units in pupils' classrooms and had an additional section. The additional section asked pupils which units they had worked on together with eliciting their responses (5 point scale A lot, a bit, not sure, not much and not at all) to statements on the following:

1. What they liked about the unit.
2. How much they thought they had learned about ways of working in science and engineering
3. How much more than usual they had learned.

In the tables for this report where the response is referred to as positive this equates to an answer of either 'Almost Always' and 'Often' or 'A Lot' and 'A bit' on the questionnaire, where it is neutral it corresponds to 'Not sure' or 'Now and Then' on the questionnaire and where a response is classed as negative it corresponds to 'Not Much' and 'Not At All' or 'Never'.

A total of 633 pre-pilot questionnaires were returned to UWE for analysis and 663 post-pilot questionnaires.

As a result there were a large enough number of responses to enable data to be displayed as percentages and although the numbers of responses before and after are slightly different the overall percentages can be still compared. The reason for including all responses rather than just paired is because we are not analysing the results of an individual and for some of the countries the pupils did not appear to use the same 'detective code' for both pre and post questionnaires which would mean that some countries would not be able to be included in the analysis thus significantly reducing the overall number of responses that could be included in the final analysis.

The number included in the gender analysis was lower - 587 in total. This is because one country returned all their questionnaires without stipulating whether they were male or female and also several pupils didn't indicate or were unclear in their response as to their gender. The number of included responses for males is 285 and females 302.

One school spontaneously reported that the pupils really enjoyed completing the questionnaire. The questionnaire was translated locally by the museum partners. The issue of language was a key consideration in this questionnaire. There is not a subject called technology in several EU countries and some countries have different names for curriculum subjects. 'ENGINEER' also has different meanings across the EU as a verb and noun.

There were questions that specifically related to the impact the units had had on the pupils' enjoyment of Maths and Science as well as the engineering:



Table 1: For All Respondents

What do you think of being in school?												
	Pre Questionnaire n(%) n=633				Post Questionnaire n(%) n=663				% Difference			
Response	positive	neutral	negative	No response	positive	neutral	negative	No response	positive	neutral	negative	No response
Do you like...?												
Doing maths	439 (69.4)	75 (11.8)	115 (18.2)	4 (0.6)	460 (69.4)	82 (12.4)	119 (17.9)	2 (0.3)	0.0	0.5	-0.2	-0.3
Doing science	497 (78.5)	52 (8.2)	80 (12.6)	4 (0.6)	500 (75.4)	77 (11.6)	81 (12.2)	5 (0.8)	-3.1	3.4	-0.4	0.1
Doing science experiments	569 (89.9)	26 (4.1)	30 (4.7)	8 (1.3)	580 (87.5)	43 (6.5)	36 (5.4)	4 (0.6)	-2.4	2.4	0.7	-0.7

Table 1 above shows that there was very little impact on whether the pupils enjoyed maths, science or experiments as a result of participating in an ENGINEER unit. The Czech Republic call their curriculum area nature study at the 5-11 age range so consequently not one pupil identified that they liked science in the survey. As can be seen 'doing experiments' was a popular activity.

With regard to gender differences Tables 2 and 3 below show the data broken down; after the piloting girls in general move towards being more negative whereas boys in general move towards being more positive in their views of the these subjects.

Table 2: For Girls

What do you think of being in school?												
	Pre Questionnaire n (%)				Post Questionnaire n (%)				% Difference			
Response	positive	neutral	negative	No response	positive	neutral	negative	No response	positive	neutral	negative	No response
Do you like...?												
Doing maths	177 (58.6)	49 (16.2)	75 (24.8)	1 (0.3)	195 (59.1)	55 (16.7)	79 (23.9)	1 (0.3)	0.5	0.4	-0.9	0.0
Doing science	233 (72.2)	28 (9.3)	40 ( 13.2)	1 (0.3)	230 (70.3)	50 (15.3)	45 (13.8)	2 (0.6)	-6.8	6.0	0.5	0.3
Doing science experiments	274 (90.7)	10 (3.3)	13 (4.3)	5 (1.7)	284 (87.1)	25 (7.7)	17 (5.2)	0 (0.)	-3.6	4.4	0.9	-1.7

Table 3: For Boys

What do you think of being in school?												
	Pre Questionnaire n (%)				Post Questionnaire n (%)				% Difference			
Response	positive	neutral	negative	No	positive	neutral	negative	No	positive	neutral	negative	No



				response				response				response
Do you like...?												
Doing maths	219 (76.8)	24 (8.4)	39 (13.7)	3 (1.1)	227 (78.0)	26 (8.9)	36 (12.4)	2 (0.7)	1.2	0.5	-1.3	-0.4
Doing science	221 (77.5)	23 (8.1)	38 (13.3)	3 (1.1)	231 (79.1)	25 (8.6)	34 (11.6)	2 (0.7)	1.6	0.5	-1.7	-0.4
Doing science experiments	252 (88.4)	13 (4.6)	17 (6.0)	3 (1.1)	254 (87.0)	18 (6.2)	18 (6.2)	2 (0.7)	-1.4	1.6	0.2	-0.4

These results can be viewed against those for reading where 77% of pupils gave a positive response and where writing was the least popular activity with 20% of boys stating they did not like it at all.

The responses to questions relating to the objectives of the ENGINEER project in relation to getting pupils to have the opportunity to work through problems themselves and increasing their knowledge about engineering and what engineers do (Table 4) indicate many more pupils 49.8% (increase of 27.5%) saying they learnt about what engineers do during their science and technology sessions. There is however less of a change indicated in their responses to having time to try different ways of problem solving.

Table 4: For All Respondents

What do you do in science and technology lessons												
	Pre Questionnaire n (%)				Post Questionnaire n (%)				% Difference			
Response	positive	neutral	negative	No response	positive	neutral	negative	No response	positive	neutral	negative	No response

How often do you...?												
Have time to try lots of different ways of solving problems	329 (52.1)	237 (37.5)	62 (9.8)	4 (0.6)	389 (58.7)	212 (32.0)	59 (8.9)	3 (0.5)	60 (6.6)	-25 (-5.5)	-3 (-0.9)	-1 (-0.2)
Learn about what engineers do	141 (22.3)	238 (37.6)	245 (38.7)	9 (1.4)	330 (49.8)	262 (39.5)	64 (9.7)	7 (1.1)	189 (27.5)	24 (1.9)	-181 (-29.1)	-2 (-0.4)

The pupils were asked what they did in science and technology lessons (Table 5) Interestingly, in this time of a strong socio-constructivist paradigm in science education, many pupils still identify 'working on their own' (57.3%) and 'watching the teacher' (71%) as important. In this case the percentages refers to 'almost always' and 'often' responses (referred to as frequently).

However, the pupils mostly did practical work (71.4% frequently). This practical work appears to have an element of teacher direction as the children did less planning (54% frequently) or having time to try different ways to solve problems (52.1% frequently) and 57.8% (frequently) work from science textbooks.

This mainly concurs with the research on pupils' experiences of science and technology. However, every single country's curricula in the EU has an element of practical science advocated (EACEA, 2013). It may be that practical work is interpreted as not just the pupil involvement but also demonstration.

Table 5: Types of Classroom Activity in Science for All Respondents (pre pilot)

Activity	Number of 'Frequently' responses	% 'Frequently'
Do practical activities	452	71.4

Watch teachers demonstrate	449	70.9
Try to solve problems set by teacher	444	70.1
Work together in pairs or small groups	426	67.3
Work from text book	366	57.8
Work on own	362	57.3
Explain how you solve problem	361	57
Plan science	342	54
Have time to try different ways for solving problems	320	52.1
Write down what you have learned	320	52.1
Choose own equipment	300	47.4
Explain what you have learnt	269	42.5
Talk about science learning	267	42.3
Learn what scientists do	217	34.3
Listen to stories about real problems for engineers and scientists.	208	32.9
Tell teacher outside	207	32.7
Learn what engineers do	141	22.3

As a result of the experience of participating in the pilots the pupils' attitudes altered.

In the post unit pupil questionnaire the pupils reported a change in classroom activity with more practical experiences, more working with their peers and more problem solving and 33% more learning about what engineers do (33% change).

In our observations of the pilots the pupils were actively involved in practical work. The percentage of time the pupils were actively involved was generally over 50% of the time. This caused some teachers a problem as there was unsuitable accommodation in the school for whole class practical activity.

