Institution: University of Northampton		
Unit of Assessment: 12 - Engineering		
Title of case study: Enabling Computing and Coding Skills in Young People		
Period when the underpinning research was undertaken: 2005-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Dr Scott Turner	Principal Lecturer	2016-2020
	Associate Professor	2017-2020
Dr Gary Hill	Principal Lecturer	2005-2020
Dr Anastasios Bakaoukas	Senior Lecturer	2014-present
Dr Mu Mu	Senior Lecturer	2018-2020
	Associate Professor	2020-present
Period when the claimed impact occurred: 2013 - 2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact

The research underpinning this project has inspired school children and teachers to develop their computing and coding skills. It has helped raise the profile of coding within schools and helped remove a perceived barrier of difficulty surrounding coding. The activities have fed into a national coding competition for primary schools, led to increased resources at partner schools, new training and proficiency amongst teachers, and increased competence amongst the students around programming and ways to link this to problem-solving. The research has explored the use of virtual reality and robotics to make computing and coding more engaging for students.

2. Underpinning research

Scott Turner, **Gary Hill**, **Anastasios Bakaoukas** and **Mu Mu** have created a body of research focused on how to increase engagement with coding, programming, and problem-solving skills in educational settings. In particular, they have focused on the impactful nature of physical computing (Virtual Reality and robots), and emphasised the visual aspects of programming, to increase the impact and engagement of students at all levels, in areas that are seen as cognitively difficult to teach. Part of the research demonstrated what the students felt was good about the approach (e.g. physical and visual nature) and less positive (e.g. the limited time with the robots because they are limited resources) **[3.1]**. Based on this, the researchers revised their methods to include a more visual or simulation approach **[3.2]**

Turner and **Hill** have argued for the need to focus initial programming education on problem-solving, prior to the teaching of programming syntax and software design methodology **[3.1, 3.2, 3.3**]. They have developed innovative methods for the use of robotics in primary and secondary schools, developing a set of outreach activities that bring engineering, computing and waste management together around robot and robot-like activities. One example of this is **Turner's** Junkbots project, funded by East Midlands Development Agency (EMDA) and Northampton Enterprise Limited (NEL). Junkbots is a project in which waste materials are combined with relatively low-cost electronics to build simple robots in order to embed environmental, engineering and computing concepts into an accessible learning activity. The research focused on developing problem-solving skills with an emphasis on physical computing, and the researchers developed a programme of work that includes developing the robots and a set of incremental exercises for programming LEGO robots.

Research has also been conducted into the use of Virtual Reality in classrooms and blended learning environments. **Mu** found that Virtual Reality 'is an ideal tool to be used in short sessions to complement convention delivery of university lectures, especially in the context of blended learning' **[3.4]**. This was further informed by a GBP30,000 Royal Society Partnership Grant led by **Bakaoukas**, which funded research into the use of Virtual Reality to make computer science more engaging for Year 12 students. For this project, researchers worked with students to develop and design a virtual reality application and collect data on its efficacy as a learning tool, which contributed to **Bakaoukas'** research on Virtual Reality **[3.5]**.

3. References to the research

[3.1] Turner, S., & **Hill, G.** (2008). Robotics within the teaching of problem-Solving. In *Innovation in Teaching and Learning in Information and Computer Sciences* (pp. 108-119). (Innovation in Teaching and Learning in Information and Computer Sciences; Vol. 7). The Higher Education Academy Innovation Way. https://doi.org/10.11120/ital.2008.07010108

[3.2] Hill, G., Wu, B. (ed.) & Kassel, S. (ed.) (2016). Review of a problems-first approach to first year undergraduate programming. In *Software Engineering Education Going Agile: 11th China-Europe International Symposium on Software Engineering Education (CEISEE 2015)* (pp. 73-80). (Progress in IS). Springer International Publishing. https://doi.org/10.1007/978-3-319-29166-6_11

[3.3] Hill, G., & **Turner, S. J.** (2014). Problems first, second and third. *International Journal of Quality Assurance in Engineering and Technology Education (IJQAETE)*, *3*(3), 88-109. [3]. https://doi.org/10.4018/ijqaete.2014070104

[3.4] Slavova, Y., & Mu, M. (2018). A comparative study of the learning outcomes and experience of VR in education. In *IEEE Conference on Virtual Reality and 3D User Interfaces: IEEE VR 2018* (pp. 1-2). IEEE. https://doi.org/10.1109/VR.2018.8446486

[3.5] Bakaoukas, A. (2020). Virtual Reality Reconstruction Applications Standards for Maps, Artefacts, Archaeological Sites and Monuments. In F. Liarokapis, A. Voulodimos, N. Doulamis, & A. Doulamis (Eds.), *Visual Computing for Cultural Heritage* (pp. 161-176). (Springer Series on Cultural Computing). Springer. https://doi.org/10.1007/978-3-030-37191-3_9

