Creativity and Science Education

Rick Hall 2016 Churchill Fellow

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Introduction

Support from the WCMT enabled my study visits to South Korea and India in October and December 2016, to research the teaching and learning of STEM subjects (Science, Technology, Engineering and Maths) and to return with lessons for practical implementation to improve STEM education outcomes in the UK.

Personal context

I am no longer a formally employed teacher, and my last Science qualification was a set of O'levels over 50 years ago; and yet the way that Science is taught, and more especially the way that children learn about Science, and even more specifically how children *learn to be scientists,* have been major concerns in my work over the past 15 years. Since I founded the Ignite! programme at Nesta in 2003, and subsequently established the independent company Ignite Futures Ltd in 2006, I have researched and developed projects and initiatives to shift perceptions of Science at school and beyond.

Throughout this report I will use 'Science' as shorthand for STEM, unless I wish to differentiate

ignitefutures.org.uk

My Churchill Fellowship came at a propitious time for me, semi-retired but not ready to sequester myself in a brown study to write books nobody will read. My appetite for programme design and delivery is as sharp as ever; and I was very grateful for the stimulus of research into how other countries meet the challenge of Science graduate shortages – and further back in the education system, how they engage young children in Science enquiry. I am especially interested in how we can encourage children to learn through practical activities (and play).

I must make clear that WCMT do not necessarily endorse my conclusions or subsequent recommendations

I am grateful to the WCMT Trustees for endorsing my proposals in 2015.

Summary conclusions and recommendations

My report draws on observations from four nations, South Korea, India, Finland and Ghana. All four have achieved stability of political support and national commitment to STEM education. My research, therefore, was designed to address the following questions for STEM education in UK:

- How can we support schools and teachers with supplementary interventions to help children discover and exercise their creativity and curiosity? How can we help schools and teachers reveal the intrinsic creativity in Science subjects?

- How can we nurture curiosity in very young children? And sustain such curiosity throughout their education?

- How can we support and encourage families and communities to build their Science capital? And to develop an appreciation of Science as part of their everyday lives and culture?

- How can we create more opportunities for children to take part in practical Science learning, and to learn how to be scientists, as well as learning Science?

- How can we provide evidence to policy makers of the value of early interventions in Science education both for the pipeline of supply of graduates and technicians for economic growth, and for the active engagement of scientifically literate and well-informed citizens?

My Fellowship research has identified **four critical pathways** which I argue should inform a progressive framework in the UK:

1. building a long-term national consensus around the importance of Science learning within the context of widely agreed and respected strategies for comprehensive education in general. Such a consensus raises the importance of Science and Science education above party political debate and short-term funding cycles.

2. embedding Science into the national culture, identity and ethos – as far as such culture can be defined – and by emphasizing the importance of creativity, imagination, curiosity and innovation as significant dimensions of Science learning and public engagement. Such emphasis highlights the importance attached to international comparisons like PISA league tables, and the economic

benefits to be derived from Science discovery and technical innovation in a global market.

3. investing in formal and informal Science education, and facilities that raise the profile of Science discovery. Museums, discovery centres and facilities in community settings are widely recognised in all four countries as integral to the perceptions of young people, their families and communities that Science IS for the likes of them.

4. developing an infrastructure for the promotion of Science and Science learning, largely through agencies at arms-length from government, and which also cross sector boundaries.

In order to develop these four critical pathways, I make the following **recommendations:**

- **DCMS should consider constituting a body to distribute Lottery funds for the public engagement and understanding of Science, including education programmes in out-of-school and community settings**. Such a function could be included in the constitution of the British Science Association.

Department for Culture, Media and Sport – responsible for National Lottery policy

- **DBEIS should establish a strategic body (or department) promoting the link between STEM programmes and creativity, not simply for the long-term impact on economic growth through innovation and technology, but also to promote progressive cultural values.** Responsibilities should include defining and promoting the STEM-based creative economy and human resources development.

Department for Business, Energy and Industrial Strategy (replaced BIS in 2016)

- **Such a strategic body should work closely with DfE towards gradual and consensual curriculum reform to promote STEM as 'creative' subjects.**

Department for Education

The following recommendations relate to my own work where Ignite! is based:

- **Nottingham should pilot a programme of Community Curiosity Labs based in local libraries (and other community venues).**

- **Ignite! should develop its offer of hands-on workshops in schools and community settings to include Science toy-making.**

Some context of motivation

Many of the conclusions in this report refer to the distinctions between:

- teaching Science
- learning Science and learning about Science
- learning to be scientists

It is my contention that if the country, for reasons of economic growth, academic research or international prestige, decides it requires more graduates in Science and engineering, and furthermore places such ambitions in the political realm, it should invest longer term in programmes and interventions starting at pre-school and primary phase. Instead, driven by short termism (or by the electoral and budget cycle perhaps?) successive governments have placed greater emphasis on converting Science GCSEs into A Levels, and A Levels into first degrees. By and large this has not worked; there is still a huge reported shortage of Science and engineering graduates now and predicted for 2020 (and beyond).

1.5m extra STEM graduates 'needed' by 2020 and an increase year on year of 40,000 technicians (CaSE Policy Briefing 2015)

This is particularly evident in the declining numbers of Science graduates going into teaching. Secondary schools report chronic shortages of Science graduates teaching their own specialist subjects; fewer Science graduates are enrolling on PGCE courses.

In primary phase the shortage of Science specialist teachers is even more worrying. Fewer than 6,000 primary school teachers, spread across 22,000 primary schools in England and Wales, have a Science HE qualification. This is at a time when school rolls are rising, with the consequence that the percentage of primary school children accessing the 'personage' of a Science graduate is further declining.

Royal Society 2010

Is it a case of too little investment, too late?

To take an analogy; if the UK decided that its international profile and economic growth lay in the development of a thriving performing arts sector (not unfeasible given the value of exports to Broadway) we would invest in dance, drama and music across all ages. And we wouldn't simply require school children to study the choreography or scores of the past; we would ensure that children danced, played musical instruments and sang, both for pleasure and proficiency, and in a greater proportion of the school day than is available now. Subject allocations and timetable pressure reflect other political priorities.

It is reassuring to learn that the 2nd Heir Presumptive will 'do' dance (ballet?) at his pre-school

To return to my contention; Science should be available both to study and to practice, both for pleasure and proficiency, from the very earliest age in a child's education journey. We may deduct from the ASPIRES research programme, that children as young as 10/11 are forming perceptions of themselves in the future, and mostly NOT as scientists. If we have 'lost' children to the fascination, appreciation and understanding of Science by the time they leave primary school, we won't get them back to enter Science related professions some 10 years later.

ASPIRES research, Prof Louise Archer et al, KCL 2012 ongoing at UCL

There is a further and wider consideration. The pace of technological innovation and Science discovery is accelerating giving rise to new and sometimes controversial areas of debate. The consequences of some discoveries and developments are far reaching and call for informed and evidence-based formulations of policy. For public policy to secure informed consent and authoritative consensus, young people, their families and communities need a level of understanding higher than they generally profess now. Active democratic participation in Science debate and decision-making in turn requires an engagement in, and a commitment to, Science education for its own sake, and not simply to fill a quota of Science graduates and technicians for future economic development.

'not for the likes of us'

An important aspect of Science education for informed democratic participation is to recognize that it can and should be an element of our cultural lives. In earlier times we would have regarded Science as part of what was defined as an 'entitlement' curriculum, an essential component of our learning for life.

The following questions, therefore, have informed my work in recent years, and my thinking in preparing an application to the Churchill Fellowship programme:

- How can we support schools and teachers with supplementary interventions to help children discover and exercise their creativity and curiosity? How can we help schools and teachers reveal the intrinsic creativity in Science subjects?

- How can we nurture curiosity in very young children? And sustain such curiosity throughout their education?

- How can we support and encourage families and communities to build their Science capital? And to develop an appreciation of Science as part of their everyday lives and culture?

'Science capital' refers to connections and resources at home or in the family

- How can we create more opportunities for children to take part in practical Science learning, and to learn how to be scientists, as well as learning Science?