The responses to 'what do you know about engineers' changed positively after completion of an ENGINEER unit. In particular pupils were more aware that engineering was a design, trial and make process (84% positive responses) in the post questionnaire. There was an increase in positive response to the idea that engineering makes life easier from 56%-71%. Girls had the greatest change in this attitude. See tables 6 – 8 below:

Table 6: For All Respondents

What do you do in science and technology lessons												
	Pre Questionnaire n (%)				Post Questionnaire n (%)				% Difference			
Response	positive	neutral	negative	No response	positive	neutral	negative	No response	positive	neutral	negative	No response
How often do you...?												
Have time to try lots of different ways of solving problems	329 (52.1)	237 (37.5)	62 (9.8)	4 (0.6)	389 (58.7)	212 (32.0)	59 (8.9)	3 (0.5)	60 (6.6)	-25 (-5.5)	-3 (-0.9)	-1 (-0.2)
Learn about what engineers do	141 (22.3)	238 (37.6)	245 (38.7)	9 (1.4)	330 (49.8)	262 (39.5)	64 (9.7)	7 (1.1)	189 (27.5)	24 (1.9)	-181 (-29.1)	-2 (-0.4)

Table 7: For Girls

What do you know about what engineers do?												
Response	Pre Questionnaire n (%)				Post Questionnaire n (%)				% Difference			
	positive	neutral	negative	No response	positive	neutral	negative	No response	positive	neutral	negative	No response
Engineering helps poor people	33 (11.0)	156 (51.8)	108 (35.9)	4 (1.3)	61 (18.5)	137 (41.6)	127 (38.6)	4 (1.2)	7.6	-10.2	2.7	-0.1
Engineering can make my home town a better place to live in	160 (53.0)	105 (34.8)	33 (10.9)	4 (1.3)	202 (61.4)	91 (27.7)	32 (9.7)	4 (1.2)	8.4	-7.1	-1.2	-0.1
Engineers help design and make things	206 (68.2)	79 (26.2)	11 (3.6)	6 (2.0)	270 (82.1)	47 (14.3)	9 (2.7)	3 (0.9)	13.9	-11.9	-0.9	-1.1
Only boys can be engineers	8 (2.6)	33 (10.9)	256 (84.8)	5 (1.7)	6 (1.8)	26 (7.9)	293 (89.1)	11 (3.3)	-0.8	-3.0	4.3	-0.4
Engineering can help make people healthy	65 (21.6)	115 (38.2)	116 (38.5)	5 (1.7)	80 (24.3)	137 (41.6)	101 (30.7)	11 (3.3)	2.7	3.4	-7.8	1.7
TV, telephones and radio have all needed engineering	176 (58.3)	100 (33.1)	21 (7.0)	5 (1.7)	199 (60.5)	102 (31.0)	24 (7.3)	4 (1.2)	2.2	-2.1	0.3	-0.4
Girls can be good engineers	230 (76.2)	55 (18.2)	13 (4.3)	4 (1.3)	285 (86.6)	32 (9.7)	8 (2.4)	4 (1.2)	10.5	-8.5	-1.9	-0.1

Engineers need to know about science	198 (65.6)	96 (31.8)	4 (1.3)	4 (1.3)	239 (72.6)	78 (23.7)	9 (2.7)	3 (0.9)	7.1	-8.1	1.4	-0.4
Engineering makes living easier	148 (49.0)	131 (43.4)	19 (6.3)	4 (1.3)	218 (66.3)	97 (29.5)	10 (3.0)	4 (1.2)	17.3	-13.9	-3.3	-0.1
I could be an engineer when I grow up	90 (29.8)	128 (42.4)	81 (26.8)	3 (1.0)	107 (32.6)	140 (42.7)	78 (23.8)	3 (0.9)	2.8	0.3	-3.0	-0.1

Table 8: For Boys

What do you know about what engineers do?												
Response	Pre Questionnaire n (%)				Post Questionnaire n (%)				% Difference			
	positive	neutral	negative	No response	positive	neutral	negative	No response	positive	neutral	negative	No response
Engineering helps poor people	43 (15.1)	136 (47.9)	99 (34.9)	6 (2.1)	60 (20.7)	130 (44.8)	95 (32.8)	5 (1.7)	5.5	-3.1	-2.1	-0.4
Engineering can make my home town a better place to live in	180 (63.4)	75 (26.4)	24 (8.5)	5 (1.8)	200 (69.0)	57 (19.7)	29 (10.0)	4 (1.4)	5.6	-6.8	1.5	-0.4
Engineers help design and make things	211 (74.0)	50 (17.5)	18 (6.3)	6 (2.1)	253 (86.9)	25 (8.6)	6 (2.1)	7 (2.4)	12.9	-9.0	-4.3	0.3

Only boys can be engineers	20 (7.0)	47 (16.5)	213 (75.0)	4 (1.4)	25 (8.6)	23 (7.9)	236 (81.1)	7 (2.4)	1.5	-8.6	6.1	1.0
Engineering can help make people healthy	79 (27.8)	84 (29.6)	116 (40.8)	5 (1.8)	94 (32.3)	86 (29.6)	104 (35.7)	7 (2.4)	4.5	0.0	-5.1	0.6
TV, telephones and radio have all needed engineering	169 (59.5)	80 (28.2)	28 (9.9)	7 (2.5)	193 (66.3)	58 (19.9)	31 (10.7)	9 (3.1)	6.8	-8.2	0.8	0.6
Girls can be good engineers	165 (58.1)	84 (29.6)	30 (10.6)	5 (1.8)	206 (70.8)	49 (16.8)	32 (11.0)	4 (1.4)	12.7	-12.7	0.4	-0.4
Engineers need to know about science	202 (71.1)	66 (23.2)	8 (2.8)	8 (2.8)	234 (80.4)	40 (13.7)	10 (3.4)	7 (2.4)	9.3	-9.5	0.6	-0.4
Engineering makes living easier	183 (64.4)	81 (28.5)	16 (5.6)	4 (1.4)	219 (75.3)	55 (18.9)	13 (4.5)	4 (1.4)	10.8	-9.6	-1.2	0.0
I could be an engineer when I grow up	105 (37.0)	102 (35.9)	71 (25.0)	6 (2.1)	110 (37.8)	106 (36.4)	69 (23.7)	6 (2.1)	0.8	0.5	-1.3	-0.1

Pupils also changed their views on who could be an engineer. Girls can be good engineers changed from 68% to 80% with the greatest change amongst the girls. The number of boys who thought girls could **not** be good engineers also reduced. The teachers also supported this finding. All those teachers observed said they saw all the girls being as involved as the boys.

The number of pupils however, who responded positively to the idea that they could be an engineer when they grow up hardly altered. The girls seemed have shifted their attitudes on the statement that Engineering makes life easier and that engineers design and make things. This needs to be explored further as features of engineering education that might appeal more to girls.

From Table 9 below it can be seen that 75% of the pupils responded positively (a lot /a bit) when asked about what **they liked about doing** the engineering unit. The most positive responses were to working with each other, carrying out their plans and learning about engineering (76%). The girls were more positive than the boys in all these aspects of the experience.

Table 9: Results for All, boys and Girls

E. Doing the ENGINEER unit													
	Everyone n (%)				Girl's n (%)				Boy's n (%)				
Response	A lot/a bit	Not sure	Not much	No response	A lot/a bit	Not sure	Not much	No response	A lot/a bit	Not sure	Not much	No response	
Did you like...?													
Planning how to solve an 'Engineer' problem	498 (75.1)	80 (12.1)	59 (8.9)	26 (3.9)	239 (72.6)	47 (14.3)	34 (10.3)	9 (2.7)	220 (75.6)	31 (10.7)	23 (7.9)	17(5.8)	
Carrying out your plan	532 (80.2)	77 (11.6)	27 (4.1)	27 (4.1)	253 (76.9)	51 (15.5)	15 (4.6)	10 (3.0)	237 (81.4)	25 (8.6)	12 (4.1)	17 (5.8)	
Working with other pupils	574 (86.6)	38 (5.7)	24 (3.6)	27 (4.1)	290 (88.1)	21 (6.4)	10 (3.0)	8 (2.4)	242 (83.2)	17 (5.8)	13 (4.5)	19 (6.5)	
Solving the problem	517 (78.0)	79 (11.9)	41 (6.2)	26 (3.9)	257 (78.1)	42 (12.8)	21 (6.4)	9 (2.7)	220 (75.6)	35 (12.0)	19 (6.5)	17 (5.8)	
Writing down what you learned	355 (53.5)	122 (18.4)	161 (24.3)	25 (3.8)	182 (55.3)	59 (17.9)	80 (24.3)	8 (2.4)	139 (47.8)	58 (19.9)	77 (26.5)	17 (5.8)	