This research was funded by:

- EMDA/NEL funding GBP20,000 - Junkbots project: https://junkbots.blogspot.com/2017/10/crumble-egg-junkbot.html;
- Three grants from the HEA (Subject Centre for Information and Computer Sciences) GBP4,000;
- HEA grant (subject centre for Engineering with Jonathan Adams) GBP1,000; and
- Caroline Chisholm School – Royal Society Grant GBP30,000

4. Details of the impact

The computing team at the University of Northampton have worked with local primary and secondary schools to introduce and improve coding and programming skills in schoolchildren, in alignment with changes to the national curriculum regarding computing in education from early years to key stage 3.

Increasing Competencies in Coding, Programming and Problem Solving for Schoolchildren

Turner and **Hill** have developed numerous workshops, modules and competitions for schoolchildren based on their research on problem solving. This has included Junkbots and the Young Coders Competition.

The Junkbots **[5.1]** project introduced over 100 children to robotics programming and problem-solving and increased the development of their problem-solving and computational thinking skills. During the COVID-19 crisis, the Junkbots work provided an opportunity to work with Roade Primary school **[5.1]** in Northamptonshire. The Computing Subject leader at the school embedded this work into their online curriculum. These resources have been made available at the National repository of Computing Education Resources, which is accessible to Computing Educators, and have been downloaded 626 times.

Additionally, **Turner** and **Hill** set up and supported Code Clubs at local schools (Roade Primary School, Northampton International Academy, St Luke's C.E. Primary School) to help participants build their computing skills **[5.1, 5.2]**. Over 30 children were involved.

In 2015, **Turner** and **Hill** established the Young Coders Competition in collaboration with the Worshipful Company of Information Technologists, Northamptonshire County Council and the local STEM contract holder - Leicester Education Business Company. The Young Coders Competition aims to tackle a national shortage in coding ability. It does this by encouraging eight-to-11-year olds to have fun coding and spark a lifetime interest in the skill that may lead them to a career developing websites, apps and computer software. The national competition has run for five years for schools across the country. The competitions have resulted in increased coding competencies for the students involved. The headteacher for Park Junior School noted that the "competition allowed some of our more able children and members of our 'Coding Crew' to develop their skills further. Working together in collaboration as part of a team, the children were able to hone their skills and share ideas with their peers" **[5.3]**.

In 2016, the Competition was recognised by The Green Organisation, a leading non-profit organisation which promotes and rewards best environmental practices internationally. During the Green Apple Environment Awards at London's Houses of Parliament in 2016, it won a Green Apple Award for Environmental Best Practice based on its innovations in facilitating the creation of games focused on saving energy in students' schools **[5.4]**.

Increasing Competencies in relation to Virtual Reality

Bakaoukas worked with the Caroline Chisholm School to develop skills in relation to virtual environments with 11 and 12 year old students. The school's Faculty Leader of Computing and IT testified **[5.5]** that through their participation in the program, students learned how to build a virtual reality app, resulting in a wide array of computing skills. These included the ability to show how the CPU processes data in a computer; build a virtual motherboard and show the flow of data; create a virtual server room so students can practice fault diagnosis; research into the effects of virtual reality on learning; and draw conclusions as to the benefit of virtual reality as a learning environment. The project resulted in an invitation for students to showcase their app at the Royal Society Student Science Exhibition in July 2020, which the school's faculty lead identified as 'an amazing experience for students' **[5.6]**.

Based on this work, the school successfully bid for further funding, and received GBP3,000 to purchase school equipment in relation to virtual learning environments. As noted by the Faculty Leader, without the researchers' help in creating the app and guidance on methods of research, they would not have been able to support their funding bid. This has resulted in their successful use of two Oculus Rifts and an app which students can use to 'step into a computer' and see a virtual simulation of how a PC works. Students acquired the programming skills to code the app and project manage the research and development **[5.6]**. The Faculty Leader of Computing and IT at Caroline Chisholm school testified that the project made computing 'more engaging for students', which 'would have been virtually impossible' without the help and support of the

researchers **[5.6]**. Students confirmed this, with one stating that 'This makes Computer Science the best subject', and another stating 'It really shows you how things work, you do not get this in normal lessons'.

5. Sources to corroborate the impact

[5.1] Roade School Testimonial

[5.2] Junkbots in Schools

[5.3] St Luke's C.E. Primary School Testimonial

[5.4] Park Junior School Testimonial (Coding Competition) and https://www.northampton.ac.uk/news/park-juniors-stand-aside-from-coding-competition-to-give-other-schools-a-winning-chance/

[5.5] Caroline Chisholm School Testimonial

[5.6] Green Apple Award Certificate