An initiative to engage more people in supporting schools embedding STEM in the curriculum: Student Digital Ambassadors

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Introduction. This note describes a new approach being taken in UK schools in Gosport and Newbury to support the introduction of the BBC micro:bit into the curriculum as a catalyst for cross-curricular practical STEM activities. It draws on the skills and enthusiasm of older students (Digital Ambassadors) to inspire and support younger ones, as well as their teachers. In turn these volunteers have access to support and mentorship from a variety of external experts both in electronics and in education.

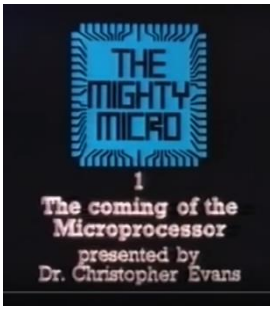
STEM education & skills. Many nations, developed or otherwise, have identified a need to better prepare school students for an increasingly technological world. Frequently this is driven by a national need to improve the skills level of the workforce, so that school leavers will be able to secure satisfying jobs, and that the companies employing them will maintain international economic competitiveness. But there are also good educational reasons to modify the separate-subject, examination-driven approach, common in many countries – not least because unmotivated students are inclined to underperform. It also provides an opportunity to develop personal skills sought after by employers, such as working with others, self-criticism, leadership and communication, as well as to participate in practical, project and problem-solving activities.

Turning STEM education & skills theory into practice in a complex educational system is a major current concern. In the UK, working with associations of STEM teachers and school directors, we have developed the iSTEM+ approach to help schools move towards embedding integrated STEM into the curriculum. Most schools offer a range of out-of-hours STEM activities such as clubs, competitions, visits and speakers – but such **Enrichment** activities only engage a minority of students and teachers. To have maximum effect, these activities are needed to enrich a curriculum which is already **Enhanced** by having an integrated approach to STEM education and skills embedded within it. An interesting example of what can be achieved to enhance the STEM provision within the curriculum is provided by the Middle Years Programme MYP of the International Baccalaureate IB. Most state schools do not have the freedom to adopt that programme, and many others lack the resources required to implement it. But the organising principles are one which any school determined to improve its STEM provision for all students can implement – with help.

We use the acronym iSTEM+ to mean "integrated STEM education involving more subjects, more skills and more people". Among those "*more people*" are groups of students willing to give time and energy to inspiring and supporting younger students, and their teachers, in STEM activities.

The idea is far from new. State primary school provision in the 19th Century in the UK depended on the one or two teachers for 50 to 200 pupils being supported by older pupils instructing the younger ones. That worked because the older pupils had already been instructed themselves by their teacher(s) who had been trained to teach the full (but narrow) curriculum of the time.

Microelectronics. In the late 1970s many countries were forced to address what is commonly called the "challenge of the chip". This first came to public attention in the UK largely through the BBC's seminal Horizon TV documentaries about technological innovation and its 1977 programme called "Now the chips are down" – also available on YouTube. This was followed by the publication in 1979 of the book "*The Might Micro – The Impact of the Computer Revolution*" by Chris Evans, a psychologist and computer scientist working at the National Physical Laboratories. It was popularised by being turned into a set of six TV programmes by ATV at end of 1979, shortly after Evans' premature death. These programmes can still be found on YouTube and were remarkably prophetic about the changes we now have all witnessed, but seemed like science fiction then.



The BBC decided to follow this up with its own "*BBC Computer Literacy Project*" aimed at the general public in their homes. A significant aspect of that project was the decision to create a very high technical specification for an educational microcomputer and to invite UK electronics companies to compete for the contract to supply it. The contract was won by Acorn Computers in Cambridge and the BBC micro was launched at the end of 1981. The model B computer I bought then for £335 would have cost nearly £900 now! At that time there was just a tiny market for computers in schools – mainly in private ones.

