Creating a Skills Pipeline for UK Semiconductors: The Case for Investment in Secondary Education

Abstract

A chronic skills shortage threatens the UK semiconductor industry's ability to compete on a global stage. As semiconductors become more critical to the success of UK plc, so there is an increased urgency to address this skills shortage, starting at the beginning of the semiconductor skills pipeline with greater focus and more investment in secondary education. The UK Electronics Skills Foundation (UKESF) is the only organisation working to proactively connect students, secondary schools, universities, and companies in the sector. As such, the UKESF is the best placed organisation for Government support in its efforts to protect and enhance the lifeblood of UK semiconductors: talented, industry-ready Electronics graduates.

The Electronics Skills Shortage

Semiconductors are critical for the functioning of the modern economy and the semiconductor and Electronics sector is a critical, fundamental enabler of the UK economy. In 2021, it contributed a turnover of £12 billion, 8% Gross Value Added (GVA) and 12% of Research & Development (R&D) spend in the UK[1].

Globally, the semiconductor industry is the 4th largest in the world behind oil production, automotive and oil refining and distribution, and revenue from semiconductors accounted for 0.5% of global GDP in 2020. Over 1.1 trillion semiconductors were sold in 2021 and the sector is thought to generate between 500 and 600 billion US dollars annually in revenues[2].

Over many years, too few UK based students have been studying Electrical & Electronic Engineering. As a result, there are insufficient graduate engineers to drive forward innovation and progress. In 2021, according to UCAS, only 3,245 UK students enrolled on degrees in Electronic and Electrical Engineering and of these only 335 were girls. This is less than half the number of students starting Mechanical Engineering degrees (7,050)[3].

This shortage is particularly acute in the sphere of semiconductor ('chip') design. We know that over 80% of UK companies involved with chip design have unfilled vacancies. Global competition for talent is fierce and other nations, such as the USA, are already investing heavily[4].

Impact in the UK

It is widely acknowledged that the shortage of people with the necessary STEM skills impedes improvements to productivity, economic growth and the fulfilment of wider policy goals, such as

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[1] ONS Blue Book 2021, quoted in Make UK Electronics Sector Bulletin: UK Manufacturing, The Facts 2022 | Make UK
[2] BEIS Select Committee Report, published in Nov 2022: The semiconductor industry in the UK - Business, Energy and Industrial Strategy Committee (parliament.uk)
[3] UCAS Undergraduate sector-level end of cycle data resources 2021 | Undergraduate | UCAS
[4] The United States allocates US$52 billion to support semiconductor production - RPRNA.

net zero and energy security. Furthermore, if the UK is to achieve its ambition of becoming a 'science and technology superpower' by 2030, urgent action is needed[5].

In the coming years, semiconductors will become ever more important to the success of the UK economy, not just as an essential enabler of existing industries but also as a driver of emerging technologies such as smart cities, autonomous driving, electrification, and artificial intelligence (AI) as a whole. Furthermore, semiconductors have been highlighted as one of the five priority technology areas by the Govt in the recent International Technology Strategy[6]. The Strategy notes that semiconductors are vital to achieving UK strategic advantage in next-generation technological areas such as net zero, quantum, 6G and AI[7].

As AI becomes embedded in people's lives, the UK finds itself at a pivotal moment. It has been suggested that AI could deliver a 10% increase in UK GDP in 2030[8]. The Government believes that, if approached correctly, this would offer huge benefits to the economy, to recovery and resilience, the environment and for people from all walks of life across all parts of the UK[9]. However, a shortage of skills is frequently cited as a critical challenge.

The UK automotive industry is a vital part of the UK economy, worth more than £78.9 billion in turnover adding £15.3 billion to the UK economy. With some 180,000 people employed directly in manufacturing and an excess of 864,000 across the wider automotive industry, it accounts for 13% of total UK export of goods, worth £44 billion, and invests £3 billion each year in automotive R&D[10]. It is predicted that by 2030, more than 50% of the cost of new car will be its electronic systems[11] and the shortage of chips is disrupting car production[12].