- How can we provide evidence to policy makers of the value of early interventions in Science education both for the pipeline of supply of graduates and technicians for economic growth, and for the active engagement of scientifically literate and well-informed citizens?

- And what can we learn from other systems and approaches in other countries to any and all of the questions above?

With these thoughts to the fore as I constructed my proposal for the WCMT Fellowship, I wanted to research attitudes towards Science education as much as methodologies and pedagogies in other countries. And my focus alighted on South Korea and India – two countries where the stakes in a Science and technology based future could hardly be higher.

Country profiles follow, but first an additional note about my other recent travels and projects.

In January 2015 I traveled to Ghana to support the establishment of the first Lab_13 in Africa. Lab_13 is an Ignite! initiative where children manage a lab space in school for their own research, investigations and experiments, guided by a Scientist in Residence. Lab_13 is a space where children learn how to be scientists as well as learning Science.

https://lab13network.wordpress.com

Ignite! had created a partnership with the Lightyear Foundation, who already had established relationships in Ghana, and via a combination of funds from a Kickstarter campaign and the RSA (The Royal Society for the Encouragement of Arts, Manufacturing and Commerce) early in 2015 we were ready to open a Lab_13 at Agape School in Bosomtwe district near Kumasi, a university city 5 hours north of Accra. My first visit to Bosomtwe in January 2015 confirmed the partnerships and practical arrangements to open Lab_13 Agape shortly afterwards.

I returned to Ghana in July 2015 to review progress. Not only had the Lab_13 opened and was active in daily use by dozens of students, but there were four Scientists in Residence working a kind of team ministry around 30 local schools with teachers workshops and Lab_13 competitions.

Lab_13 Agape, Ghana – panorama July 2015

The end of term celebrations involved over 400 students, and dozens more families and local dignitaries. I was confirmed in my belief that a facility that children managed for their own Science investigations could be a great motivation for learning, but also a hugely positive focus for community engagement.

Another local school opened a Lab_13 a few months later. And in 2016, Lab_13s in Bosomtwe District were adopted by the Hive, the enterprise and innovation hub at the Kwame Nkruma University of Science and Technology, KNUST, at nearby Kumasi.

Lab_13 Solid Hope

Following my second visit to Ghana in July 2015, I travelled to the village of Koli in Finland, initially for a vacation and to start the writing my A-Z of Creativity, but quickly to explore the possibility of establishing a Lab_13 in the school. Koli is a small village of 300 people on the edge of the Koli National Park, famed for the landscape of lakes and forests that inspired Sibelius.

The school has 22 pupils, in two classes, years 1-4 (7 years old to 11) and years 5-8 (11-15 year olds). Two teachers deliver the main school curriculum with specialists visiting one of two times a week for English, Science or music lessons, and including the Koli Artist in Residence who is invited to work with the school during their month-long residency in the village.

I find it heartening and remarkable that a village of 300 people supports an artist in residence every month throughout the year

My light touch work in the school was welcomed, but it was clear that a Lab_13 in a very small school would be an enormous commitment, especially sustaining a Scientist in Residence. More of this later in the report.

So when I was invited to submit a more detailed proposal for the Winston Churchill Fellowship, my emotional energy was already fired up by the potential of an international network of student managed, enquiry-led facilities. I wanted to extend my understanding to two other nations where STEM was intrinsically a part of the national interest, South Korea and India.

I knew enough of both countries to appreciate the investment their governments were making into a future profile in the world and ranking in global economics based in innovation and technology. There were two further areas of focus for my research; how were such global economic aspirations translated

notably the OECD PISA league tables

into, and to what extent were they dependent on, Science education? And how, and again to what extent, was an appreciation of creativity and creative thinking a factor in the success of their respective Science education programmes?

In short I wanted to investigate the extent to which creativity and curiosity were acknowledged in the STEM learning of young people and how they were nurtured and sustained throughout the education careers of Indian and South Korean students.

A brief note on STEAM

There has been a renewed interest in UK in the last two years or so in the concept of STEAM – adding Art to the traditional grouping of Science, Technology, Engineering and Maths. Apart from its initial (superficial?) attractiveness as an acronym – 'STEAM powered', and 'a new age of STEAM' etc – for me the concept carries the seeds of its own destruction. Where do we stop? Surely we can make a case for including Sociology or the Humanities in a broad, inter-disciplinary approach to the study of natural phenomena and our human interactions with nature? Or Philosophy? And then the concept collapses under the weight of its own self-regarding acronymic cleverness.

We note that the term 'Scientist' only replaced 'Natural Philosopher' as late as the 1830s

STEAM is not a short cut to a more desirable outcome - that Science should be regarded as an essential element of the cultural lives of young people, their families and communities. Adding Art to Science does not per se make it more accessible or palatable to people turned off by impressions that Science is hard, geeky, conducted in labs remote from daily life, and not for the likes of them. The motivation of programmes like Fun Palaces, which is rooted in community engagement, is more fundamental than adding an aesthetic quality to Science communication and understanding.

with its byline, 'everyone an artist; everyone a scientist' http://funpalaces.co.uk

I am more interested in the possibilities that arise when subject disciplines are underpinned by creativity and creative thinking (including problem-solving) and driven by curiosity. Creativity is not interchangeable with Art, or the arts, although art without creativity is rather mundane and meaningless. Creativity is expressed through many disciplines throughout culture and education – and some would argue that it should inform all learning disciplines.

I'm also interested in the recent Finnish proposal to do away with subject boundaries altogether and instead teach from a focus on topics and events, again informed by the combination of creativity and curiosity. It would be difficult to imagine such an approach being widely adopted in the UK.

Which brings me to curiosity. As we shall see in my visits to Pune, Udaipur and Ahmedabad in India, three outstanding education initiatives are infused by their founders' beliefs that children's curiosity needs to be seeded and nurtured at a very early age and then sustained throughout their education. Kiran Bir Sethi, the founder of the Riverside School in Ahmedabad makes 'the spirit of wonderment' a central tenet of her philosophy for learning.

Issues and concerns in the UK

In 2013, Ofsted, the Government education inspection and improvement service, produced a report on the difficulties secondary schools were facing in sustaining interest and commitment to Science subjects especially in the transition from primary to secondary phase and in Key Stages 3 and 4. The report, Maintaining Curiosity, coincided in theme and conclusions with the ASPIRES research into students' attitudes and perceptions of STEM subjects and their likelihood of considering a STEM related career or courses of HE study. Learned institutions such as the Institute of Physics and the Royal Society of Chemistry also commissioned research and programmes to counter the falling numbers of students taking triple Science GCSEs.

Maintaining Curiosity November 2013, Ofsted No. 130135

The Senior Lead for Science at Ofsted, Brian Cartwright observed:

'For pupils to achieve well in Science, they must not only acquire the necessary knowledge, but also understand its value, enjoy the experience of working scientifically, and sustain their interest in learning it. Pupils in schools need to discover the concepts revealed through observing scientific phenomena *and conducting experimental investigations for themselves.'*

my italics

And:

'Science achievement in the schools visited was highest when individual pupils were involved in fully planning, carrying out and evaluating investigations that they had, in some part, suggested themselves.'

Maintaining Curiosity November 2013, Ofsted No. 130135

The ASPIRES research, first published in December 2013 and ongoing, also recommended early interventions including initiatives at primary phase, and to build 'Science capital' at home and in family life as well as at school. The research examined children's stated aspirations and found:

'The ASPIRES research found that, on the whole, most young people aged 10-14 hold relatively high aspirations for professional, managerial and technical careers. We did not find evidence of a 'poverty of aspirations' among students or parents – almost all students reported that their parents value education and want them to do well.

ASPIRES
King's College London 2013
ongoing at UCL

'Yet very few young people (approximately 15 per cent) aspire to become a scientist. This aspiration remains consistently low across the 10-14 age range. It is lower than many other types of aspiration and appears disproportionately low compared to students' reported interest in Science, although STEM-related careers, such as in medicine, are more popular aspirations.'