Microelectronics Education. When Margaret Thatcher became Prime Minister in the UK in 1979 one of her first acts was to cancel plans recently announced by the outgoing Labour Government to establish a Microelectronics Education Programme for schools. It was her Industry Minister, Sir Keith Joseph, who persuaded her that the UK economy both needed skilled personnel, as well as a home market for its products. So in April 1981 she announced, in a very visionary speech, both a scheme to help schools purchase UK made computers, the "Micros in Schools" program, and a more ambitious and better funded "Microelectronics Education Programme" MEP. Of course very few schools had teachers proficient in programming or electronics, and schools were only being offered half the cost of a single computer. So self-help and resilience were the order of the day. Schools raised funds from Parent-Teacher Associations to buy more equipment. Local Education Authorities arranged evening courses for teachers to learn more about using the computers, and to share ideas for using them in the curriculum. Teachers' Subject Professional Associations developed and distributed supporting resources. Schools set up lunch-time and evening Computer Clubs, where students and teachers could work together to try out new ideas. Information Technology IT became a core subject on the National Curriculum alongside English, Maths and Science. Later it became Information & Communications Technology, ICT, and now it is Computing, which counts as a science subject for the English Baccalaureate EBacc. So in state schools 5-16 it is a requirement for all students to follow a Programme of Study PoS in Computing. Needless to say the UK does not have sufficient numbers of teachers with Computing qualifications, so there is an intensive campaign to recruit and train teachers of Computing. This is led by the Computing At School Group CAS, established by the British Computer Society BCS and Microsoft Research. There is now an extensive network of 11 regional and 213 local CAS Hubs.

ARM, Imagination and Raspberry Pi. I started this piece by tracing some of the early developments in UK microprocessor technology from 40 years ago. There is a continuous line both in these developments and in their educational applications – with a strong Cambridge connection, beginning with Sir Clive Sinclair as long ago as 1976. Clive set up Sinclair Research, which produced the ZX-80 build-it-yourself home computer, which led to the development of the immensely successful ZX Spectrum launched in 1982. Chris Curry had worked with Clive since 1966, but in 1978 he left to join Hermann Hauser in setting up Cambridge Processor Unit Ltd, which became Acorn Computers, and won the original contract to build the BBC micro. In order to create more powerful and efficient microcomputers, Acorn developed its own Reduced Instruction Set Computer, aka the RISC chip, led by Roger, now Sophie, Wilson and Steve Furber. Renamed the Acorn RISC Machine, the ARM chip powered the revolutionary Acorn Archimedes computer. After Acorn ran into financial difficulties a group of mainly former Acorn employees, founded ARM Holdings Ltd. This now designs the small and energy efficient microprocessors used in nearly all mobile devices, such as Apple's iPhones. ARM has recently been bought by a Japanese Bank for a staggering £24m! A less well known, but very successful British microelectronics company, Imagination Technologies, was founded in Hertfordshire in 1988 by Sir Hossein Yassaie. This makes the majority of the video chips used in mobile devices, including Apple's. Itmagination has also recently been the subject of a possible takeover, but it now appears Apple is concentrating on poaching its key people! As an aside I wondered what had happened to Sinclair Research. Actually this became the basis of Amstrad, the very successful computer company founded by Lord Alan Sugar of The Apprentice fame and which now makes the Digiboxes for Sky!

I was in Cambridge for a meeting of the Computing At School Board and Working Group in 2010. We were shown a working version of a prototype for the Raspberry Pi by Jack Lang, one the original Acorn pioneers. Jack was a member of the group of Cambridge Angels who had the vision of re-inspiring young people in computing the way the BBC micro had done 30-years previously. The Raspberry Pi Foundation recently celebrated the sale of 10 million RPis! The RPi (as it is called) was not designed for an educational market, but for hobbyists at home. By the time you have added a keyboard, mouse, screen and wi-fi you will have spent as much as buying a cheap laptop – so many schools have steered clear of this device. Needless to say it uses an ARM microprocessor – called mbed.

