

Having Fun with Computer Programming and Games: Teacher and Student Experiences

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Abstract. There has been a decline in the number of students studying mathematics, science and computing at third-level in Ireland. This may be because Ireland does not have a computing curriculum. However, in the UK higher education computing students fell in spite of the existence of such curriculum. According to teachers, student engagement and having a fun and exciting experience are essential ingredients when teaching computing to second-level students through a computing curriculum or other interventions. The Lero Education and Outreach program has developed a set of materials “Having fun with Computer Programming and Games” for second-level students aged 15-16. The goal is to engage students in computing and to offer them an enjoyable and positive experience. Working with two second-level ICT teachers, we designed a set of materials during summer 2008 that have been deployed in a number of schools.

Keywords: second-level outreach, second-level curriculum, computational concepts, computational thinking, engagement

1 Introduction

Students in Ireland choosing mathematics, science and computing¹ declined by 13 per cent in 2008.² Despite emerging opportunities and a growing need for qualified IT people in Ireland and globally, students are not signing up for undergraduate programmes in computer science [1], [2], [3].

The report [4] published by Forfás, Ireland’s National Policy Advisory Body for Enterprise and Science, highlights the need “to reverse the recent decline in the domestic supply of high-level computing” graduates.

The recent report commissioned by both the Higher Education Authority of Ireland and Discover Science and Engineering [5], states that encouraging more young people to take up a career in computing and information technology cannot be addressed in a single communications campaign, but that it needs to be tackled in a variety of ways. In the same report, it is suggested that students have a limited

¹ Computing refers to software development in the wider sense

² <http://www.siliconrepublic.com/news/article/13571>

exposure to information technology in schools and find it difficult to find a role for information technology in the educational environment.

The following sections will describe:

- Pilot rollout of the materials developed
- Initial reactions from teacher and pupils
- Plans for the future

2 Materials

“Having Fun with Computer Programming and Games” teaches computational concepts using Scratch [6] and computational thinking [7] to students. We also use Computer Science Unplugged [8] materials to teach searching methods to students without using computers. We have designed 45 hours of teaching material that teach students how to build computer games, create animations that use art and music, design, work in teams, test components of their games, modify and add new functionality to existing programs, present their projects to their classmates and provide feedback to their peers. The materials developed are available at <http://www.lero.ie/educationoutreach/secondlevel/scratchlessonplans> under a Creative Commons license.

The materials consist of 10 modules with each module containing 2-5 lessons. The lessons have been designed by experienced teachers for teachers that do not normally have a computer science background. Following the Irish National Council for Curriculum and Assessment (NCCA) guidelines for such courses, the materials teach the following key skills:

Information processing

- Researching and recording information on the Internet for research projects requires students to process large amounts of data in order to evaluate and extract appropriate information.

Critical and creative thinking

- Providing feedback to classmates by critically evaluating student research projects. They have the opportunity to incorporate creative thinking into their Scratch projects and research projects.

Communicating

- Presenting a research project and a Scratch project to the class; working in teams to build a Scratch project. Providing feedback and suggestions to classmates.

Working with others

- Planning and designing a Scratch project gives students an excellent insight into working with others, organising and delegating work within a group, taking responsibility for tasks and completing them.

Being personally effective

- Writing computer programs, animations, games and stories gives students a great sense of achievement as they are able to incorporate their ideas and designs and implement them into a finished product

3 Pilot Project

The Lero Education and Outreach Programme is targeting the optional year between the second-level junior and senior cycle: transition year. Transition year is unique in that it is an exam-free, stress-free year and it “encourages the development of a wide range of transferable critical thinking and creative problem-solving skills.”³ The Irish secondary school system is described in more detail in [9]. The “Having Fun with Computer Programming and Games” materials were rolled out in fifteen schools in geographically distributed areas of Ireland. We conducted interviews with five teachers that taught the materials during the 2008-2009 school year.

Table 1 shows the numbers of boys and girls that enrolled and completed “Having Fun with Computer Programming and Games”. It shows the total number in the group, the number of weeks and the number of hours assigned to teaching the materials. It is clear from the table that timetables and scheduling differ significantly across schools in Ireland. A Recommended Timing for Modules [10] document is available to guide teachers.

Table 1.

	Number of Boys	Number of Girls	Total In Group	Duration (Weeks)	Duration (Hours)
School 1					
	0	28	28	32	67
School 2					
Group 1	0	23	23	8	10
Group 2	0	22	22	8	10
Group 3	0	25	25	8	10
Group 4	0	20	20	8	10
School 3					
Group 1	12	6	18	16	29
Group 2	7	8	15	16	29
School 4					
Group 1	10	10	20	8	25
Group 2	12	11	23	8	25
Group 3	9	11	20	5	17
Group 4	13	9	22	6	20
Group 5	13	9	22	6	20
School 5					
		13	13	32	42
Totals	76	195	271		

In school 3 and school 5 “Having Fun with Computer Programming and Games” is an option.