There is widespread consensus that the lack of a secure skills pipeline is the greatest threat to the health of the UK semiconductor sector and its ability to compete on a global scale[13].

The UK Electronics Skills Foundation

Founded in 2010, the UK Electronics Skills Foundation (UKESF) is the only STEM organisation in the UK solely focused on Electronics skills, linking students, secondary schools, universities, and industry. UKESF has a well-established and coherent approach based on:

- Ensuring more schoolchildren gain 'hands-on' exposure to Electronics. Showing children, their parents and teachers that there are exciting challenges and worthwhile careers available as designers, engineers and technical architects in the Electronics sector.

- Providing opportunities for secondary students to develop their interest in Electronics and engineering, through to university study and/or apprenticeship.

- Supporting undergraduates in pursuing careers in the Electronics sector and ensuring that they are equipped with work-ready skills and experience.

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[5] See House of Lords Science & Technology Committee report 15th Dec 2022:
https://committees.parliament.uk/publications/33254/documents/179987/default/
[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1144576/uk-international-technology-strategy-web-version.pdf (2023, p-14).
[7] Ibid p-25.
[8] PwC (June 2017) The economic impact of artificial intelligence on the UK economy
[9] AI Roadmap, published by the AI Council Executive summary - GOV.UK (www.gov.uk)
[10] Manufacturing Technology Centre Report (2021, p-51) semiconductors-research-paper-a4-flipbook.pdf (the-mtc.org)
[11] Deloitte (2019, p-14) Semiconductors – the Next Wave | Deloitte | TMT
[12] Chip shortage could last into 2023, says car boss - BBC News
[13] BEIS Select Committee Report, Op Cit. Paras 122&123.

"It's great to see the work that the UKESF is doing encouraging more young people to pursue careers as Electronics Engineers. As the only organisation linking schools, universities, students and industry to address Electronics skills, the UKESF is poised to be an important contributor to the long term success of the industry in the UK."

Chi Onwurah MP, Shadow Minister for Science, Research & Digital

Given the UKESF's status as a micro-organisation, the Foundation has done an exceptional job of creating and delivering practical programmes that engage a wide range of pupils and undergraduates. The UKESF has effective active partnerships with 27 leading universities and has provided training and practical materials to 6th form teachers at approximately 900 schools nationwide; 20% of all A level classrooms have received development kits from UKESF. Furthermore, over 700 students have successfully graduated from our Scholarship Scheme, which prepares undergraduates for industry and provides a valuable skills pipeline to UK organisations. In 2022, the Scheme received external recognition and won a Princess Royal Training Award.

The Solution

If the UK aspires to global competitiveness and a sovereign semiconductor capability, then urgent action is required to tackle the semiconductor design skills shortage. The only viable way for UK semiconductor industry to sustainably grow and to thrive in the long term is to increase the number of students studying Electronics at degree level. This will increase the number of graduates with the necessary underpinning knowledge and understanding to enter careers in semiconductor design. In order to achieve this increase, we need a coherent national strategy to create a semiconductor skills pipeline from secondary school onwards.

The situation for the semiconductor industry in the UK, is analogous to the one that faced the digital sector a decade ago. The Government's report on digital skills [14] resulted in coordinated action, including curriculum change for computing at secondary schools and the creation of National Centre for Computer Education[15]. We are campaigning for a similar, Government led, approach to be adopted for semiconductors at secondary schools in order to create the first stage of a semiconductor skills pipeline.

The ASPIRES research programme[16], identified a phenomenon termed the STEM Decision Funnel where the number of students engaging with STEM reduces significantly as secondary education progresses. This is represented in the diagram below (Figure 1). The evidence demonstrates that both male and female students in the final year of primary school have relatively high levels of interest in science (74% and 72% respectively).

