Education and Outreach Activities in Ireland: an Experience Report

Ms. Clare McInerney, Lero - the Irish Software Engineering Research Centre

Clare McInerney is the Education and Outreach Officer with Lero - the Irish Software Engineering Research Centre. She is based at the University of Limerick, Ireland.

Prof. Mike Hinchey, Lero-the Irish Software Engineering Reseaach Centre

Mike Hinchey is Director of Lero and Professor of SE at University of Limerick.

Education and Outreach Activities in Ireland: An Experience Report

Abstract

The Lero Education and Outreach (E&O) programme discussed in this paper focuses on our goal to increase the interest and knowledge of high school students in computing and software engineering and encourage a greater uptake of computing and software engineering at university. While many high school outreach programmes operate in countries that offer Computer Science (CS) education for all high school students or at least offer a pre-university level course, this is not the case in Ireland. In terms of a national approach to Information and Communication Technology (ICT) in schools, 53% of Irish high schools are involved in the European Computing Driving License (ECDL) programme, but the focus of this programme is on computer *literacy* rather than computer science.

The outreach programme, which we have been running for four years, focusing on computational concepts and computational thinking, consists of four parts: teaching materials/curriculum, teacher training, a competition and summer computing camps. Teaching materials/curriculum include a 45 hour course designed for high school students. Teacher training is concerned with training primary and high school teachers. The competition is an annual Scratch competition run for primary and high school students. The summer computing camps are run in our university for a number of weeks during the summer period. Software engineering concepts are introduced in all four parts of the programme during the software project phases. Our outreach efforts primarily use the Scratch tool that was developed at the MIT Media Lab.

We describe each outreach effort in detail and outline our experiences based on a mixture of survey results, instructor observation and participant feedback. We will conclude by describing how the E&O programme has led to Lero being commissioned by the Department of Education to write a computing course for high school students that will be part of the official curriculum.

1. Introduction

There are many well-known and well-documented computer science outreach programmes such as "Computer Science for High School"[1] , "Georgia Computes" [2], "Computer Science Unplugged" [3] and "Just Be" [4]. The NSF CS/10K initiative seeks to develop new high school curriculum for computing taught in 10,000 high schools by 10,000 well-qualified teachers[5].

Many third-level[1] institutions around the world run outreach programmes. All share a common goal of increasing enrolment in undergraduate computer science programmes. Some outreach programmes have been specifically designed to address under-representation of women and minorities in this domain [2, 6, 7]. In order to increase the uptake of computing by students, Lero has designed and implemented an Education & Outreach (E&O) programme at the national level in Ireland. This paper presents the design and experiences of our outreach efforts at high school.

[1] Third-level refers to universities, colleges and institutes of technology

The fact that the demand for ICT professionals exceeds supply has been widely documented at both the national level and international level. In Ireland in 2012, the ICT sector employs 75,000 people in 8,000 companies[8]. The National Skills Bulletin [9] reports that despite the global financial crisis of the late 2000s, considered by many to be the worst financial crisis since the great depression of the 1930s, job vacancies continue to arise in the ICT sector with growth at 6.1% annually over the period of 2005-2010, translating into a net job creation of 11,000 over this five year period.

The output from undergraduate computing programmes is 754 in 2009 [9] and 959 in 2011. The bulletin further notes that there is a particular difficulty in filling available positions in the ICT sector for software engineers and computer programmers. Our E&O programme specifically addresses this problem. In Ireland, there is no "computing/computer science" subject, official computing curriculum or a US-like advanced placement programme at junior or senior level in high school. However, recently we have been commissioned by the National Centre for Curriculum and Assessment (NCCA) to write a 100 hour course on computing that will be part of the curriculum. We believe our E&O programme, which has been running for the last four years, has allowed us to firmly establish ourselves in the domain of computing education in high schools in Ireland. We believe the successful deployment of this programme at the national level has led the recent commission by the NCCA.

