Written evidence submitted by EUREKA Robotics Lab, Cardiff School of Technologies

Executive Summary

I. About EUREKA Robotics Lab:

i. As one of the flagship research clusters at the Cardiff School of Technologies, EUREKA Robotics Lab (Ethical-Utillous Robotics driving Economy and Knowledge Accelerator for Wales) is the innovative research hub nested in Cardiff Metropolitan University, serving Wales and global stakeholders.

ii. The founder and Principal Investigator of EUREKA Robotics Lab is Dr Eysin Chew, leading interdisciplinary Co-investigators (Dr Simon Thorne, Dr Fiona Carrol, Lisa Fenn, Dr Nikolaos Konstantakis and Nigel Jones), 12 postgraduates and undergraduate's intern from Cardiff School of Technologies and Cardiff School of Education.

iii. Partnering with international collaborators from companies and universities, the current research strands in the Lab are: Social and Service Robotics for (1) STEM Education for schools in Wales: STEM Ambassador for Wales; (2) Tourism and (3) Healthcare.

II. Background and Summary:

iv. Oxford University researchers and PwC have estimated that within the next 20 years, 47% of US and 30% of UK employments, both white and blue-collar jobs, are at risk of the Fourth Industrial Revolution [1, 2]. While robotics and efficient machines intelligence is the building blocks for the coming revolution [3, 4], ironically, powerful technologies in the human history could result in more efficient productivity, effective decision making, higher earnings, and overall job growth. Robotics may accelerate the Artificial Intelligence (AI) disruption in the jobs market; however, new jobs, new companies and new markets will be enhanced and developed on the shoulders of the next industrial revolution [5, 6].

v. This written evidence (1) argues the readiness and current gap of young people in the UK for the fourth industrial revolution, (2) discusses how best to prepare them for robotics and AI education, and (3) make recommendations for the government and a forward-thinking Robotics Lab in introducing a flexible robotics and AI education upskilling.

A. The readiness of young people: the current curriculum for the Fourth Industrial Revolution

1. Research has shown that introducing robotics in early childhood and primary education has had positive outcomes in the US, UK, Australia and China [7-10]. Using popular robots such as Lego WeDo 2.0, Mindstorms [11], Aldebaran Robotics's Nao or Pepper [12], kindergartner pupils were motivated and able to learn many aspects of robotics and programming [9]; primary school students can develop the computational concepts and algorithms [7, 10]; Singapore even experiments Robotics Tutors for two pre-schools [13].

2. In the recent publication by the UK Parliament, Artificial Intelligence (AI) in the UK: ready, willing and able?; Cardiff Metropolitan University researcher has been included as part of the written evidence to lobby the work of policy makers to embed robotics and AI into pre-school, primary education through to higher education and the healthcare sector; Microsoft also highlighted the disparities in computer science education that "in a year when China and India each produced 300K computer science graduates, the UK produced just 7K" [14]. Steve Jobs once said, “Everyone in this country should learn how to program because it teaches you how to think” [40]. The UK Department of Education could consider celebrating a nation-wide robotics programming and AI education week.

3. As one of the STEM Ambassadors for Wales, the EUREKA Robotics Lab brought NAO to schools in Wales. One project involved academics and a Robotics Lab intern from Cardiff Met have visited Year 4 and 5 pupils at Blaenycwm School in Brynmawr, Blaenau Gwent, to provide insight on the fascinating 500-year history of Humanoid Robots as well as the latest technologies including Google Glass, mind readers and flying drones [15]. The, 24 Year 4/5 technology enthusiasts then visited the University for a 2-day robotics workshops leading to a competition sponsored by OptiMusic Ltd [16]. The pupils learnt how to program a humanoid robot to dance or sing and represent an artefact homed at National Museum Cardiff. The exciting responses and engaging experiences are published in the form of videos [17]. On a third visit to the university the pupils were joined by their parents so that they could showcase their work as part of a celebration ceremony.

4. However, schools in the UK have limited access to expensive humanoid robots such as the popular Nao and Pepper. Inadequate financial resources has impacted upon the exposure schools across the UK have had and this has challenged the availability of the latest robots and skills related for the Fourth Industrial Revolutions – the real service or social robots on the market. We are greatly concerned at the UK’s low accessibility to commercialised service or social robots in competition to other countries such as Japan, Malaysia and China [18] and this has particular ramifications for the national robotics and AI curriculum, skills and real-life experiences.