Presenting what you learned to the class	374 (56.5)	119 (18.0)	140 (21.1)	29 (4.4)	195 (59.3)	60 (18.2)	63 (19.1)	11 (3.3)	157 (54.1)	52 (17.9)	63 (21.7)	18 (6.2)
Learning about engineering	506 (76.3)	72 (10.9)	58 (8.7)	27 (4.1)	246 (74.8)	40 (12.2)	35 (10.6)	8 (2.4)	220 (75.6)	30 (10.3)	22 (7.6)	19 (6.5)
Learning about science in the ENGINEER unit	487 (73.5)	93 (14.0)	55 (8.3)	28 (4.2)	237 (72.0)	53 (16.1)	30 (9.1)	9 (2,7)	210 (72.2)	37 (12.7)	25 (8.6)	19 (6.5)
Doing the ENGINEER unit	497 (75.1)	90 (13.6)	47 (7.1)	28 (4.2)	243 (74.1)	54 (16.5)	22 (6.7)	9 (2.7)	212 (72.9)	36 (12.4)	24 (8.2)	19 (6.5)
How much did you learn about....?												
Science	534 (80.5)	56 (8.4)	44 (6.6)	29 (4.4)	267 (81.2)	32 (9.7)	22 (6.7)	8 (2.4)	225 (77.3)	23 (7.9)	22 (7.6)	21 (7.2)
Engineering	542 (81.7)	47 (7.1)	43 (6.5)	31 (4.7)	267 (81.2)	25 (7.6)	27 (8.2)	10 (3.0)	232 (79.7)	22 (7.6)	16 (5.5)	21 (7.2)
Solving problems	529 (79.8)	60 (9.0)	41 (6.2)	33 (5.0)	269 (81.8)	28 (8.5)	22 (6.7)	10 (3.0)	219 (75.3)	30 (10.3)	19 (6.5)	23 (7.9)
Making things	541 (81.6)	60 (9.0)	31 (4.7)	31 (4.7)	273 (83.0)	34 (10.3)	14 (4.3)	8 (2.4)	227 (78.0)	25 (8.6)	16 (5.5)	23 (7.9)
Working in a team	560 (84.7)	37 (5.6)	33 (5.0)	31 (4.7)	282 (86.0)	21 (6.4)	16 (4.9)	9 (2.7)	237 (81.7)	16 (5.5)	15 (5.2)	22 (7.6)

Explaining my ideas	463 (69.8)	99 (14.9)	72 (10.9)	29 (4.4)	230 (69.9)	60 (18.2)	31 (9.4)	8 (2.4)	195 (67.0)	37 (12.7)	38 (13.1)	21 (7.2)
Planning a task	474 (71.6)	96 (14.5)	62 (9.4)	30 (4.5)	234 (71.3)	55 (16.8)	30 (9.1)	9 (2.7)	201 (69.1)	40 (13.7)	29 (10.0)	21 (7.2)
Asking questions	450 (67.9)	113 (17.0)	71 (10.7)	29 (4.4)	224 (68.1)	63 (19.1)	34 (10.3)	8 (2.4)	189 (64.9)	48 (16.5)	33 (11.3)	21 (7.2)



Pupils also reported positively (a lot/a bit) that they had **learned** about science and engineering (80.5 and 81.5% respectively) and reported that they had **learned** about working in teams (84.7%) and making things (81.6% positive responses).

Further analysis of Table 9 above containing the results on questions asked in section E which was only completed post the piloting and looks solely at how the children viewed completing an ENGINEER unit, shows that with regard to both genders the most positive response ('a lot' and 'a bit') to what they **liked** was 'working with other pupils' at 86.6% and correspondingly the area they said they **learnt** most about was 'working in a team' at 84.7%.

There were high percentage positive responses to the different features of working as an engineer which the pupils had **liked**:

Carrying out your plan	(80.2%)
Solving the problem	(78.0%)
Learning about engineering	(76.3%)
Doing the ENGINEER unit	(75.1%)
Planning how to solve an 'ENGINEER Problem'	(75.1%)
Learning about science in the ENGINEER unit	(73.5%)

And noticeable differences in what they reported liking the least;

Writing down what they learned	(53.5%)
Presenting what they learned to the class	(56.5%).

Girls and boys both ranked the same 4 features of Engineering as the ones which they most liked.

Working with other pupils	(girls 88.1%, boys 83.2%)
Solving the problem	(girls 78.1%, boys 75.6%)
Carrying out your plan	(girls 76.9%, boys 81.4%)
Learning about engineering	(girls 74.8%, boys 75.6%)

This could suggest that there are no real differences in aspects of Engineering which children like between boys and girls. However, the results for the girls were not as positive as the boys in three questions, these were:

Planning how to solve an engineer problem	(girls 72.6% boys 75.6%),
Carrying out your plan	(girls 76.9% boys 81.4%),
Learning about engineering	(girls 74.8% boys 75.6%),

The percentage differences are small but do mark a difference between responses to other questions where girls were more positive (or the same in one case) than the boys.

The results for 'Did you like doing the engineering unit' were 75.1% positive (a lot and a bit) over the whole groups. Whereas only 7.1% said either they didn't like it 'much' or 'not at all'.

In terms of negative responses, whilst both girls and boys disliked 'presenting what you have learned to the class' and 'writing down what you have learned' the most, there were also the greatest differences in how they responded, which indicates that more boys disliked these features than girls.

Writing down what you have learned (girls 55.3%, boys 47.8% - % difference 7.5%)

Presenting what you have learned to the class (girls 59.3%, boys 54.1% - % difference 5.9%).

In terms of children's overall responses to what they thought they had **learned about** there were high responses to most features:

Working in a team (84.7%)

Engineering (81.7%)

Making things (81.6%)

Science (80.5%)

Solving problems (79.8%)

However there were smaller percentages recorded for:

Planning a task (71.6%)

Explaining my ideas (69.8%)

Asking questions (67.9%)

In terms of gender, the greatest % differences between girls and boys reporting what they had **learned** were for:

Solving problems (girls 81.8%, boys 75.3% - difference 6.5%)

Making things (girls 83.0%, boys 78.0% - difference 5.0%)

However, it might be argued that boys already felt that they knew more about solving problems and making things and that involvement with the unit had not increased their learning in these areas.

## 2.2.6 Observations of pupils in classrooms

During their visits to schools during the outreach the evaluators noted the time spent by teachers and children on different activities. Observations indicate that in most lessons children were engaged in practical activities for large percentages of the lessons. The time allocated to children's activity was constrained by where the lesson occurred in the unit sequence. In one school the children stated:

'This is fun – I don't like the writing in science';

'I like this because you can do your own not just follow instructions';

'I enjoy this as I can do my own design'.

Data from observations in the classrooms indicate that children appeared involved in the project and were engaged with the activities. Language constraints made it difficult for evaluators to elicit more qualitative data on children's views. However, in one classroom the evaluator noted comments from children about what they had learned.

'It was a project that brought us altogether and taught us a very important lesson, that we cooperate well and we are altogether we can make everything happen'.

### **2.2.7 Summary**

The data indicate that most pupils, prior to the pilot, had a positive view of doing science, especially practical science in school. They generally consider it to be an important subject even before doing the ENGINEER unit. They reported a view of science activity in the classroom that involved practical work, possibly teacher directed rather than investigatory, and demonstrations by the teacher but there are indications of much solitary work in science. Boys indicated that they had a more negative view of school than girls, but the girls were less positive about enjoying science and maths than boys.

The pupils reported more investigative type skills work as a result of the ENGINEER unit. This was supported by observation of sessions. Pupils indicated a much greater understanding of the nature of engineering especially the design and make process. There was a shift in attitude in views of who could be an engineer in boys and girls. Girls showed a particular change in recognising that engineers could make life easier as well as awareness of the design and make process. There was little change in the idea that they could be engineers themselves although there were large differences locally in these figures indicating the complexity of such choices and factors which affect these decisions.

The pupils reported much more working with their peers indicating a higher degree of collaborative learning pedagogies as well as investigative type skills being used. The pupils indicated a positive view on the practical elements of the units but were less positive about writing and reporting to the class.

A large majority of pupils reported positively that they enjoyed doing the ENGINEER unit and that they had learnt most about working in a team and about engineering followed by making things and science.

The questionnaires indicate that the practical, open ended nature of the activities was positively received by most of the pupils, girls more than boys who support the Rose Project (Sjøberg & Schreiner, 2005) findings. The pupils reported that had learnt about the process of engineering as well as some science. The attitudes towards girls and engineers had changed positively amongst both boys and girls.

The lack of change in the attitude to 'I could be an engineer when I grow up', indicates that a single experience of engineering task, however positive, does not create an overnight change in intention to consider engineering as a career. In some countries there was a much larger movement in girls' attitudes than in other countries especially in the Netherlands, Greece, Israel and the Czech Republic. The sample sizes from each country are small originating from one school each so the data may be more school or even teacher specific than country specific. This would be worth further research. As Murphy et al. (2003:2006) indicated a choice of career is a complex process of identity, parental influence as well as societal pressures.

## 2.3 THE OUTREACH CAMPAIGN

### 2.3.1 Background context

The ENGINEER project aimed to conduct an extensive outreach programme led by museums which would target schools, teachers and teacher trainers. The outreach plan comprised teacher training in the use of materials and inquiry based pedagogic methods associated with ENGINEER; the use of these units in the classrooms of primary schools in partner countries and in science museum programmes using the projects materials/ methods for visiting school groups and the general public. It aimed to reach 660 schools, 1000 teachers and 27,000 students.

DOW envisioned that each museum partner would act as a hub undertaking several parallel outreach activities and those schools would also act as hubs for outreach efforts.

### 2.3.2 The outreach campaign strategy and implementation

The successful piloting of the teacher training materials recorded in WP3 ensured that teacher training materials had been clearly evaluated before the commencement of the outreach programme in WP5.

A clear strategy for the outreach programme (WP5) was devised by TH and all partners developed detailed plans for implementing outreach including recruitment efforts, teacher training, teachers' trainers' training and training by teachers' trainers.

The clear guidance and outreach overall plan monitoring template provided by TH enabled all partners to keep a record of their efforts in the outreach and the numbers of schools and pupils reached.