1.1 Background and Motivation

In terms of a national approach to ICT curriculum in schools, the most widely adopted programme currently being taught in schools is the European Computing Drivers License (ECDL) programme. This is currently being taught in four hundred Irish high school schools (53%) out of a total of 750 schools. While it is a worthwhile qualification in its own right, the focus of ECDL is on computer *literacy* and not *computing*. As well as computer literacy, we believe students need to have the opportunity to understand and learn more about the software contained in the devices they use. We want them to understand how software is written and how they can write their own code. We want students to have the option to learn computer science.

1.2 Structure of this paper

The Lero E&O programme will now be described in more detail. It consists of four components, which are described in this paper:

- Teaching Materials/Curriculum
- Teacher Training
- Competition
- Summer Computing Camp

The paper proceeds as follows. Sections 2 to 5 describe each of the four components of the E&O programme listed above. Section 6 describes lessons learned from adopting a national approach to an E&O programme in a small country. Section 7 summarizes and concludes.

2. Teaching Materials/Curriculum

The first component of the E&O programme is the development of teaching materials to define a curriculum that can be used by educators. We present the design of this component (sub-section 2.1) followed by results and participation (sub-section 2. 2).

2.1 Design

To address the lack of an official computing subject at high school, we devised a curriculum that enables students and teachers to experience computing and software development in a fun and exciting and hands-on way. We selected the Scratch tool [10], developed at the MIT Media Lab, and incorporated elements of the Computer Science Unplugged (CS Unplugged) project [3] to teach computational concepts and computational thinking [11]. When the E&O programme started in 2007, Scratch had just been released that summer and comprehensive teaching materials were not available. Therefore, we decided to develop teaching materials, in conjunction with high school schoolteachers.

Since its launch, Scratch has become a very popular tool for outreach programmes. Meerbaum-Salant et al. [12] have shown that Scratch is a useful way to learn computer science concepts. At the undergraduate level, Scratch is being used successfully to attract more students to participate in introductory computer science courses and to encourage students to continue their computer science studies [13-15]. Scratch has also been used in a number of summer camps [2, 16].

CS Unplugged is a collection of free learning activities that teach Computer Science through engaging games, puzzles and hands-on activities. CS Unplugged teaching materials were designed for teachers that do not necessarily have a computer science degree. CS Unplugged is sponsored by Google Inc., the University of Canterbury and Carnegie Mellon University.

The teaching materials that we have developed consist of a 45-hour transition unit comprising of ten modules. Transition units are curriculum components for the senior cycle at high school. Students are typically aged 14-15. These are not intended to be exam courses but are assessed as part of the teaching and learning. The NCCA developed templates and a handbook for developing transition units. Once the unit has been compiled, it can then be submitted to the NCCA for approval and once approved it is then posted on the NCCA website. We received approval for our transition unit in 2009 and this approval adds value for teachers as it constitutes official endorsement from the Department of Education and Skills. Our materials are freely available on our website www.scratch.ie.

Transition-year timetables vary considerably per school so a teacher can tailor the course to suit their needs from the ten available modules. Some students may have as little as a 2 to 4 hour computing experience and others may have a computing class throughout the school year for a total of 45 hours. Some teachers choose to use the materials outside transition year. For example, a number of teachers we work with use the teaching materials with their first and second year students and some teachers have set up after-school computer clubs.

The teaching materials, consisting of 450 pages, are very comprehensive and contain a detailed step-by-step guide for teachers. The modules cover all the computational concepts such as sequence, iteration, conditional statements, variables, lists, event-handling, threads, keyboard input, coordination and synchronization, random numbers, Boolean logic and user-interface

design. The teaching materials introduce students to software design, by encouraging them to specify a program prior to implementation in code. Other activities in the software development life cycle, such as requirements, design, testing, code maintenance and debugging are also covered in the teaching materials. Computational thinking elements are introduced to students through searching and sorting exercises and through the exploration of exponential growth of classic computer science problems.

To accompany the teaching materials designed for teachers, we developed a slimmed-down version of the teaching materials in the form of a student workbook. The student workbook is structured identically to the teaching materials and contains the ten modules, but is much shorter (135 pages) than the full materials (450 pages). The length and number of pages of the teaching materials made it very expensive to print (especially in color), so the availability of a student workbook enables affordable distribution of hard copies. The majority of teachers have a preference for a hardcopy of the materials book instead of working with an online version. We also include end-of-module quizzes in the student workbook. The workbook can also be used as a self-study option for students that are interested in working outside school. The teaching materials and student workbook are freely available on our website. A hardcopy of the student workbook is available for purchase for €9.00 via the online shop at the Irish Computer Society.