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[14] "Digital Skills for the UK Economy" BEIS and DCMS, January 2016 DCMSDigitalSkillsReportJan2016.pdf (publishing.service.gov.uk)

[15] computingeducation.org.uk

[16] ASPIRES, King's College London *Young People's Science and Careers Aspirations* (2013) http://www.kcl.ac.uk/sspp/departments/education/research/ASPIRES/ASPIRES-final-report-December-2013.pdf

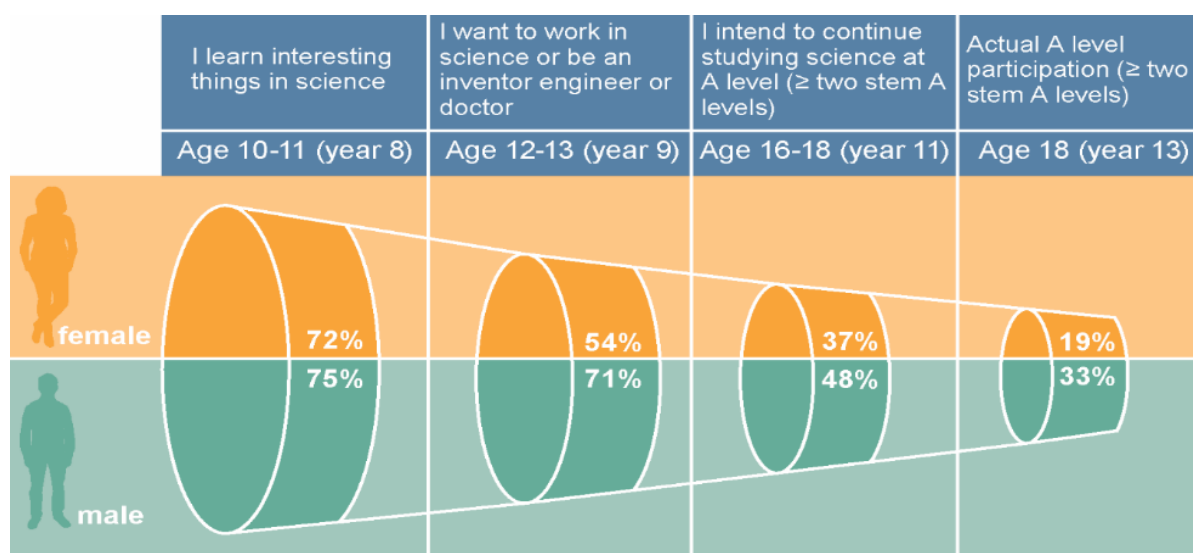| I learn interesting things in science	I want to work in science or be an inventor engineer or doctor	I intend to continue studying science at A level (≥ two stem A levels)	Actual A level participation (≥ two stem A levels)
Age 10-11 (year 8)	Age 12-13 (year 9)	Age 16-18 (year 11)	Age 18 (year 13)
female 72%	54%	37%	19%
male 75%	71%	48%	33%

Figure 1. The STEM Decision 'Funnel'.

Therefore, we believe that secondary schools should be the starting point for the semiconductor skills pipeline. This is because we need to ensure schoolchildren are more aware of Electronics and it is essential to motivate and inspire them to consider careers in semiconductors, earlier in the STEM decision 'funnel'. To begin this process, we are advocating three key priorities within secondary education: curriculum change, more engagement with the Electronics industry and improved careers advice.

Curriculum Change

First and foremost, there is an urgent need to make Electronics and semiconductors a more visible and explicit part of the secondary schools STEM curriculum. Also, to ensure that an understanding of 'deep tech' is woven into wider aspects of secondary education so children, parents and teachers are aware of how semiconductors and Electronics are fundamental to the modern world.

From this awareness, interest and understanding can grow along with the realisation that exciting challenges and rewarding careers that pay well are available for designers and engineers in the semiconductor sector. For instance, we recommend:

- Including more about physical computing and computer engineering into the Computer Science curriculum at KS4 and KS5.

- Including more about semiconductor materials and functionality in the Physics and Chemistry curricula at KS4 and KS5.

- Re-introducing Electronics into the KS5 curriculum for AS and A-Level[17].

- Increasing focus on Electronics systems in the Design & Technology curriculum at KS4.[18]

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[17] Since 2017, Electronics is not offered by major examining boards in England, it is only offered via WJEC: AS/A Level Electronics (wjec.co.uk)

[18] See: reimagining-design-and-technology-report.pdf (designtechnology.org.uk)

- Including more about electromagnetism in KS3 science (as part of teaching about 'forces').