These findings were echoed by the research for the Institute of Physics, which identified a further major concern in the gender imbalance in students pursuing A Levels and beyond. The IoP started to consider these challenges as far back as 2004, with the following questions, largely relating to image and perceptions:

The Information Needs of Students
Institute of Physics – 2004

- How can the way physics topics are taught at GCSE and earlier be made more relevant to everyday life?
- How can pupils be encouraged to be more proactive/involved in lessons?
- How can the benefits be 'sold' to pupils in KS3 and KS4?
- How can more students be encouraged to take physics at A Level?

It is significant that the IoP took an approach to changing the image and perceptions of physics that explicitly included a reference to 'putting the fun' into physics.

The Royal Society of Chemistry has similarly embarked on a five year research programme, Chemistry for All, that aims to identify strategies and interventions, including informal approaches to learning, that have positive impacts on the numbers and range of students studying chemistry to GCSE and beyond.

RSC/UCL/IOE
Chemistry for All
2014-19

The evidence that these and many other interventions across the STEM education institutions, government agencies and universities are having only marginal impact on student perceptions and enrolments suggests that there may be deeper cultural factors involved; and this brings me to my WCMT Fellowship.

Country profiles

Why South Korea and India?
And what further can we learn from Ghana and Finland?

Finland

Widely praised for the radical (some would say, progressive) reforms to its education system in the last 30/40 years, and its status as the only European country to feature in the top 10 in the PISA international comparisons league table, Finland continues to attract academic research into how and why it works. There is almost a disbelief in some educational opinion as to how Finland appears to be 'getting away with it.' After all, children do not start formal school until they are 7; they are not publicly tested until they are 15, they are not selected, segregated or setted by ability throughout their school careers, and schools are not inspected, or put into league tables.

A fuller analysis is in Cleverlands by Lucy Crehan, published by Unbound Books 2016 – my acknowledgements for drawing on Lucy's own profound research

However far Finland's success may appear to fly in the face of UK expectations and traditions, there is a much deeper analysis required to make any comparison meaningful. I shall attempt a brief summary.

School starting age and its impact on literacy: whilst it is true that Finnish children do not start formal language learning until they are seven, there is a National Curriculum for the preschool age that includes this key reference, 'the basis for emerging literacy is that children have heard and listened, they have been heard, they have spoken and been spoken to, people have discussed things with them, and they have asked questions and received answers.'

Play: as we shall learn from the Centre for Practical Science Education, SciPOP at IUCAA in Pune, and the Singhal Family in Udaipur, play (and toys) for learning features as a discreet subject of my Fellowship reflections. In Finland in early years and preschool activities play, learning and the acquisition of skills (such as co-operation and attention) are virtually indistinguishable. But a key feature is that resources and outcomes are of high quality, and learning is considered by children to be joyful and rewarding.

Comprehensive education: it is worthy of note that when the Education Act abolishing selective education by exam at age 10 was passed in 1963, Finland as an independent nation had only been in existence for 46 years. The role of education in creating a national sense of identity was hugely significant, so much so that education was largely lifted out of party political debate, and has rarely been a focus of election dissent since that act was passed.

A comprehensive system, which also prohibits private schools from charging fees, or selecting on the basis of ability, was established slowly over 16 years, building an evidence-based

It is hard to imagine such strictures on private schools in the UK ever being accepted (by the Establishment?).

consensus that testing, selecting and segregating children at 10 increases inequality, whilst having a negative impact on overall academic outcomes.

The comprehensive system in Finland is also supported by some very high quality resources including textbooks. The technical specification of equipment in the two classrooms in the Koli school (remember for 22 pupils) was higher than any equipment I have encountered in the UK. Textbooks are the most commonly used resources, and they are of outstandingly high quality in content and form.

Teachers and inspections: in Finland there are no school inspections and no teacher evaluations. Teachers, therefore, are not held to account on the basis of national tests, and there are no league tables. Nationally graded exams are held at age 15. The impact of such a system is two-fold; teachers are highly motivated, and quality assurance is built into initial teacher training, qualifications and ongoing CPD. Teaching is a highly regarded and respected and competitively desirable profession.

System-wide support: Finnish children are supported in their learning and also their lives in and out of school by teams of child welfare professionals that will include a psychologist, social worker, study counselor, a dentist, nurse, speech therapist and family counselor. It is a legal requirement for every school in Finland to have a child welfare team, even if some of the professionals are shared.

And all this support and investment has achieved a political consensus over many decades, so that as Finland celebrates the centenary of its independence in 2017, it is still the highest scoring non-Asian country in the OECD PISA rankings.

Classroom in the village school in Koli, North Karelia, Finland – the school has 22 pupils aged 7-15

Ghana

I have visited Ghana twice in the past two years in association with the Lightyear Foundation and with the aim of introducing the Ignite! programme, Lab_13, a space in schools that pupils manage for their own Science investigations, experiments and research topics.

https://www.ignitefutures.org.uk/lab-13

Ghana is another of the countries I have researched and had the pleasure to visit in recent years that is celebrating an anniversary of independence. Of the four countries in this report, Ghana is the youngest at a mere 60 years old (in 2017).

Let me quickly acknowledge that independence from a colonial authority and within defined borders is only a small part of the history of the region and country of 'Ghana'

When Ghana gained independence and joined the Commonwealth in 1957, there was one university and a relatively small number of secondary and primary schools. Gradually, as the mineral wealth of the country and the exports of its agriculture grew, Ghana increased its spending on education so that now it is between 30 per cent and 40 per cent of its GDP.

Presently, with an estimated population of 30 million, Ghana has 18,530 primary schools, 8,850 junior secondary schools, 900 senior secondary schools, 28 training colleges, 20 technical institutions, four diploma-awarding institutions, six public universities and over 15 private universities in addition to 12 polytechnics.

With a relatively stable and embedded democratic government, a new Education Plan was finalised in 2007 and the aim established to provide universal free primary education by 2015 in line with the Millennium Development Goals. Most Ghanaians have relatively easy access to primary and secondary education, within a fairly even mix of public and private schools. Many private schools are linked to particular faith groups.
The government is increasing its support for public schools with school fees, uniforms and free school feeding programmes. There are inspection and monitoring programmes, especially linked to the health of pupils including the prevalence of malaria and sexual health and the rates of pregnancy among young teenage girls.

The official language of instruction throughout the Ghanaian educational system is English. Students may study in any of eleven local languages for much of the first three years, after which English becomes the norm. All textbooks and materials are in English.

STEM education is a priority for Ghana's economy and political leaders, and the Director of the network of private schools in

Bosomtwe District, Mr Joseph Donkor, spoke to me at length of his concern that despite the wealth and potential for growth of the Ghanaian economy, without STEM education the country will be left behind.

A number of agencies are involved in the promotion of STEM subjects in Ghana, notably Wellcome Trust, the British Council and Institute of Physics, as well as in-country organisations such as GH Scientific, AWAP, the African Women's Advocacy Project, and The Exploratory.

Playtime at Agape Academy in Jache, Bosmotwe District, Ghana. A school of 400 pupils aged 5-14

India

Sweeping generalisations about 1.35bn people, around one fifth of the world's population, are pretty meaningless. In India if you are 'one in a million' there are 1,350 others just like you.

30% of the population are under 15, officially of school age though not all children are able to attend school or pre-school. That translates as 400 million children and one million schools;

and a 2012 census recorded over 58m primary school teachers and 22m secondary teachers; this is difficult to imagine, and impossible to draw sensible conclusions from.

A 2009 Act of Central Government made free education for children between 6 and 14 a right. States are the administrative level for enforcing and fulfilling the Act. The 2009 Act also banned child labour, but in India it is difficult to monitor and enforce such regulations especially in rural areas. However, in January 2016, the State of Kerala became the first to achieve 100% enrolment of primary school children, and a 2013 report recorded that over 96% of rural children were enrolled at school.

Over a third of schools are private, though fees are strictly controlled, and a 2013 census suggested that 29% of Indian school children attend private schools, with a higher percentage in cities.

In my visit to India, I visited six schools. One in Mumbai was a large comprehensive 'through' school (from 6-14 years of age), and private to pupils of a faith group. In Pune I visited two primary schools, both public; one in a fairly distant suburb of the city, and the other some four hours drive into a remote rural area. The school in Surodi had 73 pupils enrolled with two teachers, and, I must add, the support of the whole village community.

cf Koli village school in Finland

In Udaipur I visited a large state secondary school with around 900 pupils; and in Ahmedabad, the Riverside School is a private 6-14 school of 400 students.