UWE's outreach monitoring form provided support for partners to record contact details of all those who participated in the training and of their classes (see 2.4.4) In addition Outreach Questionnaires (see 2.4.6) ensured that participants' views of their training were heard.

Museum partners took the lead in the creation and piloting of the teacher training materials to be used in the outreach in liaison with their partner schools. .

The involvement in teacher training was a new feature for some science museums. There were important discussions at a number of meetings in particular in Paris (M25) concerning understanding the underlying principles behind training teachers within different European contexts and raising the question what makes a good teacher trainer?

Training teachers requires not only a sound knowledge of the materials but also knowledge of how to influence colleagues. This was taken into account in the training of teacher trainers and in the creation of professional development guides where there was discussion on possible problems which might arise during training trainers and their resolution.

In the outreach this differentiated approach to training teachers and training teacher trainers did not always occur. Some museums combined their training of teachers with the training of teacher trainers and others provided separate training opportunities. We have no data which indicate the impact of an undifferentiated approach to training trainers; however we draw attention to the importance of discussing training issues (e.g. influencing colleagues; workshop participants' diverse experiences) in workshops for training trainers.

Data from report 5.3 indicate that 7 out of 10 museums trained teacher trainers and the remaining 3 chose to do more of the teacher training themselves.

Museum partners took the lead in promoting the ENGINEER units using both their existing school networks and developing new ones.

They contributed to the outreach campaign in a number of ways:

- Publicity and information ( newsletters, websites, mailing);

- The provision of materials and kits;
- Technical support and advice on the content;
- A power – point presentation on training sessions;
- Visits to schools to train teacher trainers on site;
- Providing space at the museum to conduct outreach activities.

Data from reports for WP5 and reports on outreach activities in Paris (M25) and The Hague (M32) indicate the development of science museum hubs was dependant on local contexts and it was not easy to develop hubs in all countries.

The outreach campaign also had a broader impact on museums' roles and networks. For example, in Paris participants who had undertaken training as teacher trainers linked the ENGINEER activities to their school curriculum and shared these links on subsequent trainings which they undertook with CNAM. Productive relationships were formed with local education advisers in Athens and Paris who supported the training and teacher training activities. In Israel, the Ministry of Education supported a range of training programmes for trainers and teachers.

Data from Report 5.4 indicate that teachers from 9 partner schools were involved in the teacher training. For some teachers this was a new experience and illustrates the impact of the project on schools' and teachers' roles in teacher training.

The involvement of schools was particularly important since teachers who had contributed to the development of the materials and their rigorous piloting in the classroom were able to speak confidently and with authority on the units, how the materials could be used in the classrooms and also address practical questions from practitioners.

Involvement varied according to local contexts. School partners contributed to training at museums; organised training in their own schools; visited teachers working in their own classrooms to provide support; attended conferences and network meetings and one school organised a parents' meeting to discuss the ENGINEER materials and pupils' involvement in the project.

Data from Report 5.3 indicate that teachers also had roles in training teacher trainers with their museum partners.

Teachers' varied contributions to the outreach indicate that the project was adaptable enough to respond to different training needs and practices across varied European contexts. The intended schools hubs did not develop as extensively as described in the DOW; most of the networking occurred with hubs being created by museums.

### **2.3.3 Summary**

Successful completion of tasks in WPs during the first phase of the Project had a clear impact on the implementation of the outreach programme. Clear guidance and monitoring support also impacted on partners' reporting of the variety of their outreach activities. The outreach programme was adapted by partners to meet their different national contexts. Museums and schools were both involved in the outreach. This was a new role for many teacher partners. Museums took the lead role in organising the outreach programme; teacher training was new for some museums and the project led to fruitful discussions on models for good teacher training. The development of outreach hubs were focused more on museums than school partners.

### **2.3.4 The impact of the outreach on the numbers of schools, teachers and pupils reached**

The following table is produced from data provided in the WP5: Outreach Report. It summarises the details provided within that report on the numbers of teachers trained and the potential number

of children reached by the outreach part of the project. The numbers are as reported by the partners themselves.

Table 10: The use of ENGINEER units in schools' classes

Unit	Partner that used unit for development and outreach	Teachers trained	Pupils undertaken unit	Projected teachers to use ENGINEER in 2015	Projected pupils undertaken unit in 2015
Frisky feet	EXP	147	Not available	51	1000 estimated total for 2014 and 2015
High and Dry	EF	56	1422	52	1000
Huff and Puff	BSMJ	130	1480	140	8950 (extrapolated from data)
Knee Deep	MUST	107	950	Not available	2025
Popular mechanics	CNAM	170	480	50	1500
A Fine Balance	DM	146	456	Not available	Not available
Music to the Ears	NEMO	200	1507	20 (extrapolated from data)	125 (+ a further 200 extrapolated from data)
Suck it up	TH	113	717	13	464
High Flyers	SCIOX	290	3085	'the majority'	625
Life Support	TSC	100	150	70	700
- TOTALS		1459	10247	396	16589

The target for the ENGINEER project for the outreach and museum work was for it to be implemented in 660 schools having trained 1,000 teachers and for 27,000 children to have completed at least one unit. The table above shows that the outreach activities were indeed successful at training 1,000 teachers to use the units (1,459 including teacher trainees). However due to timing of the implementation of the outreach phase it was not possible for all those teachers trained to be able to undertake an ENGINEER Unit with their classes in school before the end of the project. Consequently the numbers of pupils are lower than would be expected (10247) but if you include the project's numbers for 2015 where teachers have said they will do a unit in the next academic year (16,589) then the number is only just short of the target. Very few of the partners reported the numbers of schools they had reached with the project – as reported in this report. But extrapolating in the same way that the WP5 report does which assumes that each school sent two science teachers then the project reached the target of 660 schools (1,320 teachers). This is an assumption however, and there are no data to support this.

UWE also monitored numbers involved in the training through an outreach monitoring form which was issued to museum partners in M24 with instructions on filling them in. The forms asked for information on teachers trained, number of schools and number of classes taught. The instructions asked museum partners to follow up on the participants at a later point in the year to record the numbers of pupils who had been taught the units. The partners were contacted at points in the year to remind them to complete the monitoring forms.

The cut off point for data recording was the end of June (M32). Many record sheets were not retrieved until August or September which may indicate different recording periods. When we



issued the forms we envisaged that the majority of training would be completed by the summer term which was not the case. Some training continued into M32-36.

Museum educators used the outreach monitoring form in some cases but others used a spreadsheet with different headings and sometimes not the same headings as requested. UWE had considered using a spreadsheet, but decided against this as there may have been problems with compatibility in software formats across countries.

Three countries did not supply data on the number of schools.

Museum educators reported that they had a lot of difficulty in the follow up for data after the training. Many got few responses to e-mails and phone requests. The numbers of reported pupils who have been taught the units represents feedback from a small proportion of those teachers who were trained. However, this may mean the teachers who did not respond to the request for numbers had not yet got around to teaching the unit.

The projections for the following year are from teachers who state they will use the units in 2014-15. Again these intentions come from a small proportion of the teachers trained, so the numbers may be greater, but also could be smaller (See D5.4).

If the intentions are put into action, the project will easily achieve its goal of reaching 19,000 pupils in schools.

#### WP 6 Outreach Monitoring Data June 2014

Number of schools Reached	Teachers trained	Pupils having experienced a unit	Pupil planned to reach 14-15
413*	1,182	8,596	17,339

\*No data from 3 countries on number of schools

### 2.3.5 Summary

The outreach programme has clearly met its targets for the number of teachers trained. Extrapolating data in the same way that the WP5 report does it could be assumed that each school sent two science teachers and then the project reached the target of 660 schools (1320 teachers). This is an assumption however and data from the outreach monitoring form do not confirm this.

It is likely that the project will reach its target number of students in 2014-2015.

### 2.3.6 The impact of the materials on primary teachers' views on their ability to teach technology and engineering to their pupils during the outreach phase.

Evaluators wanted to know the impact of the materials on primary school teachers' views on their ability to teach technology and engineering to their pupils.

Outreach questionnaires were designed to gather data on teachers' perceptions of the materials, in what ways they were useful and whether they intended to use them in the classroom. Outreach questionnaires were completed by participants following their training in outreach activities (M26-M33).

Workshop participants were asked where the training took place, the age of pupils which they taught and the number of pupils in their class.

They were asked to rate the usefulness of the workshop overall on a scale 1 (not useful) – 5 (very useful).

Subsequent questions asked participants to rate the usefulness of different activities within the workshop on a scale 1 (not useful) to 5 (very useful).

- Engineering in an Envelope
- Stable Table
- Activities from ( name of unit)
- Gender activities
- Other activities included by workshop leaders.

Participants' views were elicited on:

- The length of the workshop (OK, too long, too short)
- How well the training was structured (1 – poorly structured to 5 very well structured)

Participants were asked to respond yes/no to the following questions about the training workshops:

- Relate well to what you do in your classroom?
- Encourage collaboration between participants?
- Inspire you to teach the unit?
- Encourage you to ask questions during the session?
- Help you develop new ideas about teaching approaches?
- Help you develop new knowledge about engineering?
- Increase your interest in science?
- Increase your interest in engineering?

