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Taking Computer Science and Programming into Schools: The Glyndŵr/BCS Turing Project

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Abstract

2012 and 2013 have been challenging years for Computer Science (CS) education in the UK. After decades of national neglect, there has been a sudden impetus to reintroduce CS into the 11-16 age school curriculum. Immediate obstacles include a generation of children with no CS background and an estimated need for 20,000 new CS teachers - existing UK IT teachers being insufficiently qualified and experienced. The Computing At School (CAS) movement has been instrumental in this quantum transition from an IT to Computing syllabus, as have the British Computer Society (BCS), leading UK universities and a number of major international technology companies, including Microsoft, Google, IBM, British Telecom and Facebook.

This paper discusses the background to this position and the progress being made to address these challenges. It describes, in particular, the work of the BCS-funded Glyndwr University 'Turing Project' in introducing Welsh high-school students and staff to high-level programming and 'computational thinking'. The Turing Project uses an innovative combination of Lego NXT Mindstorm robots, Raspberry Pi computers and PicoBoard hardware together with the Robot C and Scratch programming platforms. The paper discusses initial objectives and the general approach, describes focused delivery across different age groups and ability ranges and presents results and analysis demonstrating the effectiveness of the programme. Lessons learnt and future directions are considered in conclusion.

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Keywords: Computer science, programming, computing curriculum, teacher training, British Computer Society (BCS) Academy, Computing At School (CAS), Council of Professors and Heads of Computing (CPHC), Lego NXT Mindstorm, Raspberry Pi, Robot C, Scratch, Picoboards;

1. Introduction and Background: IT, ICT, Computing and Computer Science in the UK

A few years ago, it became apparent that Computing education in schools in the United Kingdom, in common with many other countries in the world, had been in decline for several years [1]. UK schoolchildren, rather than studying programming, computer systems, computational thinking and problem-solving, etc., had grown up on a

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somewhat unsatisfactory diet of Information Technology (IT) and Information & Communication Technology (ICT). A typical IT/ICT syllabus/curriculum from 2010 would include an uninspiring combination of coursework based mainly on office software and might conclude with a project in which students created a video or some other form of presentation. Although there were some outstanding schools bucking the trend, in most, conventional notions of Computer Science (CS) were conspicuously absent.

1.1. Computing At School (CAS) in the UK

In 2008, a group of CS enthusiasts and professionals formed the Computing At School (CAS) movement [2], with the stated objective of addressing these shortcomings. Numbers were small, and influence limited, for two or three years until a series of professional endorsements [3] and media stories [4] served to raise the profile dramatically. Within a few months, government educational policy, noting a changing public tide, had shifted beyond recognition [5]. Almost overnight, the problem had transformed from one of trying to find support for a radical new curriculum to that of preparing for it being somewhat hastily implemented.



Fig. 1. The generic poster used to promote the Turing@Glyndwr project showing principal collaborators and typical activities

The immediate difficulty was then twofold. Not only were schoolchildren about to be immersed in an entirely unfamiliar syllabus but so were their teachers. Most estimates [6] put the number of existing IT/ICT teachers

unprepared for the new Computing/CS curriculum in the tens of thousands. In response, CAS, supported by the British Computer Society (BCS) [7], the BCS Academy [8] and the UK Council of Professors and Heads of Computing (CPHC) [9] set about building the Network of Excellence (NoE) [10], a national collaboration of trailblazing UK schools and universities and a number of major international technology companies, including Microsoft, Google, IBM, British Telecom and Facebook. Together they set about preparing UK schools for the CS revolution.

1.2. Glyndŵr University and North East Wales

The Computing Department at Glyndŵr University, Wrexham, commonly known as Computing@Glyndŵr (C@G) was heavily involved in CAS from its early stages and, in 2011, became the official CAS Hub for North, then North East Wales, coordinating development activity across a wide geographic area. C@G was also active in the CPHC with its successive Heads of Department serving on the national CPHC committee from 2010 onwards and chairing its Welsh region, the Council of Heads of Computing in Wales (Cyngor Penaethiaid Cyfrifiadura Cymru - CPCC).

In 2012, the BCS Academy named their annual educational bursaries the ‘Turing Awards’ [11] in honour of the centenary of the birth of Alan Turing [12]. C@G applied for, and was granted, one of the 30 grants awarded and the Turing@Glyndŵr (T@G) [13] project was born, initially planned to run over the academic year September 2012 to June 2013.

2. The Turing@Glyndŵr Project: A Response to a Changing CS Landscape

A noted problem with the sparse population in North Wales was the difficulty schools often encountered in travelling fairly large distances to attend events at the only two North Wales universities (Glyndŵr and Bangor); both cost and school-day timings were often an issue. The T@G approach was therefore to take mobile CS workshops to schools around the region and the BCS grant would be used for transportation costs (vehicles and fuel). Whilst C@G were able to supply volunteer staff and students to run the project and develop its website [13], there was little finance from the grant left for equipment.

2.1. Project Resources

Fortunately, the TechniQuestGlyndŵr (TQG) Science Discovery Centre [14] is co-located with C@G. TQG were able to supply a number of Lego Mindstorm NXT Robot kits [15], each with a supporting laptop. C@G staff loaded Robot C [16] onto each laptop (free with the NXT kits) and provided the High-Level Language (HLL) expertise to run it. TQG staff and C@G students supported the delivery in the field. C@G Foundation Degree (FdSc) students built the supporting website [13] and provided day-to-day management of the project. Google, through CAS, donated a number of Raspberry PIs (RPIs) [17], C@G purchased shared Picoboards [18] and Scratch was available via free download [19]. Scratch and the Picoboards, running either on RPIs or laptops allowed younger schoolchildren to work with a convenient Graphical User Interface (GUI) to build simple but interesting projects [20]. Robot C allowed older children to work with the NXT robots through a HLL. (The NXT Mindstorm packs have a default GUI but this was evaluated and considered inappropriate for the type of programming required.) T@G Project resources are summarised in Table 1.