India recognizes that 400m children and young people are an amazing resource for a developing nation which is pinning its international status and economic vibrancy in innovations in Science and technology. We probably all know at first hand of India's expertise in IT support, and shortly after my return to the UK, India's space agency launched 92 satellites on a single rocket delivery system, earning many millions of space technology dollars in the process.

As India also prepares to celebrate an independence anniversary of 70 years, it is worth noting similarities with Finland, Ghana and South Korea in the political commitment to investing in education to forge a national identity. The recent statute for the national anthem of India to be played before every film, entertainment and sporting event may feel old fashioned to many Brits (even to those listening to BBC Radio4 at closedown), but at the cinema I attended in Ahmedabad it was fervently observed.

So much so that when the anthem featured again in the background of a film about sporting achievement, half the audience stood up again.

Whilst I was in the country, the Indian government embarked on a most ambitious reform of the economy, removing different denominations of rupee notes virtually overnight and driving the populace to a 'cashless' economy. This is seen as an attempt to control more of the cash transactions and to raise the rate of tax returns especially sales taxes. I was told that currently only 3% of the adult population pays income tax, and the government has set a target of 17% by 2020.

With a potential tax yield five or six times its current level, the prospect of India investing in infrastructure projects is high. A similar investment in education will also transform the outcomes and long term prospects for its national and global leaders of the future.

An after school children's centre in Pune, looking after upto 200 children each evening

South Korea

Only Singapore out-performs South Korea in OECD PISA tests for reading, maths and Science. Education in South Korea is something of a national obsession, so much so that it is referred to as 'education fever'.

The goal of school education is a university place; indeed the lack of a university degree is regarded as a social stigma and carries with it not just depressed work prospects but marriage suitability. As a result over 75% of high school students go on to university. This in turn has led to academic inflation and a shortage of 'blue collar' workers (not all manual work has been automated or transferred to robots in S Korea). When the global recession hit Korea, and an increase in unemployment ensued, the stats showed that one in three unemployed people were university graduates.

In some years this figure is as high as 84%; in UK this figure hovers around 48%

With unemployment rising among young people, the Korean government sought alternatives to a university degree as the principal passport to employment, and in 2015 rapidly extended the opportunities for vocational high school students to undertake apprenticeships.

Lower down the school system there is a strong emphasis on self-discipline and respect for learning. As early as kindergarten children are taught in themes such as Disciplined Life, Sensible Life and Enjoyable Life – though one suspects that enjoyment comes after discipline and 'good' sense.

School years are divided across primary, middle and high schools, with public examinations only coming at age 15 to determine routes to university entrance (or not). Such is the pressure on gaining a university place, that students frequently work late into the evenings, foregoing teenage pursuits in favour of study, cramming for exams and extra tuition and coaching. Although this has given rise to concerns about the health of Korean young people there seems little prospect of change in the immediate future. Suicide among young people is the leading cause of death.

It is a commonly known saying in Korea that 'If you sleep three hours a night, you may get into a top 'SKY university;' If you sleep four hours each night, you may get into another university; if you sleep five or more hours each night, especially in your last year of high school, forget about getting into any university.'

I was struck by the number of commercial advertisements in Korea that made direct reference to innovation and creativity

(especially in products that involved formulations). My visit was partially motivated by a wish to discover, in a nation where conformity of behaviour appeared to be the cultural norm, whether creativity was more than simply thinking for oneself.

children at Maedong Elementary School S Korea respond to a Science workshop by the author

What these four countries have in common is the sense that their national identity, and by correlation their prosperity and status in the world, depends on systems of education that are designed to be progressive, highly valued and technical. They all place a high priority on STEM subjects and English as a second language.

And, significantly, their systems of education are generally built on consensus as part of a wider plan of nation building. Children and their parents value education as defining their national pride; they want to do well at school because they want their country to do well in the world. In such recognition, education is lifted above party politics and is rarely subject to cycles of change or restructure.

Finland	Founded 1917
India	Independent 1947
South Korea	Independent 1948/1953
Ghana	Independent 1957

And so, to return to my key questions…

On the basis of my WCMT Fellowship research in South Korea and India, and supplementary visits to Ghana and Finland:

- What can we learn from other systems and approaches in these other countries to any and all of the questions below?

- How can we support schools and teachers with supplementary interventions to help children discover and exercise their creativity and curiosity? How can we help schools and teachers reveal the intrinsic creativity in Science subjects?

- How can we nurture curiosity in very young children? And sustain such curiosity throughout their education?

- How can we support and encourage families and communities to build their Science capital? And to develop an appreciation of Science as part of their everyday lives and culture?

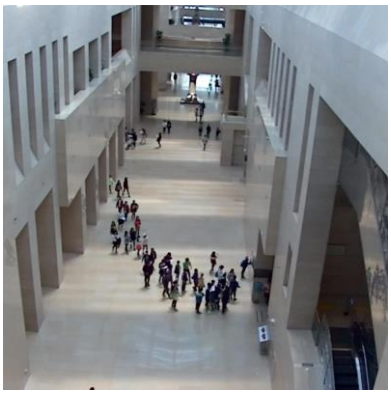
- How can we create more opportunities for children to take part in practical Science learning, and to learn how to be scientists, as well as learning Science?

- How can we provide evidence to policy makers of the value of early interventions in Science education both for the pipeline of supply of graduates and technicians for economic growth, and for the active engagement of scientifically literate and well-informed citizens?

Let me start at the second question in the agenda: How can we support schools and teachers with supplementary interventions to help children discover and exercise their creativity and curiosity? How can we help schools and teachers reveal the intrinsic creativity in Science subjects?

My argument is that the many and various interventions designed to supplement schools and teachers in the UK are united through a single though broad aim – to increase the numbers of students studying STEM subjects to a higher level, with the goal of increasing the numbers studying for MSc and PhD, the level now regarded as currency for STEM careers and/or research. In S Korea and India supplementary interventions have a greater role to play in forming the cultural expectations of young people. There is a complete acceptance

that STEM subjects are important, not simply because the economies of the countries depend on them, but because they form part of who students are as future citizens.



My visit to South Korea included the National Museum in Seoul, the Science Museum and the site of the new Children's Science Museum, currently under construction. And my visit coincided with the National Science Festival in Daejeon. The named institutions and the Festival are massive in scale and extraordinary in numbers attending. Crocodiles of small children in pairs hand in hand crisscrossed the huge atrium of the National Museum.

Bearing in mind that national identity as an independent nation is less than 70 years old in South Korea, and also the sense of cultural competition in the region, not only with its namesake neighbours across the DMZ, but also with China and especially Japan, the iconic status of the museum is of little surprise.

I was also taken by my generous host to the Imperial Palace another huge and extraordinarily impressive monument to the idea of the culture of the past informing the national identity of the present. The explicit messages are clear. Korean culture is vibrant, innovative and dynamic; it draws on the past but looks to the future – not in cliché or slogans, but as a reality of how to sustain an economy and democracy in the face of immediate and proximate competition.

For children, these iconic edifices are a source of inspiration and reinforcement of their education and attainment. The values imbued in the artifacts of the museums and the buildings of the Palace enclosure are adopted with genuine reverence, enthusiasm and fervour.

In India two initiatives stood out; in Pune I was invited by my host to a Children's Centre, looking after 200 children with activities designed to stimulate their speaking and listening skills, and to develop their powers of reflection. Storytelling and group conversations were key media. My host was keen to show how receptive the children are to activities based in Science and Science busking. My simple workshop using Science toys was accepted with delight.

Such a supplementary provision for children was sustained by charitable donations.

In Udaipur, a prosperous tourist city in Rajasthan, the Singhal family who own a local engineering and technology business and with whom I stayed, have set up an after school Science activity centre largely based on play for children in a shopping mall. They plan to open a large Science discovery centre in the city in the next two to three years. Such philanthropy is not unusual among successful Indian families.