Participants were also asked whether they;

- Intended to teach this unit in their class
- Knew enough to teach the unit
- Felt confident with the science of the unit?
- Felt confident with the engineering of the unit
- Were encouraged to think more about the value of engineering in primary schools.

Following each question, spaces were left for participants to complete their own comments.

### **2.3.7 Analysis of responses from outreach questionnaires and data from partners' evaluation of the training which they had conducted**

Unless a specific comment was made by the participant or the questionnaires were separated, it was not possible to tell whether they were completed by a teacher or a teacher trainer. Where it was possible to separate them, analysis has shown that there was no statistical difference in the two groups so the results have been combined for the purpose of the report. In total 776 questionnaires were completed from nine of the ten partners involved in the project. These alongside the visits determined that: In most instances, training activities were drawn from the professional development guide (stable table and engineering in an envelope) and the teachers'

guides to the units. The evaluation shows that all ten units developed as part of the project were used in the training sessions. Each partner used the unit they had developed for their training. Where more than one unit was used in the training the questionnaires revealed the extra ones used were either *Suck it Up* or *High Flyers*. In both cases these units were used by two other partners.

Where a unit was completed the participants were asked to score it out of 5 where a score of 1 meant 'not useful' and 5 meant 'very useful'. The results are in the table below:

Activity	Score out of 5
Engineering in an Envelope	4.1
Stable Table	4.6
Gender information	3.5
Frisky feet	4.5
High and Dry	4.8
Huff and Puff	4.5
Knee Deep	4.6
Popular mechanics	4.5
A Fine Balance	4.0
Music to the Ears	4.5
Suck it up	4.8
High Flyers	4.6

Of the nine partners that returned questionnaires seven partners had sessions that incorporated both the *Engineering in an Envelope* and *Stable Table* workshops as can be seen from the table above; both were thought to be useful exercises. Qualitative comments indicate that these activities were considered thought provoking introductions to engineering. It was felt that these could also be adapted to the age of the children:

"Engineering in an Envelope and stable table are the most accessible without the training and are good to set the scene and encourage practical team work"

"Envelope activity was thought provoking"

According to the questionnaire returns, teachers reported that only two consortium partners included information on gender and engineering. As can be seen from results listed above (3.5/5) gender information was ranked the least useful of the workshop activities.

Each science museum was expected to implement training for teacher trainers with the support of teachers from their partner schools. Many teacher trainers were also recruited following the training workshops. It was interesting to see from the questionnaires that of the 776 completed only 19 (2.4%) participants in their qualitative responses mentioned that they were looking forward to sharing details with colleagues. This may be a feature of the teaching culture in a number of countries where one teacher is not expected to run training for another.

Most partners adapted the training materials for their own individual contexts and in particular reduced the amount of time allocated to the training. With the support of the Ministry of Education, BMSJ was able to undertake training for a longer period of time, (three days) which enabled them to provide a variety of activities; to inform participants of the whole range of the ENGINEER materials and also to invite professional engineers to join the programme.

Other partners planned for whole day or two half day trainings which enabled them to introduce the EDP to teachers and also to share some of the design challenges with them. Some partners planned for single half days and this limited the opportunities which partners had for explaining the ENGINEER project and introducing a range of activities. However, given this range of training the questionnaires revealed that the vast majority 709 (91%) felt that the length of training was 'OK'.

"Just the right amount of time spent on each unit to ensure it was explained in enough detail to share and implement the knowledge"

Where the participants indicated that the time allocated to the workshop was 'too short' 26 (3%) comments were made that indicated that the reason for this was because they wanted more time to improve their design.

"It would have been great to have time to really experiment"

"I would have liked to have tried out more things to make me feel more confident"

A number of the training evaluations also indicated that teachers valued the interaction and dialogue as they engaged in the ENGINEER challenges and when training time is reduced, this limits the occurrence of such opportunities.

"Meeting teachers from other schools was really useful"

"I really valued the opportunity to meet and talk to other teachers"

Only 30 (4%) felt the training was 'too long' and those that commented implied that they were teacher trainers and would make the training shorter for teachers or they were teachers that felt that a particular activity had gone on too long, rather than an issue with the length of the training. A remaining 2% chose not to answer the question.

Overall the training workshops were found to be 'very useful' (average score of 4.5 out of 5) and very well structured (average 4.5 out of 5).

"It was a great way to break the myths about engineering I think that this is really important so that children (girls in particular) don't get frightened of the idea"

"Really enjoyed the hands on practical experience it has me more confident to try it with children"

The pupils the teachers taught varied in age from 4 – 19 with the average age being 10 and the average class size 25, showing that the materials provided should be enough to cover the average class. A couple of teachers of larger classes did comment that the reason that they were unlikely to teach units to their own classes was down to the ability to be able to resource the sessions for such large numbers of pupils. Many of the participants commented on the easy availability of the materials and were appreciative of being able to have a class set of resource kits for free.

"The free resources a brilliant and make it far more likely I'll try it in school"

"Materials are easily available to a teacher"

"It's very important for a teacher to see how everything works"

These comments were also in line with comments from partners who evaluated their training sessions in D5.3. Partners commented:

'They said that getting the kits gave them the PUSH to start teaching the unit and to use them for guiding other teachers'.

'Some of the teachers said that having the showed them that it is not so complicated to get and arrange the materials needed for operating the unit'.

'They appreciated the kit and valued it as an important tool for the schools for going on working on the training and for convincing other teachers to participate'.

'The material kits were appreciated as safe, simple and easily accessible'.

Partners also recorded the impact of teacher guides (WP3) on their training.

'It's very helpful – its structure is very clear and the content is very useful'

'The teaching guides were a helpful tool for the implementation of the unit and training of other teachers'

The units are designed to be suitable for 9-12 year olds. It appeared to depend on the unit/country as to whether the teacher of the younger or older pupils felt that the units could be adapted to fit their age range. For example those that taught younger pupils felt that the flight unit could be adapted for younger pupils and those that taught older pupils seemed to believe that the suck it up unit could be adapted for their classes. Where comments were made in relation to the other units this did not seem to be the case. For example the Popular Mechanics Unit was felt 'too difficult' to adapt for younger pupils.

On the questionnaire there were a series of questions that related specifically to the workshops and the units the results of these questions are shown below:

Did the training workshop....	Answered YES
Relate well to what you do in your classroom?	85%
Encourage collaboration between participants?	93%
Inspire you to teach the unit?	94%
Encourage you to ask questions during the session?	88%
Help you to develop new ideas about teaching approaches?	88%
Help you develop new knowledge about engineering?	85%
Increase your interest in science?	79%
Increase your interest in engineering?	84%

In relation to the questions about whether the training had increased their interest in science or engineering where comments were made these all stated that the lack of increased interest was because they were already very interested in those subject areas.

As a result 706 (91%) of participants said that they intended teaching the units they had undertaken in class. Where those that didn't intend to teach it had commented it was because they either didn't have a class to teach it to – were head teachers for example or felt that the age of the pupils they taught was either too young or too old for it to be appropriate.

Further questions	% that responded YES
Do you intend to teach this unit in your class?	91%
Do you know enough to teach the unit?	84%
Do you now feel confident with the science of the unit?	83%
Do you now feel confident with the engineering of the unit?	83%

When asked if they felt they knew enough from the training to teach the units 84% said that they did. Of those that commented the main reason they felt they weren't was due to a lack of subject knowledge or wanting to better understand the content of the units. In line with this 83% also said

they felt that they were confident with the science of the unit and 83% felt they were confident with the engineering content of the unit.

"I loved it but wonder how someone like me without a science or engineering back ground will cope with the children's questions."

"I could teach it only after reading up a lot more about the subject and the process"

Therefore, teachers who lack confidence in teaching science or who are unfamiliar with scientific knowledge may also require more time to engage in workshop activities and develop their personal understanding of skills and concepts involved.

The final question asked if the workshops had encouraged them to think about the value of engineering in primary education. The results showed: 81% thought Yes, 11% a little, 4% no (6% did not respond to the question). For those that answered 'a little' or 'no' the accompanying comments suggested that that was because they already highly valued the role of engineering in primary education.

The comments in more general terms related to how inspiring the participants found the workshops with 67 recorded comments referring to how inspiring or thought provoking undertaking the workshops was.

"I have little knowledge of engineering and I found it inspiring as to what I could do in class"

A number of teachers said that they had found the training enjoyable or fun and 69 commented it was good to learn some useful ideas or hints and tips for including engineering in the class room.

Alongside these 13 participants commented that they would look to use the language of engineering in the classroom in future as it had made them realise that it could be relevant in several areas of the curriculum.

"It has raised my awareness that I need to talk more about engineering and the process"

"It gave me clarity of experiences in school that I would never have linked to engineering"

Only participants from England and the Netherlands made any comments relating to its relevance to the curriculum and could see its usefulness in cross curricula activities. But there were comments by participants from every partner country about how it is useful to be able to try the activities for them to get an idea of how pupils would find them and to see the sessions from the pupils' perspectives.