2.2. The First Visit

Initially, seven schools in the counties of Denbighshire, Flintshire and Wrexham (Wales) and Shropshire and Cheshire (England) were invited to join the T@G project. Initial visits were made with small teams (three to five) of G@G/TQG staff and students working with school classes of between 20 and 30 children and their

teachers. A typical introductory session lasted two to four hours with the only exceptional requirement of the hosting school being a reasonably large amount of floor or desk space available to experiment with the moving robots. The TQG laptops were usually necessary due to the tendency for school computers to be locked down and unable to download/install the Scratch/Robot C software.

Table 1. A summary of Turing@Glyndŵr resources, quantities and providers

Resource	Quantity	Provider
Transport and fuel	865 miles	C@G/BCS Academy
Staff/Student time	720 person-hours	C@G/TQG
Turing@Glyndŵr website	1	C@G
Lego NXT Mindstorm robots	15	TQG
Toshiba Satellite Pro laptops	15	TQG
Robot C programming language	30 (laptops & lab PCs)	Free with NXT kits
Raspberry Pis	15	Google/CAS
Scratch Picoboards	8	C@G
Scratch programming environment	30 (laptops & lab PCs)	Free download

Sessions generally started with an introduction to the hardware and software to be used followed by a simple demonstration of the robots and boards. The first ‘challenge’ would be to extend the function of one of the examples in a trivial manner. Exercises would then become more challenging until – time, age-group and experience permitting – the children were solving more complex problems from first principles. The focus throughout was always on practical problem-solving and having fun. Teachers were always integrated into sessions, supporting the T@G teams. Numerous examples can be found on the project website [13].

2.3. *The Project Website and Second Visit*

The final stage of the introductory session was twofold: students were set a more challenging assignment (relative to progress already made) and introduced to the project website [13]. The new challenge could be approached incrementally, in stages, with each interim attempt at a solution being uploaded to the website for consideration by the T@G team, who could then provide remote feedback and suggestions for improvement or enhancement. A key feature of this stage of the project was that exercises could be simulated in software without the need for the hardware kit to remain with the school. (Essential as this would now be needed in other locations around the region.)

Finally, after a lapsed period of two to three months, a second visit was made to each school. The robots and boards returned to the classroom and the students’ solutions could be implemented in practice and assessed. Progress was discussed and children and their teachers completed a feedback questionnaire.

3. **Feedback, Results, Progress to Date and Looking to the Future**

All students taking part in the T@G project provided feedback in one form or another, approximately 300 of them. Some completed written or on-line questionnaires; others were interviewed individually or in groups, some by the T@G team and some by their teachers. Questions were appropriately phrased for each age-group and time-frame. This range of tools and techniques naturally gives rise to a large and somewhat unstructured data-set. However, Table 2 is a reasonable and well-intentioned overview.

Table 2. A summary of student responses to questionnaires and related feedback.

Composite Question	Yes	Don't know/No change	No
Are you pleased you took part in the T@G project?	92%		8%
Has your overall interest in CS/Computing increased?	69%	26%	5%
Has your particular interest in programming increased?	82%	14%	4%
Would you now consider Computing and/or Technology as a hobby or programming in your own time?	47%		53%

The last result in Table 2 indicates strongly that nearly half the students genuinely considered the material fun in its own right, not merely in a school context! Across all sessions, 68% of responding students were girls and 32% boys. 22% were in the 11-14 age-group, 69% in the 14-16 age-group and 9% were over 16. There were no significant sub-trends within these groups.

3.1. *Some Intermediate Reflection*

Teaching CS and programming to schoolchildren can be a challenge and the standard adult “Hello World!” approach [21] can be dull. Teachers have similar problems both in delivery and getting to grips with material in the first place. The CAS approach [22] has always been both to engage schools fully and focus on problem-solving and ‘computational thinking’ and the T@G project follows this model at all levels. Using the Lego robots and Picoboard enables students to consider programs in the real-world rather than as abstract concepts. The immediate response from the robot interaction is also invaluable. “Why does the robot go the wrong way? Look at the program code. Correct the algorithm. What happens now?”

The T@G initiative is a very effective collaboration in terms of both the expertise and equipment all partners bring to it. In truth, an astonishing amount has been achieved in a short time, largely due to the enthusiasm and commitment of all the staff and students of the schools and other institutions involved. This is fortuitous since time is a luxury UK CS certainly does not have. The T@G model is a very cost-effective and time-effective solution to a real problem. Ultimately, the T@G model, its resources, exercises and experiences can be passed across to teachers for them to deliver themselves.

3.2. *The Next Phase*

T@G has demonstrated proof-of-concept of this hands-on approach and the value of this form of outreach delivery, particularly in rural areas. The intention now, already being put into practice, is to extend the project in both scale and scope.

Using the evidence of the initial project, further funding, approximately six times the original amount, has been secured from another educational grant [23] and more advanced robots [24] and additional equipment is being bought. The C@G project is set to be extended across a wider geographic area, reaching more schools, with a larger range of projects and an enhanced website. Future students will also be able to work towards a nationally recognised vocational award [25].

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