The Children's Science Museum

Back in Seoul, my host explained that he is the design and content consultant for the new Children's Science Museum, under construction and due to open in 2018. The plans are the most ambitious for a Science learning centre of any I have encountered and I am delighted to have permission to share some of the general floor plans and range of content under consideration.

As the illustrations show, the museum will combine the most advanced technical innovation with artifacts and exhibits of human ingenuity as well as the natural world. There is a clear curatorial philosophy here, that creativity and curiosity are the faculties of the mind that will guide young people to even higher levels of invention. It is interesting that when the Children's Science Museum opens it will share a feature with the Natural History Museum in London – the skeleton of a Blue Whale; except that the atrium in Seoul will be a digital light projection.

The National Science Museum in Seoul is one of many claiming national status, and there are over 120 Science museums in the country (of 50m population). In the UK there are 60 Science and discovery centres and organizations registered with the Association for Science Discovery Centres (ASDC) (serving a UK population of 65m).

I visited the National Science Museums in Seoul and Daejeon. Both impress in size and range of exhibits, activity zones and opportunities for visitors, especially children, to learn scientific concepts by doing 'experiments'. In Seoul, the entire top floor was devoted to Science labs used by school students. In one I observed students examining slides of brain tissue under microscopes; and pondered where in the UK such an activity could take place with school age students.

The range of cultural references in the National Science Museum is extensive. I'm conscious of not merely producing a photo essay so will place a further selection of pictures as an appendix, but the following pictures are as illustrations of the comprehensive nature of the Science Museum exhibits and activities.

A panorama of the National Science Museum

Pictures of Faraday at the RI and Joseph Wright of Derby at the National Science Museum

Nurturing curiosity

- How can we nurture curiosity in very young children? And sustain such curiosity throughout their education?

I came to South Korea with a question, 'is a highly competitive education system conducive to sustaining the natural curiosity of children and young people?' In simplistic terms in the UK do we squeeze curiosity (and creativity) from young people in pursuit of SATS and GCSEs? I would argue that two related developments in assessments in the UK have contributed to the devaluing of curiosity; one, the decline of course work in GCSE assessment with the consequent loss of opportunities for students to design and deliver their own Science investigations; and two, a decline in practical work in STEM, especially those which offer opportunities for variations and experiment.

Practical work and 'hands-on' experiments in Science lessons (and Science fields trips) have been in decline in the UK for at

least 15 years – a SCORE Report highlighted the decline in 2008; a Parliamentary Select Committee confirmed the concerns in 2011; and the Education department of Wellcome Trust reported their concern in both a report on Primary Science and a blog in 2013. In each report cited, a number of causes were examined including a lack of confidence and experience in Science teachers, limited space and facilities, and a concern over Health and Safety reflected in extensive risk assessments for each activity.

Science Community Representing Education (SCORE) – Practical Work in Science Report 2008;
HoC Science and Technology Select Committee, HC1060-1 2011;
Wellcome Trust blog 2013

In one of his last monthly commentaries, the Chief Inspector of Schools and CEO of Ofsted, Sir Michael Wilshaw, expressed concern about the status of Science teaching in Primary schools including an observation that some children could not remember the last time they had a Science lesson.

HMCI's Monthly Commentary May 2016 https://www.gov.uk/government/speeches/hmcis-monthly-commentary-may-2016

A number of initiatives have been introduced over the past ten years or so to address these concerns; notable are programmes from the Science Council and learned institutions including the Royal Societies of Chemistry and Biology and the Institute of Physics. These have been supplemented by programmes from trusts and foundations, especially Wellcome Trust and Ogden Trust. Wellcome have invested heavily in themed programmes with extensive reach, offering resources, boxed kits, to all schools at Primary and Secondary phases on topics such as diet (The Crunch) and cleanliness (Dirty Stinky Kids).

In a much smaller way, Ignite! through Lab_13, has attempted to provide an alternative case study of laboratory based learning, not just in Science subjects but also in the scientific methodology of heuristic learning – how to BE scientists.

By distinct contrast…

India started its journey towards a universal provision of an integrated Science curriculum soon after independence with a commission into Secondary education, 1951-53, which recommended teaching General Science as a compulsory subject. The Indian Government established a separate Department of Science Education in 1961, but as with the other countries in this report, policies aimed at raising attainment in Science were regarded as matters of such national importance that they were lifted out of the cycle of party politics. The Department of Science Education brings together many of the functions which in the UK are divided among the Government departments of Education, Business and Skills and arms length bodies like the Science Council, Royal Society and British Science Association.

India has adopted various programmes for Science curricula including Nuffield with its emphasis on Lab-based practical

experimentation for the discovery and verification of Science principles. This posed an immediate problem for the Indian Department of Science Education with regards to the lack of facilities and resources; a critical factor that I shall return to.

Another important initiative from the Department of Science Education in 1963 was the Science Talent Search Scheme, designed to identify students with an aptitude for Science, and to stimulate interest in STEM subjects. It is interesting that the Talent Search scheme started in India over 20 years before the British Science Association introduced the CREST Awards, and Young Scientist of the Year.

Nurturing and sustaining curiosity was the driving motivation behind the inspirational work of Professor Arvind Gupta at Pune University, which in turn was a prime reason for my proposal to visit India with WCMT. Now retired from his formal university post, Arvind Gupta is renowned for his popularization of Science learning, especially his ingenuity in making 'toys from trash'.

arvindguptatoys.com

Arvind Gupta started his mission to bring Science to the masses at Kanpur in the mid 1970s and later opened a centre for practical Science resources, SciPOP, at the Inter-University Centre for Astronomy and Astro-physics (IUCAA) at Pune University. I was excited and grateful to spend a week at IUCAA to meet the current Head of the Centre, Ashok Rupner, and a team of dedicated volunteers and staff.

SciPOP perhaps rather defensively declares its credo thus, '*Science is not a boring subject and Teachers are not boring people. This is a fact and SciPoP has taken the responsibility to make this clear to students as well as educators!*
One of our main activities is the development and collection of resources for free distribution amongst progressive teachers and Science popularisers'.

The Centre runs a very busy programme of lectures, demonstrations and outreach activities in schools across the state of Maharastra. Ashok Rupner generously gave up many hours of his schedule to introduce me to an after school centre for children in Pune, and to two schools including a village school in Surodi some four hours drive from Pune.

By offering workshops of my own, and learning from the staff teams at both the informal after-school centre, and the two schools, I learned the significance and vital importance placed on hands-on Science learning, in some of the poorest locations where resources are extremely limited.

My workshops were filmed at the IUCAA base, and I am honoured by their being dubbed into Hindi and Kannada by Arvind Gupta himself.

https://www.youtube.com/watch?v=VsUOyXW7Ef4

I spent time at the Science Education Initiative based at Ferguson College in Pune; SEI is a programme within an independent campaigning organization, Science For All, part funded by grants from international development charities. The purpose of the programme is to raise the standard of Science teaching in low income areas, by selecting and supporting recent graduates through a Fellowship programme.

SEI's mission statement: *While over 80 million students are enrolled in secondary schools in India, standardized assessments show that Indian students are among the worst performers internationally. This is largely because education systems in India (and other developing countries) are biased to the top of the income distribution. Designing systems that provide equal access to high-quality science education to the "bottom of the pyramid" (students who go to low-income schools, who live in rural areas) where there is a huge untapped reservoir of talent, could potentially transform the economic and intellectual future of the developing world.*

I delivered a workshop to 30 SEI Fellows and appreciated the additional support they accessed through mentoring and familiarization with teaching resources. The programme has some similarities with Teach First in the UK not least as a response to a shortage of Science graduates considering teaching as a career.

I also visited and gave a workshop to the Indian Institute of Science Education and Research in Pune. Each IISER (there are seven across the nation) is an autonomous institution awarding its own Masters and Doctoral degrees. Students are encouraged to carry out research projects.

The IISERs represent a unique initiative in India where teaching and education are totally integrated with research into both curiosity and creativity.