"Great opportunity to try the activities before talking them into the classroom"

"It was great to experience how a child would approach it"

Where there was concern expressed it was around the lack of support when they were back in schools some asked if would they be able to contact their local partner for help with the activities if necessary and a couple of others questioned the easy availability of the website.

"If I don't have the website link how will I find out about this? I can't find it by using search engine alone"

One person appears to have succinctly summed up the thoughts from the teacher training;

"Very well prepared workshops with clear, interesting activities which are child friendly using resources that is readily available which is great. Can't wait to try it with my pupils in school".

### **2.3.8 Outreach case studies.**

Outreach activities were influenced by the contexts presented by different countries as illustrated in these brief case studies of three museums' approaches to the outreach which took into account different forms of educational organisation, curriculum contexts and the museums' collections.

ENGINEER training in the UK was observed at UWE in Bristol, since SCIOX has no museum space available. Approximately 25 primary teachers who had responsibilities for leading science education in their schools attended the one day training. They came mostly from local schools although one participant had come over 80 miles to undertake the training. The training was a balance of activity for the teachers and theory and guidance. The trainers used the Stable Table, Engineering in an Envelope, Suck it up and the High Fliers activities. The two trainers complemented each other, one with engineering background knowledge and one with more pedagogical subject knowledge. The trainers responded to the needs of the participants and drew on concrete knowledge of having used the units with children. The teachers were observed to enjoy the training and were positive in their comments about its potential use in school. They particularly liked the Suck it up unit.

In Sweden 11 teachers representing 11 schools from 6 out of 14 communities in the northern part of Sweden took part in the teacher training. The teachers were science co-ordinators in their schools, which educate a variety of age groups (not just 10-12 years). Some of them spend more time engaged in science subject co-ordination than actual teaching in their schools. After the training sessions they will teach other teachers from other schools in their community. ENGINEER was new and unfamiliar to all the teachers except the pilot school teacher.

TH organised the training over two half day sessions which were designed to prepare teachers to teach the ENGINEER unit to children and to train other teachers in how to teach the units. The training used Engineering in an Envelope, Stable Table and elements from, the Swedish ENGINEER unit (Suck it up), the Teacher Guide and the ENGINEER Teacher Training Guide for its basis.

The teachers responded very positively to all elements of the training and all were also positive about the units and the aims and objectives of the ENGINEER project. The teachers were also positive about disseminating what they had learned with pupils and colleagues.

In Paris there have been changes to CPD training during 2013-2014. Primary teachers are entitled to 18 hours training during the year (9 hours active participation and 9 hours virtual training). The museum is dependent on a good network of pedagogical advisers who can support teachers in attending the ENGINEER training. The training offered by the museum comprises three hours of the primary teachers' training allocation.

The training occurred at CNAM and good use was made of both the ENGINEER materials and the objects displayed in the museum. Teachers were asked to write down two words to describe an engineer which was followed by discussion and an explanation of the engineer design cycle. Teachers' attention was drawn to mechanical engineering and they were asked to identify objects in a picture which were examples of mechanical engineering. Key features of mechanical engineering were identified through discussion.

Teachers were then asked to create a mechanical counter using prepared resources. They worked on the problem and created different counters which they tested. Examples of children's solutions to the design challenge were also shown.

Teachers were shown around the museum and their attention drawn to examples of mechanical engineering providing solutions to problems occurring in everyday life. In particular, their attention was drawn to the effects and changes of engineering on people's lives – for example in the development of weaving machines.

To encourage engineering in Parisian primary schools, the museum organised an Engineering Challenge Day in May 2014. This will develop in future years to be a national engineering challenge using the ENGINEER materials.

### **2.3.9 Summary**

The ENGINEER training was considered to be very useful by almost all teachers. They mostly rated the activities as very useful, found the length appropriate (even if it varied greatly) and commented on the provision of materials as a positive feature.

The teachers indicated that the ENGINEER materials were inspirational, appropriate for their classes they taught and that it raised their interest in science and engineering education.

They mostly stated that the training had given them the confidence in science and engineering to teach the unit although a few teachers expressed concern about their own subject knowledge.

Almost all intended to go and use the materials in their schools except those without a class.

Information concerning gender and engineering was seen as the least useful information in their training.

## **2.4 STRENGTHENING THE COOPERATION BETWEEN SCHOOL AND INFORMAL SCIENCE LEARNING INSTITUTIONS AND ENRICHING FORMAL SCIENCE EDUCATION WITH INFORMAL EXPERIENCES IN THE SCIENCE MUSEUM.**

The ENGINEER project provided a range of opportunities for museums and schools to work together. In this section we evaluate ways in which co-operation has been strengthened between schools and museums.

### **2.4.1 Schools and museums working together**

The design of the WPs ensured that extensive, structured opportunities were planned for schools and museums to work together throughout the project. The project enabled some museums to strengthen their existing networks with schools and for other museums to develop new networks. In some cases, museums used established relationships with individuals in schools to ask teachers to join the Project. In one country, the teachers had worked on previous curriculum materials with the museum and in another the teacher had worked for a period of time at the museum. Museum partners were the key elements in supporting the network of school partners and liaised closely with them during all phases of the project.

During the creation of the design challenges (WP2) five teams of partners comprising two pairs of museums and schools worked together with academic guidance and support from MMU. Schools and museums also worked together on the development of the teacher training materials (WP3). All materials were rigorously piloted in schools (WP4) with museums offering support and guidance to their partner schools, including the observation of partners' teaching units in their classrooms. In the outreach phase (WP5) schools and museums worked together in providing teacher training. These planned opportunities for collaboration have strengthened the cooperation between museums and schools.

The relationship and division of labour in the creation of materials in each country varied and was summarised by one partner as one of mutual support where partners worked within their different priorities. Teachers' main priorities are teaching with heavy workloads; museum staff often had more experience in developing curriculum meetings as well as time to do the writing.



Museums worked in different ways with their partner schools. For example, in Israel the museum and school staff developed their materials following a meeting with many participants (biomedical engineer from the Israeli advisory board, museum staff members from the education department as well as from the development department and the school teacher) to discuss and decide the specific topic of the challenge. Specific roles were identified; the museum was responsible for organising the resources and also observing the activity; the school teacher was responsible for teaching the engineering challenge in her class.

The museums were viewed as providing unique creativity and background science expertise to the development of the challenges. One teacher wondered if it was because museum staff has a greater understanding of informal learning through the use of artefacts. One WP leader stated that the museum staff brought a creativity that was different to projects involving educational officials or academics.

Partner teachers were able to modify ideas to fit into the school context. They were able to say when scientific concepts in units were too challenging for the target age group and advice on materials, space requirement available in primary schools. They also advised on pedagogical approaches in the challenges.

During the piloting (WP2) museums procured materials for implementing the units and translated the Teacher Guides, pupil and teacher questionnaires and teacher logs. Both museums and school partners were supported in their evaluations of classroom piloting activities through different tools which enabled them to analyse issues such as lesson introductions; use of open-closed – science and EDP questions, context, pupils' involvement, working in groups, gender differences, teacher difficulties with materials or science background knowledge, timing.

Observing and commenting on school partners' lessons were new experiences for museum educators and required listening, negotiating and mentoring skills.

During the piloting one museum educator commented, 'This has provided a unique opportunity to work with teachers – to get to know teachers' views and the difficulties they encounter'. Interview data from the piloting also indicate the impact of museum educators working in close collaboration with schools.

One museum educator commented, 'I learned so much from observing in school during the pilot phase. The way the teachers formulate their sentences is so interesting and so different from how I learned. It would be good for all pedagogical staff at the museums to visit schools and to see how children are taught there'.

The importance of pedagogy was re-iterated by another museum educator, 'I need to know about the pedagogy as well as having knowledge about the subject'.

During the piloting school partners commented on the helpful support that they had received from museums particularly in relation to science and engineering subject knowledge.

The strong relationships which were developed during the piloting also contributed to the successful outreach activities in WP5.

### **2.4.2 Summary**

ENGINEER has provided many structured opportunities for schools to work together with museums as well as opportunities for informal networking.

### **2.4.3 The development of a strong European network of museums interested in Engineering**

The project has fostered the development of a strong network of ten museums across Europe who has a deep interest in engineering education. Throughout the project there have been numerous opportunities for museums to work together and to share ideas. Museums lead five of the eight WP and consequently were present at all the consortium and WP leader meetings. This enabled these museums to make strong contributions and also to have ownership of the direction of the project.

The consortium meeting in Paris (M 25) provided an important opportunity for museum educators to share their experiences of advocacy and outreach. It also enabled them to learn of different partners' approaches to outreach and networking with schools.

The strength of the network was in evidence at the ECSITE conference in The Hague (M32). Museum partners collaborated to run very successful workshops using materials from the ENGINEER project.

The creation of a strong museum network has implications for the sustainability of the project and the potential for the development of further funded projects.

### **2.4.4 Summary**

Engagement in the ENGINEER project has resulted in the creation of a strong European network of museums interested in ENGINEER network which is characterised by collaboration and mutual support.