Since the publication of the Government's review of science and engineering skills in 2002, there has been a number of well-intentioned, but not always well-coordinated, initiatives to encourage schools to provide a better STEM education for all learners. Some of the background detail is contained in the last couple of sections of this note. Digital skills have been the subject of considerable concern over recent years with major reports and recommendations from both the House of Lords, and the House of Commons. We submitted our own written evidence to the Commons Select Committee on Science and Technology, chaired by Nicola Blackwood MP. It is available here. There is a Government Minister with responsibility for Digital Policy within the Department of Culture, Media and Sport DCMS. He is Matt Hancock MP, formerly the Skills Minister in both DBIS and DfE, and then Industry Minister at DBIS.

Two significant events have taken place this year which we believe are reinvigorating an interest in improving STEM education in schools. These are the `Race to the line' competition for rocket powered model cars, and the BBC micro:bit device.

The Bloodhound schools' rocket car challenge. An article in 2013 states: "*The current world land speed record stands at 763.035 mph, as set in October 1997 by British Royal Air Force pilot Andy Green driving the jet-powered Thrust SSC. Green is looking to break his own record and has a new team and a new car behind him. The car he will use is the Bloodhound SSC, which in addition to a jet engine comes with a rocket-propulsion system that Green hopes will take him to a top speed in excess of 1,000 mph. The team behind the Bloodhound SSC is predicting a speed of 1,050 mph*!" The Government funding for that project (and the provision of the Rolls-Royce jet engines) was on condition that it should be a STEM education project *par excellence* to enthuse the next generation of UK engineers. Last year the Bloodhound Education team, led by Aulden Dunipace, mounted the first national competition for secondary schools to build model cars powered by chemical rockets. The event was a huge success with nearly 600 schools taking part. The British Army supported the event by donating free kits to schools and providing 1-day workshops to train student rocketeers. Entries for this year's event are now open, and this time primary schools can enter teams. One condition of entry is that each car must carry a BBC micro:bit device (see below) to record accelerometer data. Training and race events are organised through a network of local Bloodhound Hubs. The Newbury Hub is based at Park House School. The Portsmouth Hub is based in Gosport at Bay House School in partnership with Gomer Junior School.

The BBC micro:bit. The BBC has embarked on an ambitious programme called "Make It Digital" which "*aims to get the nation truly excited about digital creativity. Inspiring audiences young and old through world-class TV, radio and online content, and focus on helping younger audiences discover their creative potential and take their first steps. Make it Digital will also amplify the great work already taking place across the UK through major initiatives with partners, and ensure young people can continue their learning journeys*." One million BBC micro:bits have been distributed to UK state secondary schools during the first six months of 2016 to give free to every 11-year old student. Park House was one of the original trial schools for the device which was supported by many organisations, including Microsoft, Samsung and the IET. Once the distribution was completed in July, BBC micro:bits were released for sale on the open market. A micro:bit with USB cable and battery box costs about £15, which is incredible value. Needless to say it includes an ARM mbed microprocessor. There are several different ways the device can be programmed including on-line editors developed by Microsoft as an extension of their Touch Developer system. These include a graphical, Scratch-like editor and a JavaScript text editor, as well as an on-screen emulator. There is also support for MicroPython. They can each output a compiled hex file which can be uploaded to the micro:bit with a USB cable. The micro:bit is armed with a powerful array of sensors e.g. for

temperature, light, acceleration and heading, as well as a BlueTooth Low Energy BLE radio. The device can be wirelessly paired with Windows, Android and Apple platforms so that programs and data can be transmitted through BlueTooth. An extensive set of notes is available here. There is a BBC micro:bit special interest group on the STEM Learning site. The main education site is here, and there is a new site for the general public here.

Despite the large amount of supporting resources which have been developed to support the use of the BBC micro:bit in schools, many schools are not geared up to make good use of them. Park House School in Newbury and Bay House School in Gosport have come up with an innovative use of their students' enthusiasm to help their fellow students and their STEM subject teachers by developing stimulating cross-curricular activities using the BBC micro:bits with younger students – both in their own schools and in their local feeder Primary Schools. These volunteer **Student Digital Ambassadors** will be supported by local engineers, educationalists and enthusiasts. They are being drawn from Year 10 and Year 12 classes. As both these schools are hosts for their local Bloodhound `Race to the line' competition Hubs, their Student Digital Ambassadors will also be helping groups of KS3 and KS2 students to design and build their rocket cars.