2.2 Results and Participation

In terms of results, as of October 2012, over 100 schools, or 13% of the total number of high school schools, are using Scratch, have downloaded the teaching materials and are participating actively in our E&O programme. The uptake of this course is entirely voluntary by the schools and teachers. Since November 2008, the teaching materials have been downloaded 2,122 times, of which 851 were from locations in Ireland. Our goal is to engage with 50% (approx. 370) of high school schools in Ireland.

3. Teacher Training

The second component of the E&O programme is teacher training. This section presents the design of the teacher training (sub-section 3.1) and the results and participation (sub-section 3.2)

3.1 Design

Teacher training is essential to enable the delivery of the teaching materials in schools. A national network of Teacher Education Centers (21 operating full-time and 9 operating part-time) have been established around the country to provide Continuing Professional Development (CPD) for teachers and to address identified needs of teachers and schools. In cooperation with the Computer Education Society of Ireland (CESI) and the National Centre for Technology in Education (NCTE), training sessions have taken place in these centres. Training sessions have also taken place at the Irish Computer Society.

Since June 2011, over 150 high school teachers have participated in a two day introductory training sessions in education centres around the country. The goal is that trained teachers would deliver the transition unit in schools. During the introductory training course, we cover sections in 3 out of the 10 Modules of our teaching materials. Participants are given time to work on a final

project in groups and required to present their work to their colleagues. We use the Scratch.mit.edu galleries to upload and share projects, and in particular we focus on the Scratch elements of the materials.

We also conduct one to three-hour Scratch sessions at various events throughout the year, in particular at two annual conferences attended by teachers responsible for the delivery of computer classes and ICT coordinators. These conferences are ICT in Education Conference and the Computer Education Society of Ireland conferences. We estimate that since 2009, close to 400 people have participated in these shorter training sessions.

Because the focus of this paper is on high school, we have not yet reported on Scratch activities at primary level. However, we designed a 20-hour training course titled "The use of Scratch as a tool to develop pupils' numeracy / mathematical skills", for primary level teachers during the summer of 2012. This course was designed to address numeracy issues[2]. In terms of what was covered, we mapped elements of the primary school mathematics curriculum to Scratch. These included Number strands (Place Value and Operations), Shape and space strands (Lines, angles and area), algebra strand (directed numbers and variables), Data strand (representing and integrating data) and skills development. As an incentive for participation in a 20-hour summer course, participating primary level teachers qualify for three Extra Personal Vacation (EPV) days during the school year. We estimate that 200-300 teachers have participated in this course during the summer of 2012.

3.2 Results and Participation

We will now present some feedback from 55 teachers that participated in a two day introductory training session. 73% considered the course "extremely helpful" and 27% "helpful". Ninety-five percent of participants said "they would recommend the course to a colleague." Ninety-three percent of participants said that "the course met my expectations." Participant feedback was very positive as indicated in the comments below:

"very motivating course as had little or no background knowledge of the programme prior to today,really looking forward to getting children on board with thier own projects and also in using it as teaching tool, many thanks"

"Can't wait to get started"

"I am extremely happy with this course"

We believe that the increased levels of participated in teacher training translates to increased levels of computing activity in the classroom.

4. Scratch Competition

[2] http://www.into.ie/ROI/LiteracyandNumeracy/Downloads/LiteracyNumeracyStrategy_DES.pdf

The third component of the E&O programme is the Scratch competition, and focuses on involving students, rather than teachers. Like the previous two sections, we present the design of this component in sub-section 4.1 and results and participation in sub-section 4.2.