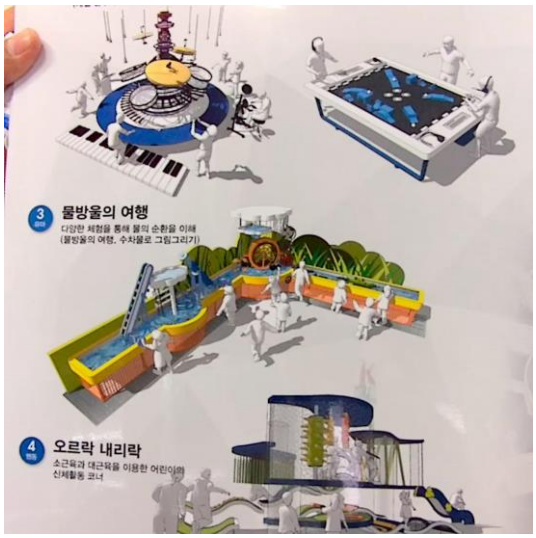
Meanwhile in South Korea…

The centralized education system supports a progression in Science understanding in a highly structured way. Elementary schools aim to familiarize children with basic concepts in Science; middle schools introduce pupils to scientific ways of thinking, and the curriculum in high schools is designed to develop understanding of the systems of scientific knowledge.

Resources in schools in Korea are now of a very high standard and middle schools have specialist teachers in Science. I observed a lesson in chemistry in an elementary school which was based on hands-on experiments and detailed observations.

Recent reforms in Science education have included a more open curriculum to recognize students' individual strengths and interests, accreditation for Information Technology, and STS (Science and Technology in Society) as a separate High School course. When these reforms are set in the context of high levels of investment in Science Museums, Fairs, and exhibitions with extensive media coverage it becomes a little more appreciable why Korea features so highly in the PISA tables (behind Singapore).

In the Science Museums I visited in Korea there was a strong focus on providing opportunities and spaces for children to invent and make things, especially using a combination of play and imagination.



In the new Children's Science Museum there are large areas for games and play (above) as well as making and a giant 'marble run' (below L and R respectively)..

In the National Science Museum, there are workshop and makers' spaces equipped for proto-typing and fabrication. The message was clear and emphatic – museums are places not simply for observation and learning, but for experiment, invention, exercise of the imagination, making, innovation and enterprise.

Images here show the entrance to the Kids Maker Studio and the bench of 3D printers available at the National Science Museum

In Finland, the Heureka Science Centre is also a learning facility as well as a resource for play and invention. The Idea Workshop is described as an area for creative problem solving.

'Play is the highest form of research.'

Creativity – again

My visit to South Korea culminated at the World Festival of Creativity at Daejeon University. Daejeon is South Korea's fifth largest city with over 1.5m people. It is home to the Korean Advanced Institute of Science and Technology (KAIST) and three universities specializing in STEM subjects. KAIST is rated the top university in Korea, and 6th in the world for innovation.

The World Festival of Creativity coincided with the Korean National Science Fair where tens of thousands of students visited a very large festival site; comparisons do not shed much light, but I was reminded of the US Science Fair on the National Mall in Washington (think presidential inauguration for scale and crowds).

National Science Festival Daejeon, site map – the exhibition areas extend well over 2kms

The University of Daejeon which hosts both KAIST and the World Creativity Festival and is described as the MIT of Korea has a Faculty of Creativity. The atrium is dominated by a huge 84 inch HD video LED screen sponsored by LG. The connection between the faculty and technical innovation could not be more obvious to all visitors.

The World Creativity Festival is in effect a three-day invention competition, targeting students from seven nations in East Asia and Saudi Arabia. Notable omissions from the association of Festival nations are China and Japan though there were students representing Hong Kong and Taiwan.

Nations were represented by teams of students in two groups broadly drawn from primary and secondary phases; they were all designated (and self-identified) as Gifted and Talented; the stakes in the competition of the Festival were incredibly high, national pride and honour were clearly to the fore. Each country's teams made presentations about their homeland, its culture and natural beauty.

Teams had chosen problems to solve using creative thinking and technology. Topics ranged from inter-generational activities focusing on mutual well-being to the challenge of finding a toilet

if you are 'caught short' on motorways. Each team made presentations to judges (of which I was invited to be one).

As well as the competitions entries that had been prepared in advance of the trip to Daejeon, students were required to take part in a test of creative problem-solving over a two hour session- which astonishingly, to me, was conducted under exam conditions. Judges were also invited to take part in a similar (shorter) exercise in creative thinking about future themes for the Festival.

I declare that I was awarded a Silver Prize in this exercise.

The final celebration and awards ceremony was conducted amid much emotional investment from teams, their teachers (and a group of parents). The overall winner was indeed, Toey Toey, the toilet finding application presented by a team from Indonesia.

Further images from the WCF in the appendix to this report

It is interesting to compare that in the UK support for children identified as 'Gifted and Talented' has shifted to largely private associations and away from the public sector. The National Academy for Gifted and Talent Youth at Warwick University won a Government contract for five years from 2002 but closed in 2007. It has been superseded to some extent by a more informal network, the International Gateway for Gifted Youth (IGGY) and parental associations.

I reflected on the experience of the World Creativity Festival that whilst the emotional cost for students was high, for both winners and losers, the profile achieved for participating nations was in line with their cultural expectations and the drivers of national pride and international status.

KOFAC
Korean Foundation for the Advancement of Science and Creativity

Established in 1967 as an association to support Science and technology and subsequently, in 1992, restructured as a public foundation for the public understanding of Science, KOFAC acquired its current status as the umbrella organization to advance Science and creativity in 2008. The history of KOFAC is informative as the nation's economic growth relied increasingly on technical and scientific innovation, and creativity became the central and widely accepted paradigm.

Among the four main divisions of the Foundation are the following 'offices':

- Creative Economy Culture Planning
- Future Creative Human Resources
- Creative Culture Planning
- Science and Creativity Contents
- Science Culture Diffusion
- Science and Convergence Education
- Supporting the Gifted in Science

Science dreams of a better tomorrow and realizes the dreams through creativity and imagination. – KOFAC mission statement

What is significant is the linking and overlap of Science, Creativity and Culture as expressions of human activity and learning. KOFAC drives the culture of Science and creativity across a society that is obsessed with education attainment.

The cultural ambitions of KOFAC are backed up by programmes of marked strategic goals founded in the promotion of a society where people invent and make things. I can not think of any UK organization that brings the following six such strategic goals together under one policy umbrella:

1. Promote the Maker Movement nation-wide
2. Collaborate globally for Science Culture
3. Expand creative hands-on activities
4. Reinforce computational thinking based on Software Education
5. Develop and distribute Science, technology and ICT contents
6. Establish Science and Mathematics Education Standards

The range of programmes that are initiated or supported by KOFAC is impressive; to give a few examples:

Under the Division of Diffusion of Creative Economy and Culture, KOFAC runs and /or supports:

- Maker Education Programme across different life cycles

- College Students' Business Start-up Ideas Forum
- Creative Ideas Lab
- Managing Exchange Spaces for Creative Economy and Culture

Creative Ideas Labs – described as creative spaces in our surroundings such as museums, libraries and community centres, that assist and enhance people's creativity and imagination by supporting development and realization of their ideas.

In my own company, Ignite!, we have piloted Community Curiosity Labs in libraries and community centres, but we know of relatively few other models in the UK. (Vienna has a network of Knowledge Rooms that convey a similar purpose of community engagement with scientific concepts and questions.)

The KOFAC priorities reflect the revisions to the Korean National Curriculum in 2009 which placed Creativity and Character Building as the fundamental building blocks of learning. Under the KOFAC Division of Cultivation of Creative Human Resources for the Future programmes are designed to increase student-centred experience and learning, and to implement education for happiness. Programmes include:

- Cultivating Leading Teachers of Creativity – Character Education
- Creativity – Character Education Forum
- Base Centres for Creativity – Character Education
- Korea's Promising Future Leaders Awards

Finally in this section, the KOFAC Division that is charged with the Development of Science Culture Content, includes as programmes:

- Certification of Good Science Books
- Science All – an online platform
- Korea Science Culture Awards
- Science and Creativity Ambassadors
- Hands-on Science Classes

Hands-on Science takes place out of school for young people to experience lectures, experiments and creative hands-on Science in local community centres

KOFAC is Korea's leading and unifying government agency for promoting Creativity in STEM Education, with a remit that extends across school and university education, business and enterprise, support for innovation and start-up business ideas.