5. We think that the UK curriculum from the primary to higher education for robotics and AI is falling behind other countries, especially the five major world robotics market, the key robotics leaders and drivers: China, Japan, Korea, US, and Germany [19, 20]. Taking the current curriculum in Wales [21] for example, there is no mention of "robot" or "artificial intelligence" in its main educational guides and policy, i.e. ICT in the national curriculum for Wales [22]. Design and technology in the national curriculum for Wales [23] and Science in the national curriculum for Wales [24]. The newly updated Digital Competence Framework guidance [25] is also outdated with the four decades of computational thinking elements. However there is a new curriculum for Wales to be introduced in 2020 [26] which provides an opportunity to fully embed Robotics and AI at its core.

B. The impact of the Fourth Industrial Revolution on the delivery of teaching and learning in schools and universities – The suggested responses to the UK Government and Welsh Assembly

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1. **International investment in Robotics and AI for the Fourth Industrial Revolution:** Between 2012-2016, the US invested approximately $18.2 billion in AI, compared with $2.6 billion by China, and $850 million in the UK. The Chinese Government issued the 2017 New Generation of AI Development Plan to help boosting the intelligent economy [27]. “Artificial Intelligence 2.0” is the Chinese comprehensive effort to boost investment in AI education and development, adopted in China’s Five Year Plan for National Science and Technology Innovation [28]. The following figures depict the increasing supply and demand of industrial robots globally [29]:

![Diagram showing estimated worldwide annual supply of industrial robots](image1)

We strongly believe that the Fourth Industrial Revolution is disrupting and changing the transformation of entire ecosystem of education and businesses, from curriculum to employment, operation production to strategic management and even governance. Moving ahead into the new era, traditional “digital skills” and “computational thinking” are decreasingly relevant. Older generation and current employees need to be upskilled, while younger people need to be educated in a reformed curriculum that include robotics and machine intelligence. National and enterprises’ investment in raising public awareness and exposure to the advanced in-the-market service robots can set up the real-life context and daily scene for the reformed education. Both dimensions are closely intertwined in the international horizon.

2. **A new Robotics and AI Competence Framework Guidance/ new Robotics and AI in the national curriculum for Wales:** It is suggested that a transformed educational programmes or curriculums needs to be reflected from pre-school, Key Stage 1-4 and through to higher education for developing graduates with the higher-level thinking skills that will never be replaced by AI and robots [30]. Since the industrial revolution, our students have been educated for being better skilled labours in the educational sausage factories. When these jobs are being taken by AI and robots, it is the time to reflect what knowledge and skillsets are belonged to human, truly human and higher-level education. A national forum and in-depth study, can be conducted by interdisciplinary experts (Educationists, Robotics & AI researchers, Educational Psychologist and etc.): (i) what curriculum content to be included at what key stage; (ii) all possible jobs to be taken by AI and those which aren’t [30] and (iii) to develop the new Robotics and AI Competence Framework and national curriculum to include robotics, AI and IoT. For example, AI related curriculum in China Primary schools [31, 32].

3. **Global partnership in the global competitions:** The UK Government needs to invest further to form international partnership with Asia /Australia for (i) researchers, students and teachers mobility programme; (ii) educational robotics manufacturers or dealers; (iii) invest national robotics innovation hubs to research and import economical but quality robots from the largest industrial robots suppliers in Asia / Australia to embed across local Schools with related AI curriculums; (iv) to establish the National Institution, e.g. British AI and Robotics Society in Education as a catalyst for excellence for national and international showcasing and good practices; (v) to adapt on-the-market proven robots in other leading countries to local companies and public sectors.

4. **Universities-Schools collaborations:** Universities that have world-class expertise in robotics and AI can partner with local schools to develop robotic tutors and periodically workshops for various subjects and implement it for educational intervention – public readiness.