4.1 Design

When we developed and piloted the teaching materials and started training teachers, a number of teachers suggested setting up a Scratch competition to encourage and engage students. Since 2010 we have been running an annual Irish Scratch competition. Projects are submitted by both primary level and high school schools. We have run a number of regional competitions that have culminated in a national final competition. Each competition partner supplies a judge for the day. Project finalists demonstrate their projects to students, parents, supporters and the general public at the national finals. The Scratch finals have been held on International Scratch Day which has been in May for the last three years. International Scratch Day, an initiative from MIT, is a worldwide network of gatherings where people come together to meet with other Scratchers, share projects and experiences, and learn more about Scratch[3]. This helps emphasize the international and global nature of the Scratch project.

The Scratch competition complements the Teaching Materials/Curriculum. In module ten, entitled "Scratch Project", students create a concrete piece of work at the end of their in-class course. In this module, students must plan and design their project and, if working in teams, they must assign individual tasks. Students are encouraged to submit this final project for the Scratch competition. According to teachers we work with, many students spend time working on their Scratch projects for the competition outside school hours. This encourages an independent interest in computing and "I'm doing it because I want to" rather than "I'm doing it because the teacher says I must" attitude. By the time a student has progressed to the national finals, they tend to be very proud of their Scratch project.

We have established partnerships with two third-level institutions: the Institute of Technology Tallaght and the Institute of Technology Sligo. Prizes at the last three editions of the Scratch Competition were sponsored by the Irish Computer Society. This sponsorship enables us to award prizes to students that qualify for the national competition finals. Certificates are awarded to all students that submit a project for the Scratch competition. We use Scratch galleries to manage project submissions and for coordinating and managing the judging process. In some schools, the Scratch competition galleries are displayed during School Open Evenings when new students are recruited. Regional competitions may be virtual competitions in which case the Scratch galleries are very useful.

4.2 Results and Participation

The participants in the latest edition of the Scratch National Final were quite enthusiastic, as their feedback below indicates:

"I learned loads doing our project and absolutely enjoyed the day and it was lovely to see everybody else"

[3] http://day.scratch.mit.edu

"I am very happy to be part of such a wonderful community"

"The whole process was fun and educational. The competition was a good way to practice communication. I liked seeing the work my peers had done"

There is great variety in the types of projects we have received and the projects that have won prizes. This year the winning project in the Animation category was titled "*Learn Spanish*". This is an interactive tutorial for improving Spanish. The project is available for viewing online[4].The winning project for the game category is titled *"Armageddon 2012"*, a multi level mathematics tutorial game. The user can work through twenty levels solving mathematics problems. It is also available online.[5]

At the primary level many of the projects are animations that incorporate photos and sound-recordings of the students. Storytelling is also very popular amongst younger students.

In terms of numbers and results, in 2010 we received 60 project submissions from 12 schools. In 2011 we received 90 project submissions from 20 schools. In 2012 we received 194 submissions from 54 schools and organizations. To stimulate high-quality submissions, schools are limited to ten project submissions. Schools are encouraged to organize in-school competitions. We would like to see the number of project submissions increase for 2013. For the last three years about 70 people attend the National Finals.

5. Summer Computing Camps

The fourth component of the E&O programme is our involvement in Summer Computing Camps. Like the Scratch Competitions discussed in the previous section, these focus on involving students. Design of this component is presented in sub-section 5.1, and results and participation are presented in sub-section 5.2.

5.1 Design

As well as running teacher training during the summer, we have run summer computing camps for the last three years at an Irish University. In 2012, we ran three-day camps for two weeks, with two sessions running in parallel each week. We covered Arduinos and Sensors, Scratch [10], Computer Music, LEGO Mindstorms [17], Electronics Foundations and Greenfoot [18]. We provide a brief description of each session:

- In the Arduinos session, students explore the open source software, Pure Data, in conjunction with a range of sensors and construct a musical instrument for the 21st century capable of producing a range of strange and wonderful sounds.
- Students learn computational concepts using Scratch and work in teams to build a Scratch project. Students also use Scratch boards to program light, sound, slider and push button sensors.