### **2.4.5 ENGINEER and informal learning experiences offered by museums.**

Data from Report 5.1 indicate that museums were able to successfully adapt the ENGINEER units for school visits to museums. Museum partners indicate that workshops lasted between 45 minutes to 2 hours, with most lasting just over an hour. This is considerably less time than was planned for the units to be used in schools and raises the question if pupils have less time to engage with the challenge is there a tension between trying to complete a product and engaging with the processes of design and testing. It may be that in informal learning contexts, there are fewer possibilities for a systematic and prolonged engagement with the EDP.

Data from Report 5.1 show that by June 2014 there had been over 250 school group workshops involving around 5,600 pupils. In addition more workshops are planned for 2014 -2015 which further indicates the impact of the project and its sustainability.

Reports from museum partners at The Hague (M32) indicate the creative ways in which these adaptations occurred and the popularity of some of the activities. For example, in Israel the Frisky Feet activity had been adapted to coincide with the Passover holiday and focused on a sandal in the desert. Here the additional resources and equipment which BMSJ had available enriched the family activity. This was also found to be the case in TH and NEMO where more sophisticated means for testing High Fliers were available, enabling participants to test using a range of variables. At EXP participants used infra-red thermometer guns for testing insulation properties.

Museums planned for drop-in sessions and some also included pre-booked sessions for families. The drop-in sessions generally lasted for shorter periods of time (NEMO estimated 15 minutes) whilst pre-booked family sessions could last up to 2 hours (e.g. SCIOX, EF).

As noted in the comments concerning ENGINEER workshops in museums, time is an important factor in enabling engagement with the EDP. It may be that museums have a more important role in stimulating interest in ENGINEER through informal experiences, which can then be capitalised on when children (pupils and children from family groups) return to school for more formal experiences and structured opportunities to engage with the EDP.

Data from report 5.1 indicate that over 120 workshops/workshop days had been conducted during the outreach by June 2014 (M33) reaching over 10, 800 participants. Many of the science museum

partners have also stated that they will continue to offer ENGINEER activities during the summer 2014 beyond so it is estimated that at least 5000 more visitors will take part in the ENGINEER activity workshops.

These examples indicate ways in which museums are able to complement learning in more formal contexts through their provision of a wider range of resources, space and equipment.

Involvement in the development and piloting of the unit materials has provided museum educators with opportunities to reflect on differences in organising activities for different target audiences (school children and the general public). This was particularly in evidence in discussions which concerned the consideration of the adaptability of the project materials for different contexts. Data from report 6.3 indicate the varied ways in which museums did adapt the units to their different contexts.

Working with schools on the project and evaluating pedagogy and curriculum materials also impacted on museum educators' views on their own roles as educators. There were important discussions on how to facilitate learning in the museums and in particular how to support museum educators to develop skills in intervention; knowing how to create spaces for learning, when to hold back and when to intervene.

BMOS contributed to these discussions at The Hague (M32) and described their explainers' education programme. Implications for changing explainers' practices through changing the pedagogical question from, 'How can I explain this to them?' to 'How can I help visitors to arrive at their own conclusions?' were explored in detail and raised issues concerning learning in both informal and formal contexts.

Discussion focused on different pedagogical strategies and examples of how these issues might be addressed in training.

Issues concerning what is appropriate training for museum educators focusing on Engineering across Europe may be a focus for future projects.

#### **2.4.6 Summary**

The organisation of the WPs has provided useful opportunities for schools and museums to work together and share expertise. ENGINEER materials have been adapted successfully for use in informal learning contexts. The project has facilitated important discussions on pedagogy in informal contexts and the training of museum educators.

### **2.5 DISSEMINATION AND ADVOCACY ACTIVITIES FOR PROMOTING THE LONG TERM GOAL OF INTEGRATING ENGINEERING INTO SCIENCE TEACHING IN PRIMARY SCHOOLS THROUGHOUT EUROPE.**

#### **2.5.1 Background context**

In this section we evaluate firstly dissemination activities which have supported the advocacy activities and secondly, advocacy activities for promoting the long term goals of the project.

#### **2.5.2 Dissemination strategy and implementation**

Dissemination WP 7 was intended to raise awareness about the project and advertise its goals and programs by using a wide array of dissemination activities and materials to reach targets in the partner countries and throughout Europe.

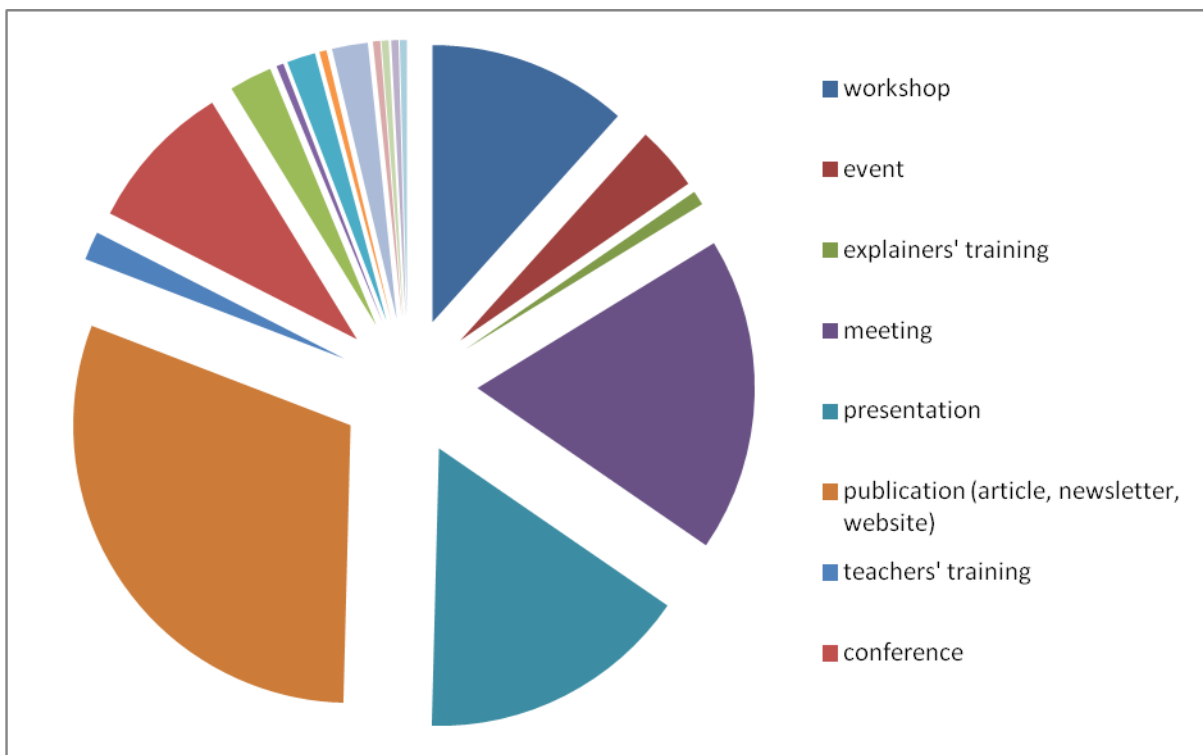
In this section we:

- a) Briefly describe the key vehicles for dissemination across the consortium partners.
- b) Evaluate them in terms of impact and reach across Europe.

Dissemination was co-ordinated in each country by the ENGINEER consortium partners and activities varied between partner museums. However, drawing on data from WP7's reports we can see that all partners included newsletters sent out to partners and subscribers as well as information on the museums' websites. These, along with teacher workshops, publications, media interviews, meetings and email letters have resulted in a positive and wide-reaching dissemination of ENGINEER units. Dissemination target audiences vary considerably, from primary school pupils to school leaders, museum educators and educational policy makers. This added to the complexity of the task and required consortium partners to organize materials, events and communication on multiple levels simultaneously.

Meetings with engineering bodies and STEM employers have resulted in new, potentially useful partnerships and avenues for dissemination and advocacy. A range of educational, scientific and STEM orientated conferences have been attended by consortium partners where ENGINEER has been advertised through presentations and the distribution of flyers.

The table below shows the range and proportion of dissemination activities undertaken. By far the most common activity is distribution of published materials. This represents a wide audience but limited scope for direct contact or elaboration on the materials; second to this come meetings, workshops and presentations. These events represent a smaller but perhaps more targeted audience and have the advantage of face to face contact through which those invited can question and more fully understand ENGINEER.



Systems for recording and reporting on dissemination activities have been clear and user friendly, though making the distinction between Dissemination and Advocacy was challenging for some partners and finding clarity between the two required considerable discussion at consortium meetings (e.g. at Paris M 25). Though the timeline for reporting on activities was clear, partners have responded differently to this, some reporting their activities and impact more promptly than others.

### 2.5.3 ENGINEER Website:

The project website presents an overview of each of the ten units as well as downloadable PDF files of the Teacher Guides and Teacher Training Handbooks. This means that anyone visiting the site has full access to all the ENGINEER units and guidance on their use. Resource lists for each unit explain the materials and equipment needed to successfully teach the units. Units can be clicked on and viewed via both their Titles (e.g. 'Suck It Up') and the associated field of engineering (e.g. electrical). This means that teachers or museum educators can find the unit they want whether they are interested in the particular design project (e.g. making a vacuum cleaner) or the particular field of engineering (in this case electrical).