India and Creativity

I spent Christmas Day 2016 with the staff and families of pupils from the Riverside School in Ahmedabad. In the morning I joined hundreds of excited children at the special fundraising screening of the latest Bollywood movie, Dungal, a fictionalized bio-pic of two Indian sisters who became Olympic wrestling champions thereby excelling the career of their father. In the evening I attended a performance at the school of The Grinch – the Musical, at which like proud parental audiences around the world,

cameras were flashing as the performers sang and danced their way to ecstatic applause.

The sense of belonging to a creative learning community was palpable throughout my visit to Riverside. As older students prepared for a prom, I was happy to share a few ballroom moves, and later with younger students, to demonstrate the range of Science busking activities that had worked so well throughout my travels.

Riverside is a truly remarkable school, a reflection of the philosophy of its founder Kirin Bir Sethi to encourage children to reveal and exercise their sense of wonderment, and to take responsibility for both their learning and growth of personality. Students may be asked to take a day of fasting without warning to remind them of others in the city who may not have such a choice. Programmes which encourage creative enterprise and social responsibility and engagement with the city authorities are popular and integral to the Riverside ethos.

AProCh – a Protagonist in every Child – is the Riverside programme for a Child Friendly City, which includes days when children take over streets for play, environmental improvements, debates with adults and health promotion activities.

Riverside is a model of education that many in the West familiar with Montessori schools, Summerhill, and Reggio Emilia styles of pedagogy would recognize.

The Grinch who stole Christmas – Riverside School

Lab_13 and India and South Korea

My purpose in undertaking my Fellowship was to learn, not to promote my own work and the interests of Ignite!. I was delighted to offer lectures and workshops in both countries, and to take part as a judge in the World Creativity Festival. I found many points of recognition in the places I visited and expressions of interest in areas of mutual understanding in programmes to develop young people's creativity and curiosity.

I was especially grateful for the debates with hosts and colleagues around the culture of education and learning. I found recognition and interest in programmes designed to help children reveal or discover their creative thinking abilities, and then to exercise them. I found further mutual appreciation of the importance of curiosity and how to sustain it as children grow older.

Following the introduction of Lab_13 to Ghana, I have been able to raise the possibilities of establishing new Lab_13s in Surodi village school near Pune, Maharastra, and at Riverside School in Ahmedabad in India, and at Maengdong Elementary School, Chungcheongbuk-do, in South Korea. In August 2017, the first Lab_13 in Finland will open at Koli village school, North Karelia. We also have a partner exploring how to add a new Lab_13 in Ghana in the capital, Accra.

These developments are a most welcome subsequent additional outcome from my WCMT Fellowship.

Children in Ahmedabad

Conclusions and lessons and few tentative recommendations
General conclusion

The opportunity to build consensus towards a policy for the teaching and learning of Science, to include Public Engagement and Understanding, has been grasped and realized to great effect and impact by the four countries I have researched for this report. As I have illustrated, Finland, Ghana, India and South Korea have forged their national identities as relatively new independent countries by developing a culture of learning and achievement that places extremely high value in Science, Technology, Engineering and Maths.

All four nations have achieved stability of political support and national commitment to STEM education through **four critical pathways:**

1. building a long-term national consensus around the importance of Science learning within the context of widely agreed and respected strategies for comprehensive education in general. Such a consensus raises the importance of Science and Science education above party political debate and short-term funding cycles.

2. embedding Science into the national culture, identity and ethos – as far as such culture can be defined – and by emphasizing the importance of creativity, imagination, curiosity and innovation as significant dimensions of Science learning and public engagement. Such emphasis highlights the importance attached to international comparisons like PISA league tables, and the economic benefits to be derived from Science discovery and technical innovation in a global market.

3. investing in formal and informal Science education, and facilities that raise the profile of Science discovery. Museums, discovery centres and facilities in community settings are widely recognised in all four countries as integral to the perceptions of young people, their families and communities that Science IS for the likes of them.

4. developing an infrastructure for the promotion of Science and Science learning, largely through agencies at arms-length from government, and which also cross sector boundaries.

In the UK we are where we are, with a desperate will on the part of literally hundreds of different organizations to increase the

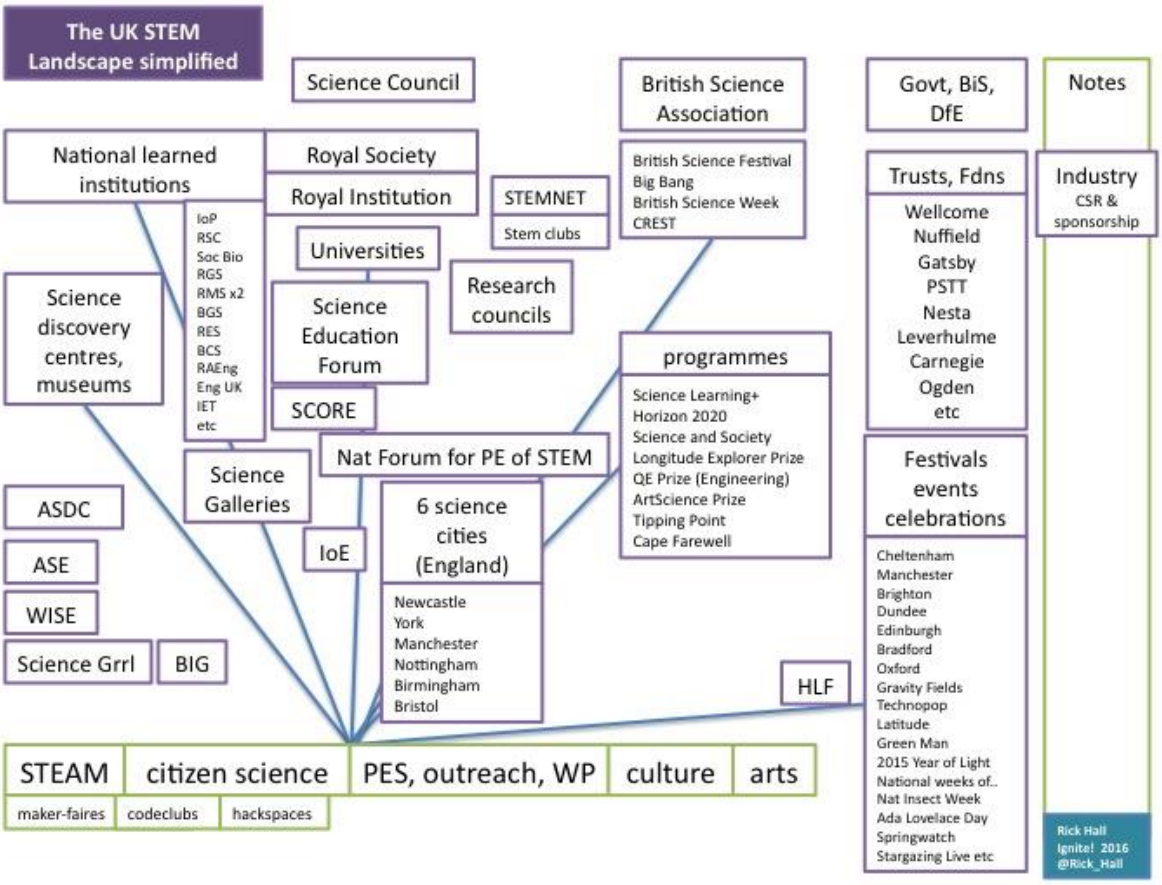
numbers of students studying Science, and to reach further into a potential talent pool where currently too many people think of alternative routes to personal success. Attempts to build consensus of approach have sometimes foundered on the rocks of short-term political or economic expediency. Independent organizations like trusts and foundations have often shown how to pilot, develop and adopt better ways of working.