- Developing an education and resource pack for STEM teachers to help them understand semiconductors and with ideas for including in their teaching.

Engaging with Electronics

Beyond the curriculum, there is a need to provide engaging enrichment activities and more extra-curricular opportunities for pupils to deepen their interest in Electronics and semiconductors. This is because evidence shows that multiple and sustained engagements are needed to ensure a positive, long-term, impact on students' aspirations towards STEM careers[19] and we have seen this approach be successful with 'coding'. Therefore, there is a need to support those organisations who can, for instance:

- Provide external support (resources, advice and industry ambassadors) to teachers to help them deliver enrichment activities in Electronics across KS3-5.

- Supply schools with 'hands on' projects to introduce Electronic engineering and microcontroller concepts to pupils and allow them to explore creative applications and uses.

- Encourage participation through external recognition (e.g. through CREST Awards[20]).

- Deliver on-line resources to help augment classroom-based engagement activities.

Improve Careers Advice

The ASPIRES 2 survey data revealed that less than two-thirds (63%) of students aged 15-16 reported having received careers education and only half had undertaken work experience. They found that careers education provision was patterned by social inequalities, with working-class, minority ethnic students, girls and lower-attaining students being significantly less likely to receive and benefit from high quality careers support[21].

There is a lack of awareness about the size, impact and diversity of the Electronics Sector in the UK and this has an adverse impact on the perception of Electronics as a rewarding career in the UK. There is also a common (mis)conception that Electronics is only thriving in other countries and not in the UK. As a result, secondary school students are not actively encouraged to pursue an interest in Electronics as they don't believe it will lead to a rewarding and worthwhile career. Therefore, we suggest:

- Encouraging stakeholders from across the STEM eco-system to 'highlight' the importance of semiconductors in their promotional and careers information.

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[19] See *Implementing co-ordinated STEM engagement in schools* from Tomorrows Engineers: PowerPoint Presentation (tomorrowsengineers.org.uk)
[20] CREST Awards.
[21] ASPIRES 2 Report February 2020 p-22: Moote_9538 UCL Aspires 2 report full online version.pdf

- Creating a campaign to support young people to change the world and fulfil their potential through careers in semiconductors.

- Highlighting, with specific suggestions of concepts that could be included in their teaching, the strategic and fundamental importance of semiconductors through high-profile 'use cases', such as in health care, transportation, space exploration and green energy.

Final Thoughts

The Government recognises that semiconductors are critical to the functioning of our modern economy and therefore, aspires to create a sovereign capability within the UK. However, there is widespread consensus that the lack of a secure skills pipeline is a significant threat to achieving such a capability.

The only viable way for our semiconductor industry, in particular chip design, to grow sustainably is to increase the number of UK students studying Electronics at degree level. To create this skills pipeline, we need to start at schools and ensure there is greater focus on semiconductors in secondary education. Therefore, we are advocating Government-led intervention focussed on three key areas: curriculum change, more engagement with the Electronics industry and improved careers advice.

As the leading Electronics focussed STEM charity in the UK, the UKESF stands ready to work with the Government to support and deliver these interventions. However, this won't be achievable without Government investment. Without such investment, then enrolments on university courses will continue to be insufficient to meet industry's demand for Electronics graduates.

24th April 2023

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Attachment:

1. About the UKESF.
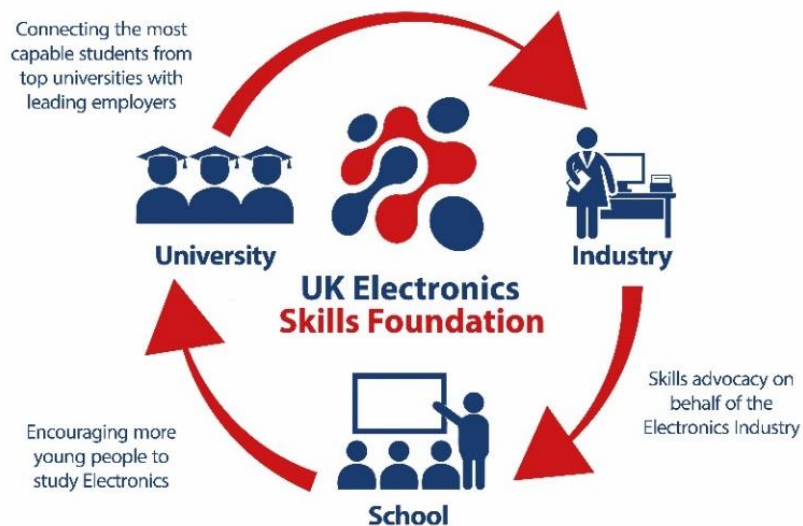
About the UK Electronics Skills Foundation

The UK Electronics Skills Foundation (UKESF) is an educational charity established in 2010. In the UK, Electronics, especially semiconductor design and manufacture, is a growing and strategically important sector of our economy. However, the demand for capable graduates far outstrips supply.

The UKESF works to tackle this national skills shortage in a coherent way; it operates collaboratively with major companies and leading universities. The UKESF also undertakes outreach and engagement activities to ensure that more schoolchildren are aware of Electronics and the opportunities available. This is achieved through a range of education Electronics-focused activities, projects and teacher training, and media campaigns such as "Turn onto Electronics".

At the heart of the UKESF is an undergraduate Scholarship Scheme. This, award winning, training programme provides professional education, development activities and work placements with leading employers for students from universities right across the UK. The Scholarship Scheme is now considered to be an exemplar of effective engagement between industry and universities. It is the basis of the UKESF's wider collaboration between higher education, industry and schools.

"The UKESF is the body responsible for education and skills in the UK Electronics sector. We've been really impressed with the quality of people coming through their programme."
Director Engineering Development, ARM

"Moving beyond talk about the skills shortage to take positive action is what the UKESF is all about."
Stew Edmondson, CEO, UKESF

Registered charity number: SC043940

UK Electronics Skills Foundation Projects and Initiatives

Electronics Everywhere | Ages 14-18

Electronics Everywhere is our flagship project for schools. It provides teachers with training and engaging interactive resources designed to support the teaching of core Electronics concepts found in A-level Physics and Computer Science.

- 650 secondary schools across the UK have received kits
- 80% teachers rate the kits 'excellent' or 'good'
- Thousands of students have benefited

An Introduction to Electronics Engineering | Ages 14-18

Developed by the UKESF in collaboration with the University of Birmingham, this free, online course introduces the fundamentals of Electronics in an accessible way. It supports students to develop their interest and prepare for further study.

- More than 1,500 learners have signed up in the 5 months since launch
- Average feedback 4.8 out of 5.

Insight into Electronics | Ages 14-18

Insight into Electronics gives young people a unique opportunity to get hands on with a microcontroller. This interactive course is a collaboration between the UKESF and Aston University, inspiring students to delve further into Electronics at home.

- More than 600 kits sent out in 2021 to individuals and schools
- 93% of pupils rated the kit 'excellent' or 'good'
- 88% of pupils felt more enthused by Electronics

#TurnOnToElectronics | Ages 14 to 18

The #TurnOnToElectronics website provides a wealth of information and advice for young people looking to get into the industry.

- Campaign fronted by Georgie Barrat, Technology Journalist and Broadcaster
- 15 case studies
- 12 industry supporters

Girls into Electronics | Ages 15-17

Taking place at leading universities nationwide, this one day event gives participants the chance to hear from women who have studied Electronics and work in the sector. The pupils tour an Engineering department, participate in interactive Electronics activities, and attend an Electronics lecture.

- 230 participants attended in 2022
- 97% of participants rated the day 'excellent' or 'good'
- 89% of participants felt more enthused about Electronics

Award for Female Students | Ages 17-18

This Award is for students before they embark on their first year of an Electronics-related degree. Award winners benefit from a bursary, a paid summer placement at a leading semiconductor design company and membership of the Women's Engineering Society.

"It has not only boosted my confidence to pursue Electronics, but also provided an invaluable opportunity to gain a first-hand insight to the industry."