[4] http://scratch.mit.edu/projects/alexandracollege/2414574

[5] http://scratch.mit.edu/projects/ycmcinerney/2580301

- In Computer Music, students develop a musical composition in a few easy steps. Students will become familiar with basic concepts in digital music such as MIDI, audio loops and mixing techniques.
- In the LEGO Mindstorms sessions working in teams, students design, program and control a fully functional robotic model.
- In Electronics Foundations, each student builds and tests a transmitter. The transmitter can be tuned between 88-108 MHz by adjusting the variable capacitor in the circuit.
- Students use Greenfoot to try out Java programming. Greenfoot is a framework for creating graphical demonstrations using the Java programming language that is suitable for novice programmers.

5.2 Results and Participation

A total of 169 students have participated in the summer camps over the last three years. Attending students were between 14 and 18 years of age.

The camps took place over three days with each session lasting three hours. We administered a survey in 2011 created by Adams [16], who has run similar summer camps. We administered this pre and post survey to 38 students. In the pre-survey questionnaire we asked students: "*Have you ever written a computer program*"; the results are shown in Table I.

Answer	Score	Percentage
Yes	4	10.5%
No	24	63.2%
Don't know	10	26.3%

Table 1. Have you ever written a computer program?

These results demonstrate that there are a considerable number of participants that have never previously written a computer program. However, interestingly 26% of participants do not know whether or not they have written a computer program. This highlights the need for an E&O effort in our country.

Figure 1 presents the results for pre-camp survey and post-camp survey in response to the question: "*Are you considering doing a computer science related course at third level?"*

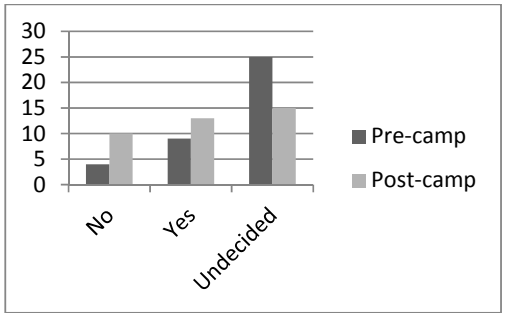

Figure 1. Results of pre-camp and post-camp survey: "Are you considering doing a computer science-related course at third-level?"

The figure shows that the number of "undecided" has decreased, which demonstrates that the camp has helped students gain a better and clearer understanding of computing. Even though the number of "No's" is higher, we would hope this addresses the retention issues in first-year undergraduate computing courses.

Figure 2 presents the results of the question "*Would you recommend the Cybercamp to your friends?*" The results indicate that 45% said "Yes" and 18% said "Absolutely" when asked if the would recommend the camp to their friends. We consider this to be very positive.

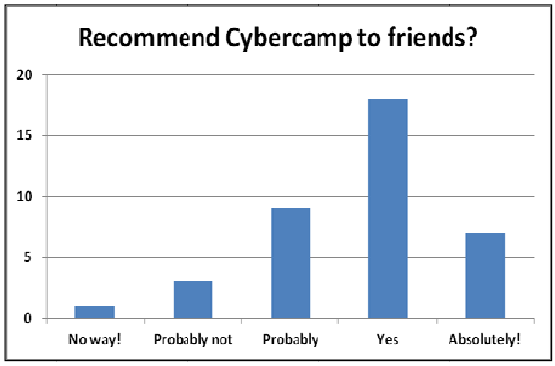

Figure 2. Would you recommend the Cybercamp to your friends?

We also asked the students whether they would attend a follow-up camp next summer. The results are shown in Figure 3.

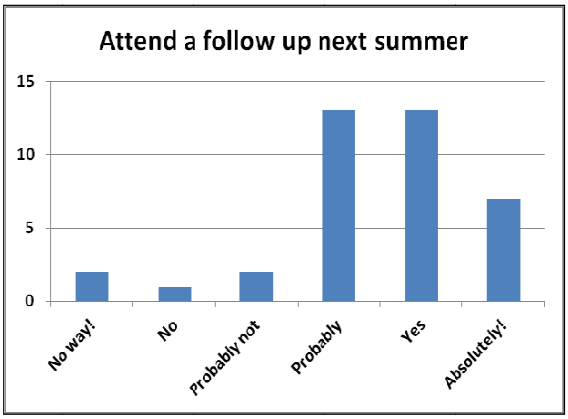

Figure 3. Would you attend a follow-up camp next summer?

