



Figure 1
Industry at
Royston Gateway,
Royston; what
goes on inside the
walls?

The team at CIEC outline how science capital can be developed through their Children Challenging Industry programme

Increasing science capital by building relationships between industry and the local community

Positively changing children's scientific values and attitudes

In recent years, research has shown that the proportion of young people considering science for future study and careers is not significantly improved by increasing their enjoyment of science at school.

Rather, it is more important to help children understand that science is done by people like them and that science is relevant to their daily lives. Researchers at King's College London, who have done extensive research into this phenomenon, have coined the term 'science capital'. This team of researchers, led by Louise Archer

(Archer *et al.*, 2013), measures a child's science capital in a number of areas:

- scientific literacy;
- science-related attitudes, values and dispositions;
- knowledge about the transferability of science;
- science media consumption;
- participation in out-of-school science learning contexts;
- family science skills, knowledge and qualifications;
- knowing people in science-related roles;
- talking about science in everyday life.

Children who have high science capital tend to come from advantaged homes and be white or Asian males; their family members may well have science-based careers or know people that do. In contrast, over 25% of children surveyed by Archer and her team had low science capital, and these children tended to be female

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and from disadvantaged homes. Some young people do not believe that science is relevant to their lives either now or in the future. Research carried out by the Centre for Industry Education Collaboration (CIEC), based at the University of York, corroborates the idea that many young children of primary age see science as irrelevant to them and can struggle to see the links between science taught in school and its uses in the world around them. Children seeing science as important, useful and 'everywhere around them' is vital for fuelling their interest and increasing their science capital.

In a corner of North Hertfordshire in eastern England, an exciting STEM programme developed by CIEC, called 'Children Challenging Industry', is helping primary-age children to become immersed in local industry and find out more about how the science they study at school is used within the manufacturing processes of industry. The local children grow up looking at the buildings belonging to nearby industry as part of their everyday landscape, but unless they have relatives who work there, what goes on within the walls of the buildings can remain a mystery to them (Figure 1). Like Roald Dahl's Charlie, they gaze at the buildings housing the chocolate factory and wonder what is inside.

By making links between industry and schools, we aim to open children's minds to the science of 'making things' and to the range of roles and expertise within industry. Developing children's experiences of science in industry promotes their science capital and underlines the importance of science in the real world around them.

Promoting children's science capital through industrial site visits

Developing science capital is currently at the forefront of our minds when we are trying to encourage more young people to enter the world of science and engineering. Important dimensions of science capital focus on family science skills, knowledge and qualifications, and on knowledge of the transferability of science (i.e. that science 'opens doors' to many careers). Archer *et al.* (2013) found that children

aged 10–14 with close family members working in science-related jobs are far more likely to aspire to science-related careers than those without parents working in these fields. Many parents, however, do not have STEM-related backgrounds, so it is therefore enormously beneficial for children to meet adults who work in STEM fields and who can share their knowledge of science with enthusiasm.

The CIEC research team investigates the changes in the attitudes of children participating in Children Challenging Industry over the course of their involvement. The children experience three science sessions in school followed by a site visit (Figure 2) or an ambassador visit. Post-programme research undertaken by CIEC in 2018 shows that when children are taken into a local industrial site and find out about what happens there, they are fascinated by the science; the percentage of children who feel they are more likely to want to work in industry in the future jumps from 30% to 40%.

An important element in achieving this change in attitude is the relationship CIEC develops between the local schools and companies. This relationship is multifaceted. It begins with ensuring that a series of classroom-based practical problem-solving activities focus not only on the National Curriculum, but also on the scientific processes in which the companies and their scientists and engineers are engaged. Everyone in participating companies also knows in advance what the children have done in the classroom, and they have often had a go at this primary science themselves!

Children go on to meet a range of

adults who work in a local company and feel a much stronger connection with the buildings, the people and the industrial processes that are happening close to their schools and homes. Science and engineering are no longer mysterious, but become an engaging and enjoyable experience. This connection then cascades to the whole family. As the assistant head teacher of one local school commented:

Local families look forward to their children visiting Johnson Matthey in Royston when they reach year 6 and it has become part of our school calendar.

Thus, science capital is developed through engaging with families through their children's experiences and developing positive science-related attitudes and values. The experiences lead to talk within the home about science and related careers. Chris Morgan, Technology Director at Johnson Matthey in Royston, told us:

I have seen the benefits of Children Challenging Industry from both sides: firstly, seeing the children's enthusiasm about Johnson Matthey when they visit the site, and, secondly, as a parent of two sons, one of whom spent 45 minutes explaining to me what Johnson Matthey does after his class took part, instead of the more usual 'I can't remember' response about his day!