Park House School already works closely with the former BBC Tomorrow's World presenter, Maggie Philbin and her TeenTech initiative. One of these initiatives is the Young Digital Taskforce. The picture shows Maggie with two of Park House's students at the annual BETT show in London in January. So the idea of student involvement is already firmly rooted at Park House.

The Erasmus+ KIKS project. Tony Houghton, Elizabeth Crilley and I are the UK members of an international research project called KIKS – Kids Inspiring Kids in STEM. Our European partners are from central Finland, Budapest in Hungary and northern Spain. Park House currently has 12 Year 11 students involved in the project, who took part in an inspirational kick-off activity at the RAL Space Centre at Harwell supported by local teachers, STEM Ambassadors and Space Scientists. They have since agreed to become the first group of Park House Student Digital Ambassadors supporting the development of the inspirational Bloodhound and BBC micro:bit activities in the school. They will shortly be joined by other Year 10 and 12 students. Bay House school has recently joined the project and they have a group of three Year 13 computing students already enrolled as Bay House Student Digital Ambassadors. These will also shortly be joined by other Year 10 and 12 students. When we launched the project, we did not envisage that it would become a vehicle for solving a live issue in very many UK schools – linked to a major STEM enrichment event.

Alongside the KIKS project in these schools we are also developing a support network of local experts through the Solent IET network, the Winchester Science Centre STEM Ambassadors, the C&EC Enterprise Advisers and other interested organisations such as the University of Portsmouth and the BetaPlus Club.

To conclude, here is some more background about new initiatives which should also help reinvigorate an interest in STEM education and skills in schools, academies and colleges 5-19.

STEM Education. Between 2006 and 2010 there was a national STEM education initiative called the STEM Cohesion Programme. This was concentrated on Science and Mathematics in secondary schools, and there was no compunction for schools to participate. The main legacy of that initiative is the National STEM Learning Centre in York, which has an enormous and growing collection of digitised resources across the STEM subjects. The seeds of STEM education were sown in the 2001/2 Review of science and engineering skills called "SET for Success" commissioned by HM Treasury and undertaken by a Royal Society group chaired by Sir Gareth Roberts. It was that review which recommended the inclusion of M, for Mathematics, along with Science, Engineering and Technology. An organisation called SETNet was established which pioneered the first Ambassador scheme to provide a register of engineers who volunteered to help with Enrichment activities in schools. This was replaced by STEMNet, which set up 9 regions and 40 local contract holders. Another consequence of the Roberts' review was the establishment of a National Science Learning Centre in York, funded by the Wellcome Trust, and a network of 9 regional Science Learning Centres, funded by the Department for Education. When the initial funding came to an end, this network was managed by an organisation called Myscience, which became STEM Learning Ltd in 2015. In August 2016 STEMNet merged with STEM Learning and so we now have a single national organisation which includes:

- the National STEM Learning Centre, York which provides intensive, residential professional development alongside a library of STEM teaching resources, both on- and off-line,
- the network of 50 Science Learning Partnerships in England which provides locally available DfE supported science focussed professional development and
- a slimmed-down network of 19 regional STEM Hubs responsible for the recruiting, training and supporting STEM Ambassadors from local employers to support STEM enrichment in schools.

I am a STEM Ambassador through the Winchester Science Centre – so just one of the 31,000 Ambassadors in the UK!

Employer support for schools. The previous coalition Government set up the Careers & Enterprise Company C&EC to establish an Enterprise Adviser Network, creating powerful, lasting connections between local businesses and the schools and colleges (12-18) in their area. Enterprise Advisers (EAs) are volunteers drawn from businesses who are working directly with the school's leadership team to develop effective employer engagement plans. They are working with other local businesses to equip young people with the skills they need – especially in the STEM area. Each EA is attached to one school or college and is supported by a full time Enterprise Coordinator (EC). The ECs are jointly funded by the C&EC and their Local Enterprise Partnership (LEP). There are 39 LEPs in England, each with a Growth Plan which includes skills. By the end of the year nearly all state secondary schools in England will have an Enterprise Adviser. The current Government has recently announced that each Business Minister in the Department of Business, Energy and Industrial Strategy DBEIS will work as a Local Growth Champion with a group of LEPs. There are also a number of national Engineering organisations which are working to improve employer engagement and support in schools. The Institution of