Overall, these results suggest that students have positive views on attending a follow up camp next year. All students that participated in the Cybercamps were awarded a certificate of participation and a Cybercamp t-shirt. For the three years that we have run the camps, we have offered a number of funded places for disadvantaged students. These students are members of the *University*

Access Programme. This programme is designed to support the participation of students from groups who have been underrepresented in third-level education.

Similar summer computing camps are run in a number of third-level institutions around the country. This initiative is supported by the Higher Education Authority (HEA) in Ireland. This year the camps took place in 16 third-level institutions. Two institutions contacted us this year and used our Scratch teaching materials and student workbook during their summer computing camps. Feedback from the two institutions was very positive and they indicated their intention to continue using these materials in the future.

6. Lessons Learned from a National Approach

Ireland is a small country with a population of 4.5 million and 750 high schools. Rather than implement an E&O computing programme that focuses on requiring us to deliver in-school or on-campus activities in the surrounding areas of our university, we decided to adopt an approach that focuses on delivery by the teacher. This allows for a national and scalable rollout of a subject not currently recognized as an official subject on the curriculum and targets a larger number of schools and students. We adopted this approach for 3 out of the 4 components in the E&O programme. To ensure a feasible national approach, we take responsibility for providing curriculum and training teachers and the teachers are responsible for delivery in the classroom. To ensure a feasible national rollout, we rely on the enthusiasm of our teachers to participate in the programme. We present three lessons learned for people thinking about scalable computing outreach in a small country with limited resources when the subject is not yet recognized by the education system.

Lesson 1: Costs

Participation in the programme should not incur any costs for the teachers and students. Government funding for ICT in schools has prioritized internet access for schools, teacher professional development for ICT, ICT infrastructure deployment in schools and deployment of curriculum-relevant digital content. This funding priority and recent budget constraints would discourage participation in the E&O programme if there was an associated cost.

Lesson 2: Teaching Materials/Curriculum

Development of teaching materials/curriculum for teachers and students design should assume no prior computing experience. Considering we do not have a computer science teacher preparation programme in any university in Ireland, we cannot assume any prior computing experience. Occasionally we work with teachers that studied computer science, changed careers and completed teacher training or teachers that would have worked in the UK education system as ICT teachers and moved back to Ireland but these would be exceptions.

Lesson 3: Build Relationships

Build relationships with national networks/bodies responsible for curriculum development and for activities relating to teachers and ICT. Leverage and utilize resources, infrastructure, communication channels, and so on, for established subjects to spread the word about the E&O programme.

Over the last four years we have been building relationships with the National Centre for Curriculum and Development (NCCA), the National Centre for Technology in Education (NCTE),

the Computers in Education Society of Ireland (CESI) and the Irish Computer Society (ICS) and believe these relationships have contributed to the success of the programme.

The mission of the NCCA (also established in 1998) is to advise the Minister for Education and Skills on curriculum and assessment for early childhood education and K-12. The NCCA approved our teaching materials/curriculum as an optional "45-hour transition-unit" in 2010. This approval adds value for teachers as it constitutes official endorsement from the Department of Education and Skills even though it is still not a recognized subject.

The core objective of the NCTE is to promote and support the integration of ICT by teachers and students in teaching and learning in K-12 education. The NCTE provides a range of ICT-related support services to schools including delivering continuing professional development to teachers.

The Computers in Education Society of Ireland (CESI) [19] was established in 1973. CESI promotes the practical implementation of ICTs at school and classroom level. Through cooperation with CESI and NCTE we were able to prepare, plan, organize and deliver 2-day teacher training sessions around the costs with little or no costs incurred by participants (Some education centres charge a minimal fee of €10 which is the equivalent of $13.

The Irish Computer Society (ICS) was founded in 1967 as the national body for Information and Communication Technology (ICT) Professionals in Ireland. The ICS support our E&O programme and award certificates to students that participate in the programme.