From the standpoint of the companies involved, there is pleasure and surprise in helping the children to learn about science and in tackling unexpected questions. Nick Cooke, Director at Sartorius Stedim, Royston, commented:

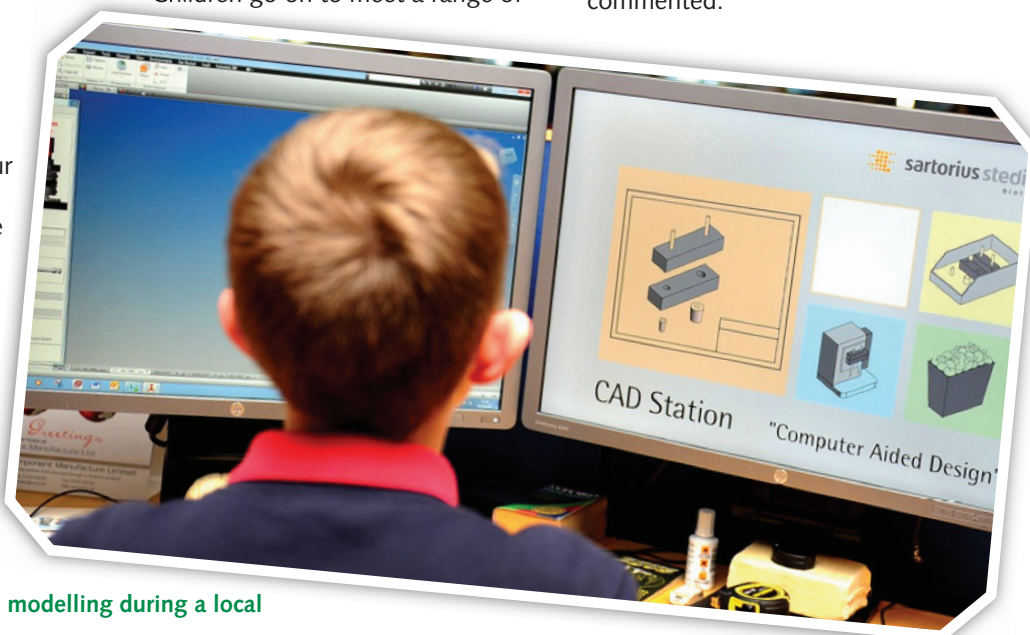


Figure 2 A pupil explores CAD modelling during a local industry site visit

We are really pleased to be able to make a contribution (however small and however long term) towards reducing the shortage of engineers and scientists in the UK. We also really value the opportunities the programme gives us for members of staff to work cross-functionally and to learn new skills in working with the children. However, above everything else, the team simply enjoys sharing what we do and getting such positive engagement on the site visits – the buzz across the site when the children are with us is tangible.

From the perspective of the children, they enter a world of work that is totally new to them, engaging in exciting as well as educational activities. Their science capital is further developed as these out-of-school experiences give the children a chance to meet many people in science and engineering roles. The children leave their visit buzzing and, importantly, their knowledge about the transferability of classroom science into real-life manufacturing contexts is increased. For some, the visit could have planted the seed of an ambition which may come into fruition later, as this letter from a pupil following a site visit shows:

Dear Sartorius,
Thank you to the people who gave their time to give us the best school trip ever. My favourite parts was when we built part of the Ambr 15 and got to test it. I loved the fact that we got to go behind the scenes and see what customers never see, how much work goes into making the machines they buy.

Real and relevant science in the classroom – the ambassador's role

What better way to nurture science capital and make children feel that science 'could be for them' than introducing them to some inspiring role models. Ashwell School in Hertfordshire recently received a visit from an industry ambassador as part of the Children Challenging Industry programme (Figure 3). The children got the chance to work alongside a 'real scientist' from Johnson Matthey, who manufacture active ingredients that are crucial to the exhaust systems of all cars in reducing pollution. These ambassadors also gain from adding a new dimension to their working day and get satisfaction from inspiring young people, as one



Figure 3 An industry ambassador explains her role as an engineer during a school visit

ambassador commented:

From my afternoon with year 5, I can see that meeting a real scientist was something the children were really excited about. The questions asked during the Q&A ranged from 'Who inspired you to study chemistry?' and 'Is working at JM a big responsibility?' to 'Have you ever handled anything radioactive?' All these questions help to develop more curious minds, which have an improved appreciation of science and industry.

Developing a 'science identity' among children in school

Archer (2018) describes in her article, 'Engaging children with science', how developing a child's 'science identity' (the extent to which they 'see themselves [and are more likely] to be recognised by others, as being a science person') is an important aspect of science capital. The classroom-based activities the children carry out as part of the CIEC programme are all available as free downloads to any teacher who wishes to foster this attitude in their own classroom and help raise science capital (see *Weblinks*). Most have industry storylines threaded throughout the sequence of science activities and all are easily resourced and support the teacher in covering the science curriculum, with scientific enquiry and exploration playing a crucial part.

Embedding these activities in a

whole-school action plan will ensure that schools are delivering STEM enrichment in a systematic way. Teachers can also adapt the approach used by the CIEC advisory teachers in school, with children working as teams of 'consultant scientists', putting them in the driving seat of the investigations and decision-making. As 'experts', the children help industry to find solutions through conducting investigations for the company that they will

visit or from which they will receive an ambassador visit. Often a letter or an email from the director of the company is used to help the children assume 'the mantle of the expert'.

These lessons are of 1–2 hours duration and are carefully chosen to enable the children to assume the role of scientists working for the company and to learn and experience some of the science that they will see happening in the local industry at first hand in the classroom. For example, the children may learn about the viscosity of different liquids and devise and carry out their own investigation into how to accurately test the viscosity of liquids; or they may purify salt and have their resulting samples analysed by scientists in their partner company (see *Weblinks*). These activities create a particularly strong bond between the children, their science, and their understanding of its importance in the work place.

Research findings – an increase in understanding

Programmes and resources developed by CIEC have been evaluated robustly for over 30 years, with the Children Challenging Industry programme being the subject of research for the majority of this time. Currently, this involves pre- and post-project questionnaires for participating teachers and children. The aim is to explore changing perceptions of science, engineering and industry as a result of their engagement. Crucially,