Engineering and Technology IET has an established track-record of supporting schools 5-19 through its Faraday site. It also has a network of local branches – I am a member of the IET Solent Network. Each local network has a volunteer Schools' Liaison Officer SLO and there is an IET Schools' Liaison Community which supports them. The Tomorrow's Engineers programme is an initiative led by EngineeringUK and the Royal Academy of Engineers to improve the image and take up of engineering by young people. It has recently established a network of Employer Support Managers led by Sarah Davenport. The Tomorrow's Engineers national network is working with companies who encourage young people to consider engineering careers via a schools outreach programme (of any size and scale). They are building a network of employer support managers across the country, starting with four pilot areas and developing this capacity over the next two years. The C&EC, the IET, STEM Learning and Tomorrow's Engineers have all agreed to promote the iSTEM+ approach in their contacts with schools.

There is general agreement on the importance of catching students' interest at an early stage. After the age of 14, students will have made decisions about which subjects to study at GCSE (the public examinations taken at 16) and beyond. The iSTEM+ approach aims to achieve this by providing rich and stimulating joined-up STEM activities (both Enhancement and Enrichment) at Key Stage 2 (7-11) and Key Stage 3 (11-14). The involvement of student Digital Ambassadors from Key Stage 4 (14-16) and Key Stage 5 (16-19) is an innovative way to support schools and teachers in providing the much needed STEM stimulus for younger students. It also helps schools to plan for progression and continuity, as their students progress from primary to secondary schools.

Many schools are struggling to recruit and retain teachers with STEM skills, especially in key areas such as physics, computing, design technology and mathematics. They also lack the up-to-date equipment and resources which employers would expect students to have learned to use, such as CAD software and 3D printers. The recent initiatives for the direct engagement of local industries and employers with their neighbouring schools through programmes provided by the Careers & Enterprise Company, the Institution of Engineering & Technology and Tomorrow's Engineers, build on the local employer/schools engagement already provided through STEM Learning's STEM Ambassadors. Together, these provide opportunities for local communities to play an active part in helping schools to improve the STEM education and skills opportunities for all learners. Each of the 39 English Local Enterprise Partnerships already have responsibilities for developing local economic growth within their region, working together with Government and local employers. Through their Enterprise Coordinators, the LEPs now have a direct engagement with local secondary schools, academies and colleges 12-18. The iSTEM+ approach of local clusters of schools supporting each other, together with the student Digital Ambassadors initiative, provides an effective means to spread that down into the Primary school sector.

The Government's recent initiative to establish Business Ministers as Growth Champions within the LEPs could help address the issue of up-skilling and re-tooling schools. For example the current Gosport iSTEM+ cluster, led by Bay House School (11-19) and Gomer Junior School (8-11), is within the Solent LEP region which takes in Hampshire, Portsmouth and Southampton and includes many major companies which are employers of STEM skills. The Growth Champion for the Solent LEP is Jo Johnson, who is Minister for Science and Innovation in the Department of Business, Energy and Industrial Strategy. He is also Minister for Higher Education in the Department for Education. As Science Minister he announced in January a package of measures to "*make the UK the best place in world to do science*".

This included a £30m `Inspiring Science Capital Fund' from which Science centres and attractions across the UK, such as the Winchester Science Centre & Planetarium, will be able to bid into the fund to refresh and refurbish exhibitions and infrastructure to inspire young people from all backgrounds to engage with science and consider a STEM career. We hope that the Government and LEPs will work together to establish a network of school-based iSTEM+ Innovation Hubs equipped with the resources to support STEM Enrichment and Enhancement for students in local schools. These Hubs would also be the focus for local initiatives to support STEM teachers' continuing professional developments – providing a meeting ground for employers, teachers, families and students to refresh their skills and knowledge.