To date (September 2014 - M36) the site has been publicly recommended on google 4 times, 'liked' on Facebook 40 times and tweeted on Twitter 32 times. The website analytics to date are as follows:

First period October 2011 – March 2013	Second period April 2013 – September 2014
<b>2 183 visits</b>	<b>8 920 visits</b>
<b>6 412 page views</b>	<b>25 550 page views</b>
<b>32.8% Returning visitors</b>	<b>32.6% Returning visitors</b>
<b>67.2% New visitors</b>	<b>68.4% New visitors</b>

Increased web traffic in the second period is due to additional material on the website, links to Facebook and other social media, the addition of downloadable guides and outreach and dissemination activities from all partners. Though there have been some teething issues to resolve (formatting, use of pictures, achieving a gender balance in images and translation to Standard English) some of these are an expected part of the web design process. Overall the website has been a useful resource for those who visit and use it, as well as being an effective promotional, dissemination tool for the ENGINEER Project.

CNAM reported in the consortium meeting in Bristol (M36) that the website was receiving hits from across the world with highest responses from India, USA and France.

A Google search on the word 'ENGINEER' does not yield the project website as a search result. However, searching on 'ENGINEER project' yields the project website on the first results page. This is the result of Search Engine Optimising (SEO) and is extremely beneficial for the dissemination process and increases the likelihood of teachers, pupils, parents and museum educators finding the site without having been directed to it. The table below gives more information about how visitors navigated to the site during the first and second periods.

First period	Number of visits	Number of news visits	Number of page views during a visit (average)	Duration of visit (minutes)

(none)	747	361	3.81	04.53
Referral	719	534	2.67	01.40
Organic Search	717	571	2.30	01.28
<b>Second period</b>	<b>Number of visits</b>	<b>Number of new visits</b>	<b>Number of page views during a visit (average)</b>	<b>Duration of visit (minutes)</b>
Organic Search	3 540	2 737	2.48	01.58
Direct	2 373	1 526	2.84	02.41
Referral	2 247	1 377	3.58	04.15
(no set)*	619	352	2.92	03.20
Social	141	110	2.28	01.26

It is interesting that the number of organic views was the least in period one but the most in period two. This bodes well for the future sustainability of the materials and their use.

#### 2.5.4 Advocacy

The Advocacy WP (WP8) was built into and funded within the programme. It had three objectives:

1. To undertake lobbying efforts aimed at persuading European decision makers to support the widespread introduction of engineering into the teaching of science and museums.
2. To promote ENGINEER's programme as a practical and proven way of teaching science.
3. To invite large corporations to play a key role in persuading policy makers to introduce engineering in school at national levels

#### 2.5.5 Advocacy strategy and implementation

Early on it was decided to target partners' own Museum Directors as ambassadors for ENGINEER. It was hoped Museum Directors would convince other museums and schools to get on board, hopefully providing a legacy for ENGINEER. Information from the partners as reported in the WP8 Advocacy report indicates that only five of the ten partners had advocated ENGINEER to the directors of their own museums and in one case the president of the museum actively chose not to advocate for the project.

An advocacy guide was created to help partners in their advocacy of the project to local stakeholders, it included instructions on how to advocate effectively and a workshop was held in Paris for all Museum Partners in M25. This workshop was aimed at getting the partners to be able to discriminate between advocacy and dissemination and to build their confidence in advocacy. Members of the evaluation team observed the workshop and it was clear that confidence and understanding greatly improved throughout the process though some partners appeared more confident than others about approaching policy makers and corporations about ENGINEER.

A number of flyers and booklets were produced by ECSITE which were targeted to high profile organisations at high profile events. A video was also produced and used during presentations at

international events. Comments received about the promotional material were very positive both from the partners and through anecdotal evidence from those the material was disseminated to.

The main targets for advocacy by the partners were their Ministries of Education and large relevant corporations based within their own country, here some appear to have had an element of impact. Success varied widely from one partner (BMSJ) whose museum is now working very closely with officials from the Education Ministry to incorporate engineering onto the curriculum, through to those that are still in discussion with theirs to see if they can get engineering incorporated into the curriculum as part of science or technology teaching. For some partners technology and science do not currently feature at primary level and so advocacy to get engineering onto the curriculum is likely to be difficult to achieve in the shorter term. On the other hand, in England and Germany engineering opportunities already exist on the National Curriculum at primary level. Where discussions are underway with ministries these are expected to continue following the end of this project.

ECSITE themselves contacted six EU commissioners asking them to meet in person but at yet there has been no positive response. So it is impossible to determine whether this approach will have any impact. However, ECSITE has also advocated the ENGINEER programme and units Europe wide and evidence suggests that some of these activities have had an impact. For example ESCITE project workers have been contacted by interested parties from non-project EU countries asking if they can have more information or be involved in the project such as an academic in Ireland and Science and Technology companies in Spain.

A number of partners have managed to get companies on side who they are now working with to lobby their local ministries or to provide further funding for the development of ENGINEER in schools in their countries. Examples include BSMJ and NEMO.

The Advocacy report also states that: ECSITE has established a partnership with Science Business, a web based company dedicated to helping Europe innovate. A banner on their website was shown to gain interest above the industry average of 0.1% (sourced from DoubleClick) with ECSITE quoting a click to impression rate for ENGINEER of 0.43%. E - mails sent to stakeholders were determined by ECSITE to have an open rate of 33% compared to the average of 19.7% (Silverpops 2013), indicating that there is a high level of interest in the ENGINEER programme across Europe

### **2.5.6 Summary**

Partners report undertaking a range of dissemination activities. Use of the ENGINEER website is increasing and the website has the potential to ensure the sustainability of the project in the short term.

It is difficult to evaluate the effectiveness of the advocacy of the project but it is clear that partners have made efforts to undertake advocacy - some with more success than others - and at this stage some partners and ECSITE are having an impact on getting engineering incorporated into the primary school curriculum and/or involving corporations to support the project into the coming years.

### 3 CONCLUSIONS

The project has been characterised by co-operation between partners who have shared ideas, listened to different points' of view and taken on responsibilities to ensure the successful completion of all tasks. This co-operation has led to high levels of engagement between partners who have a sense of ownership of the project.

Important relationships between universities, schools and museums have developed which might lead to further fruitful collaboration.

ENGINEER has created distinctive materials for European contexts based on the EDP.

It has also produced guidance on the processes involved in creating ENGINEER units which will be of value for those interested in creating further units. Classroom evaluation tools and mentoring guidance may also support the development of future units, as well as ensuring that the quality of training is maintained.

The topics focused generally on societal issues and were designed to appeal to both boys and girls. Our data do indicate some differences between attitudes and preferences of boys and girls. We have quantitative data which indicate that girls enjoyed the activities, but it would be useful to undertake more sustained research on girls' and boys' views of the units using more qualitative methods to illuminate numerical data.

It was disappointing that information concerning gender was rated the least useful by workshop participants in the outreach campaign. It is not clear from the data whether this was because teachers already felt they knew about gender differences or whether they felt they were unimportant. This might also be another area for future research.

Training evaluations indicate how well the materials were received in all countries. We know from WP2 survey data that there were different approaches to learning and teaching science in partner countries. Thus it may be that the ENGINEER materials will be useful to provide guidance on innovative pedagogies in countries where they are less common practice. (E.g. active learning, group work, problem solving). The teacher guides provide important information on pedagogy.

The pedagogy focusing on group work and interaction has an impact on teachers' roles, emphasising the importance of facilitating learning rather than imposing a body of scientific knowledge on their pupils. This pedagogy also has implications for the role of museums and science educators, impacting on the environment of museums and new ways of interacting with visitors.

The materials have exposed pupils to different ways of working and also broadened their knowledge of science and engineering.

ENGINEER has provided many structured opportunities for schools to work together with museums as well as opportunities for informal networking. It has provided opportunities to raise the profile of schools through involvement in the project and through schools becoming involved in more activities such as the training in the outreach programme.

Museums have widened their network and become better known within their area and maybe even their country in some instances. This also therefore has an impact on reaching a wider range of young people. Children from middle class families tend to go to museums; if museums have a higher profile in schools they might attract visitors from a wider range of backgrounds.



The project has facilitated a strong network of museums focusing on Engineering. It was evident at ECSITE (M32) that museum partners were respected highly by museum communities across Europe for their expertise in this field.

Continued training will contribute to the sustainability of the project. Here the guides and kits have an important role. The kits are important in supporting teachers to use the materials in their schools and may also facilitate sharing with other teachers.

There is a continued need to gain the support of engineering companies for this work. In particular, the outcomes of this project do indicate that primary aged children can engage enthusiastically with Engineering and it is important that this age range is supported since many attitudes and beliefs are established before children enter secondary education.

Finally, the ENGINEER project has successfully met its objectives – however, whilst there is already evidence of impact in the short term, evaluating the impact of the project needs to be more long term.

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