STEM in the cultural life of the UK

In 2015 I was commissioned by the Arts Council of England to summarise the range of possibilities for closer relationships between the Arts and Sciences – bridging the Two Cultures. My maps of the STEM/STEAM Landscape merely served to illustrate how many agencies were involved and the diversity of priorities and motivations for enacting programmes. I thought that little could compare with the complexity and diversity of provision across the million schools in India and the different priorities at national, state and local levels. But in many ways, the picture in the UK is far more complex and diverse, with fleeting unity of purpose and a sometimes bewildering diffusion of initiatives.

Through extended histories (Royal Society 1660 onwards) every branch of Science has its learned society, a significant number of which have a Royal charter or patronage. The majority of such societies raising funds from membership subscriptions offer grants for outreach, public engagement (PE) or public understanding (PU) of their particular discipline.

Complementing the range of PE and education initiatives are national umbrella organizations attempting to balance what many regard as conflicting ambitions to maintain highest standards of scientific research and to popularize Science in the new media age. In other areas of human activity such a division would be characterized as High Art and popular culture.



As a policy setting and strategic body for the Arts, the Arts Council of England distributed £672m in grants in 2016/17. In Science, there is no such equivalent body. Nor is there a Lottery distributing body representing Science as a 'Good Cause'. The body most closely associated with promoting the role of Science in the cultural lives of communities is the British Science Association. The BSA also promotes PE programmes with deprived and disadvantaged communities, which would also align it to the priorities of Lottery distributing bodes and the preferences of players.

Suggestion: DCMS should consider constituting a body to distribute Lottery funds for the public engagement and understanding of Science, including education programmes in out-of-school and community settings.
Such a function could be included in the constitution of the British Science Association.

In Korea, promoting the link between STEM subjects and creativity was considered a priority, not simply for the long-term impact on economic growth through innovation and technology,

but because it reflected progressive cultural values. The structure of KOFAC, the most influential strategic body in Korea for education policy and the definition of creativity, innovation and culture, reflects the integrated approach to key concepts.

(sic) Office of Creative Culture Planning

For a variety of reasons, mostly historic, no such single strategic body exists in the UK.

Question: How could a body be brought into existence in the UK to develop the strategies for such a range of programmes as those of KOFAC above?

And where would resources for such a body come from?

DBEIS should establish a strategic body (or department) promoting the link between STEM programmes and creativity, not simply for the long-term impact on economic growth through innovation and technology, but also to promote progressive cultural values. Responsibilities should include defining and promoting the STEM-based creative economy and human resources development.

In India, celebrating independence as I write, where Science innovations such as space technology are funded from a Government tax revenue of less than 11% of GDP, the importance of studying Science is a matter of cultural priority. In Ahmedabad at the Riverside School, the philosophy of 'Wonderment' infuses learning across creativity and curiosity.

OECD Report 2013/14 (World average 15%)

In the UK, creativity and creative thinking feel isolated, cut off from the 'mainstream' curriculum of the majority of schools where outcomes are translated as outputs to be tested and measured and regurgitated as league tables. At best, with the

exception of arts subjects now in serious decline in schools, creativity contributes to pedagogy rather than content.

Question: If Science is genuinely to be regarded as a 'creative' subject, where will curriculum reform come from to design new content?

Such a strategic body (DBEIS above) should work closely with DfE towards gradual and consensual curriculum reform to promote STEM as 'creative' subjects.

I visited centres in Korea and India where Science was practiced in community settings, in Science Museums, libraries and community centres in Korea; in shopping malls and an after school club in India. For all the growing interest in Citizen Science in the West, there are relatively few opportunities for young people, their families and communities to design their own projects. The cultural significance of Science in the Community is very under-developed. We recognize and value reading groups, community choirs, youth dance groups – but not youth Science, or community curiosity clubs. Why not?

with the honourable exception of Fun Palaces funpalaces.co.uk

Question/suggestion: What more can we do in the UK to promote Science as a reflection or part of our 'culture'?

Nottingham has achieved UNESCO City of Literature status, and is a designated City of Football. Both initiatives have led to community based activities and programmes; reading and creative writing projects, football at grass roots level. Not many citizens know that Nottingham is also one of six English Science Cities. What community programmes in Science could be developed to emulate football and creative writing?

and bidding to be EU Capital of Culture 2023 – now in doubt

Newcastle, York, Manchester, Birmingham and Bristol are the other five

Suggestion: Nottingham should pilot a programme of Community Curiosity Labs based in local libraries (and other community venues).

Play is considered an important mode of learning in the countries I visited, and not simply for pre-school groups of children. In India the SCi-POP Centre at IUCAA in Pune has built a library of resources for the stimulation of Science learning and understanding that draws on the expertise of academics, teachers and industry volunteers alike.

Proposal: Ignite! should develop its offer of hands-on workshops to include Science toy-making.

Translating reflection and learning into action

Since my return from my travels, I have undertaken a number of speaking and workshop engagements to promote creativity, curiosity and practical activities for STEM learning.

- Workshop sessions for teachers and student teachers, Nottingham Trent University
- Nottingham Festival of Science and Curiosity
- MINT CPD Workshop for British Council in Berlin
- Supermarket science workshops
- Lab_13 Lectures Irchester Primary School
- Public Engagement workshops University of Nottingham
- School workshops, Koli, Finland
- Teachers Workshop, Boys' Education, British Council Jamaica (skype session)
- Workshop at Creative Collisions conference, for Wellcome Trust, on informal STEM activities for youth organizations
- Inaugurated Lab_13 Koli, Finland and appointed first Scientist in Residence
- Nottingham Primary Parliament workshop
- Attendance at Connecting with the Crowd Conference NHM
- Workshop for Science Has No Borders at UCL
- Workshops for Nottingham Schools, and City Council Education
- Workshops at Forest of Imagination, Bath
- Workshops at Bulwell Arts Festival, Nottingham
- Speaker at British Interactive Group (BIG) Conference on working overseas
- Community Family Fun Days in Nottingham x 6
- Fun Palaces 2017, in Nottingham Library and Shuffle Festival
- Pilot Science Workshops in Youth and Play groups, and SEND Youth Club, Nottingham
- Science Fair at Nottingham City Council Offices
- Engineering workshops at Nottingham Primary Parliament

MINT is the German equivalent of STEM

Additionally I have joined the Education Working Group of the European Citizen Science Association; Education Forward (a campaign group for reform in Education); and Innovation and Education group at the RSA.

Final Reflections

Although the UK is pre-occupied with other political imperatives, now might be exactly the right time and opportunity to learn from models overseas and to redefine and reconfigure a more integrated approach to Science learning.

I am grateful to the Winston Churchill Memorial Trust for their support for me to research Science learning in India and South Korea and the opportunity to contribute these reflections to the wider debate.

Rick Hall
December 2017

WINSTON
CHURCHILL
MEMORIAL
TRUST

Appendix 1
A personal footnote

Whilst in Ahmedabad towards the end of my journey, I visited the Ghandi Ashram – where I wrote the following note of personal reflection.

Ghandi was 79 when he was assassinated in Delhi in 1948.
There will always be so much more still to do, and our starting point feels forever shifting and often pushed back.
My belief in the potential of young people will be undiminished to my last breath.
We must continue to offer them more opportunities.
We must respect their rights.
We must encourage them to claim and realize:

- self-determination
- self-definition and identity
- learning, development and self-fulfillment
- and on their own terms

Anything that impedes, hinders or delays must be swept aside.

So where sit creativity and curiosity in this manifesto?
Let's suppose that creativity and curiosity are life forces, whose negatives are conformity and acquiescence.

Lab_13

Lab_13 is a simple case study for children who are inclined to curiosity about natural phenomena and our interpretations as human kind on a small blue planet in an average solar system at the end of a spiraling galaxy.

In Lab_13 children learn to be scientists/natural philosophers.

Lab_13:

- recognizes their curiosity and nurtures and sustains it
- disregards their age and experience as limitations to their desire to research, investigate and experiment
- celebrates their questions and provides a context for their appetite for understanding
- puts children in positions of responsibility for a space, for activities and for each other
- exposes children to adults with expertise and scientific and technical know-how
- connects groups of children across the world through a global network of curiosity and enquiry

Appendix 2

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