5. **To consolidate evidence from both the Education Committee and AI Select Committee in the House of Parliament to draw the ecology of robotics and AI education and practice, from curriculum to national**

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[27] Artificial Intelligence 2.0
[28] Five Year Plan for National Science and Technology Innovation
[29] Estimated worldwide annual supply of industrial robots
[30] Higher-level thinking skills
[31] AI related curriculum in China Primary schools
[32] AI related curriculum in China Primary schools
market supply and demand: Policy makers have the responsibility to guide the transition and transformation of jobs to be replaced by robots, i.e. to help in reskilling and education and to introduce robot tax to fund support for or retaining of workers put out of job by robots [30, 33].

6. Public and life-long education for ethical and legal readiness for the Fourth Industrialisation: to educate and retrain all citizens for the legal and policy for commercialised service and social robots – embed this agenda in all curriculum, companies policies and life-long learning materials. For instance, to consider the adaption of the EPSRC Principles of Robotics to govern the Fourth Industrialisation, such as (i) Robots should not be designed as weapons, except for national security reasons; (ii) Robots should be designed and operated to comply with existing law, including privacy; (iii) Robots are manufactured artefacts: the illusion of emotions and intent should not be used to exploit vulnerable users; (iv) It should be mandatory to find out who is responsible for any robot intelligence application [34, 35]. As the use of service robots start to invade all aspects of life, it is crucial that civil governments do not lag behind in responding to robotics and AI developments as they did with the development of the internet, e.g. ensure the respect for international human rights standards [36, 37] or to penalise unethical conduct in designing AI algorithms and robotic programs [30].

7. To open industry-university matched-funding R&D grant calls and competitions to accelerate the commercialisation and creativity of service robots and interdisciplinary projects that involved as many schools’ pupils and Universities’ students as possible from the start – a national holistic STEAM (Science, Technology, Engineering, Arts, and Math) delivery plan.

C. The role of EUREKA Robotics Lab in the Fourth Industrial Revolution (2018–2028)

(a) Place-based (University-School) strategies for education and skills provision. The think tank’s annual report 2018 suggests that almost one in four jobs in Welsh cities could be lost to robots by 2030 unless skills change [38, 39]. The EUREKA Robotics lab aims to be one of the Research and Enterprise flagships and teaching programmes innovation that amplifies the Welsh Government’s economic action plan [39] through the following initiatives:

1. To continue the 4-steps framework for University-Schools engagement across Wales:
   i. The delivery of half a day workshop at schools, “500-years history of Humanoid Robots” as well as the latest technologies including wearable, mind readers, flying drones and humanoid robots.
   ii. Two-day robotics workshop at the University that involve STEAM applications using humanoid robots.
   iii. A Robotics and AI competition related to Welsh culture and arts: learn how to put the "A" in STEM.
   iv. A Robotics and AI Competition Award Ceremony that involved both pupils and their parents.

2. To introduce new robotics and AI higher degrees that will produce highly skilled robotics graduates to feed into the new robotics related vacancies for job retention in Wales.

3. To implement the prototype of "The Next Wave of Learning with Humanoid Robot" [40] by embedding Educational Robotic Tutors across partner schools as an extension of Science and Technology teachers.

4. To develop and commercialise Multilingual Humanoid Service or Social Robotic Solutions (i.e. English, Welsh and Chinese) for stakeholders in Wales. By increasing robotics capacity in service-based organisations, the operation can create high-skill jobs retention within Wales and inject economic benefits into the Ecosystem in Wales from developing high knowledge workers to feed into the new robotics vacancies and related high skills technological jobs.

5. To offer internships opportunities for a flexible apprenticeship programme to recruit pupils from schools and university students: to coach young people to take advantage of future opportunities in a fourth industrialisation revolution preparation.

(b) For lifelong learning in re-skilling the current workforce

1. To develop and deliver from 1-day to 1-week "Business-Robotics Surgery Workshop": business alignment capability building and action plans for robotics ad AI solutions.
   1a. Produce expert-guidance materials and world-leading R&D publicly available papers to inspire and promote current workers’ exploitation of appropriate robotics solutions.

   1b. Promote physical or remote access to the expert surgery sessions using Video Conferencing and Interactive Panapto video training [41], to enable more business to participate.

2. Provision of Robotics Innovation Advisory Services from the start of each project: consultancy in the multidisciplinary fields of robotics acquisition with ethical-social-legal and security audit, IPR development and exploitation of code of conduct, standards and regulations embedding them in current workforce and new businesses.

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