7. Summary and Conclusions

In this paper we have reported on the Lero Education and Outreach (E&O) programme, which is an initiative at the national level in Ireland to reach out to students in order to stimulate a larger uptake of computing at third-level institutions. The programme consists of four components, targeting both teachers (Teaching Materials and Teacher Training) and students (Scratch Competition and Summer Camps). Up to this point one of the main challenges we face is convincing schools to get involved in the E&O programme. This of course is driven by the fact that computing is not on the official curriculum. However, the situation is changing.

We have recently been commissioned by the Irish government to write a computing course for high school students that will be part of the official curriculum. We believe our success and experience running the E&O programme for over four years, has played a major role in Lero being selected for this task. Our commissioning involves writing a 100 hour junior cycle short course template on computing. This short course will roll out in a number of schools starting September 2014. We are very excited about the future of computing in schools in our country.

Acknowledgements

This work was supported by Science Foundation Ireland grant 03/CE2/I303_1 and 10/CE/I1855 to Lero – the Irish Software Engineering Research Centre (www.lero.ie).

Bibliography

1. Carnegie Mellon University, UCLA & University of Washington. Computer Science for High School. Retrieved November 23, 2012 from http://www.cs4hs.com/.
2. Bruckman, A, Biggers, M, Ericson, B et al. 2009 "Georgia computes!": improving the computing education pipeline, *SIGCSE Bull.*, 41, 86-90.
3. Bell, T, Witten, I., and Fellows, M. Computer Science Unplugged. Retrieved November 23, 2012 from http://csunplugged.org.
4. Cottam, JA, Foley, SS & Menzel, S. 2010 Do roadshows work?: examining the effectiveness of just be. In *Proceedings of the 41st ACM technical symposium on Computer science education*. Milwaukee, Wisconsin, USA, pp. 17-21.
5. Transforming High School Computer Science: CS / 10K Project. Retrieved December 13, 2012 from c2474712.cdn.cloudfiles.rackspacecloud.com/ACM-Ed-Week-CS10K.pdf.
6. Teague, J. 2002 Women in computing: what brings them to it, what keeps them in it?, *SIGCSE Bull.*, 34, 147-158.
7. Klawe, M, Whitney, T & Simard, C. 2009 Women in computing---take 2, *Commun. ACM*, 52, 68-76.
8. IDA Ireland. Retrieved December 13, 2012 from http://www.idaireland.com/news-media/press-releases/enterprise-development-ch/.
9. Forfas. National Skills Bulletin 2011. Retrieved November 23, 2012 from http://www.forfas.ie/media/EGFSN110706-National_Skills_Bulletin_2011.pdf.
10. MIT Media Lab. Scratch. Retrieved November 23, 2012 from http://scratch.mit.edu.
11. Wing, JM. 2006 Computational thinking, *Commun. ACM*, 49, 33-35.
12. Meerbaum-Salant, O, Armoni, M & Ben-Ari, M. 2010 Learning computer science concepts with scratch. In *Proceedings of the Sixth international workshop on Computing education research*. Aarhus, Denmark,
13. Malan, DJ & Leitner, HH. 2007 Scratch for budding computer scientists. In *Proceedings of the 38th SIGCSE technical symposium on Computer science education*. Covington, Kentucky, USA,
14. Wolz, U, Leitner, HH, Malan, DJ & Maloney, J. 2009 Starting with scratch in CS 1. In *Proceedings of the 40th ACM technical symposium on Computer science education*. Chattanooga, TN, USA,
15. Wolz, U, Maloney, J & Pulimood, SM. 2008 'scratch' your way to introductory cs. In *Proceedings of the 39th SIGCSE technical symposium on Computer science education*. Portland, OR, USA,
16. Adams, JC. 2010 Scratching middle schoolers' creative itch. In *Proceedings of the 41st ACM technical symposium on Computer science education*. Milwaukee, Wisconsin, USA,
17. Lego Mindstorms. Retrieved September 05, 2012 from http://mindstorms.lego.com/en-gb/Default.aspx.
18. Greenfoot. Retrieved September 05, 2012 from http://www.greenfoot.org/
19. Computer Education Society of Ireland. Retrieved November 23, 2012 from www.cesi.ie.