³ Department of Education Transition Year Support Service <http://ty.slss.ie/>

3.1 Computational Concepts using Scratch

When designing “Having Fun with Computer Programming and Games” materials, we evaluated a number of software tools that could be used to teach computational concepts to second-level students. For instance, we considered Greenfoot [11]. It is an excellent tool for teaching programming and freely available; but given the limitations of technology infrastructure in Irish secondary schools (a JVM generally requires more than 256MB of RAM) and lack of Java programmers amongst second-level computer teachers, the tool was deemed unsuitable for the Irish secondary school system.

Scratch is being used successfully to teach programming skills to novices. It has been used as an introductory language at undergraduate level [12, 13]. We are using it at second-level schools in Ireland. Scratch is freely available and easy to install and use. Scratch teaches computational concepts to students in a fun and engaging way. Teachers reported that student engagement with Scratch was “far superior”⁴ to the level of engagement while studying ICT literacy skills and that “motivation levels were high among all students”.

In Module 1 we show students how music can be incorporated into Scratch. Students take part in a battle of the bands competition. This task was very engaging for students. In school 4 the teacher remarked that “this was very popular and we had a big band jam on the projector with the speakers turned up”.

In Module 2 we introduce algorithms. We asked students to design an algorithm on paper to draw a picture. Students enjoyed this task. Students were introduced to turtle graphics and drew squares, circles, etc... However, once students started working with more complex shapes that used nested loops, “students appeared unimpressed”. This lesson lost the attention of students and teachers were obliged to continue with other materials.

In Module 5 Scratch cards are distributed to students and they are required to implement solutions to various problems. There are three levels of Scratch cards: easy, difficult and extreme. Solution cards are provided for teachers. The cards are used to revise all computational concepts that have been taught. Easy cards were completed by all students and difficult cards were completed by many students. While the teacher in school 1 remarked that the extreme cards were “too difficult to do alone”, the teacher in school 4 commented that the “level of tasks and their challenge was very appropriate” at the extreme level.

In Module 6 students are given a code maintenance task. They are presented with existing Scratch projects and asked to make modifications. Teachers reported that this task “gave them confidence”. The teacher in school 2 commented that “Module 6 was the most successful module with students. It allowed less able students to complete minor modifications and more able students to complete more advanced modifications”. The teacher in school 5 indicated that “more modifying code lessons would be welcome.”

In Module 10 students design and implement a final project in groups. They are required to fill out a project worksheet to document their work as the project

⁴ All quotations in “” are taken verbatim from teachers in one of the five schools studied

progresses. They present their project to their classmates when the project is completed. In terms of presenting the completed product teachers reported that “the groups were very enthusiastic about displaying their work”. The teacher in school 3 reported that “some students showed good initiative and worked on parts of their project at home”.

Irish secondary schools have open days for primary school students. In school 3 a number of students presented Scratch and their projects to prospective students and according to the teacher involved “this was very well received both by parents and prospective students”.

Based on teacher feedback, students and teachers had a positive and engaging computing experience learning computational concepts in Scratch.

3.2 Computational Thinking

The “Having Fun with Computer Programming and Games” materials include computational thinking. In her computational thinking paper [7], Jeanette Wing suggests that when problem solving we might ask “How difficult it is to solve?” In our materials we present students with complex problems and solution implementations. We want students to gain an understanding about the complexity of problem solving. We are not asking students to build solutions to the complex problems, but manually solve a complex problem game. By presenting complex problems in this way, we want to give students an appreciation for the grand challenges in computer science.

In Module 7 lesson 1 we present students with an implementation of the Towers of Hanoi⁵. We ask them to solve the problem for 3 disks. The teacher explains how the number of moves required to solve the problem increases significantly as the number of disks increases. The teacher in school 3 reported that “there was great competition in class to see who could solve with 3 disks. A few students were able to solve the problem in 7 moves and moved onto 4 disks.” In Module 7 lesson 2 we present students with an implementation of the Traveling Salesman Problem⁶. Students are asked to find the optimal tour for 10 cities. Again we explain how the complexity of the problem increases as the number of cities increase. The teacher in school 4 noted “the Traveling Salesman Problem was less popular than the Towers of Hanoi game. Only the more persistent, mathematically-minded pupils found the activity engaging”.

Feedback from teachers indicates that it is possible to interest and engage a wide variety of students in understanding complex computer science problems by allowing them to solve a complex problem game. The competitive aspect of games is appealing to students. Teachers reported that students enjoyed the computational thinking module.

⁵ http://nlvm.usu.edu/en/nav/frames_asid_118_g_3_t_2.html

⁶ <http://www.tsp.gatech.edu/games/tspOnePlayer.html>

CS Unplugged

The “Having Fun with Computer Programming and Games” materials include a lesson from Computer Science (CS) Unplugged. CS Unplugged, based at the University of Canterbury in Christchurch New Zealand, is a well established project running for over 15 years. CS Unplugged teaches computer science without a computer. CS Unplugged teaches “principles of computer science such as binary numbers, algorithms and data compression through games and puzzles that use cards, strings, crayons, and lots of running around”[8]. In Module 3, we use CS Unplugged materials to teach searching algorithms. Linear search, binary search and searching using hash tables are taught in a battleships game. The teacher in school 3 commented that “students really enjoyed the Battleships exercise. There were 1 or 2 moments of confusion with some students but nothing significant and the exercise proved to be good fun”.

Feedback from teachers reveals that students interacted well in their teams during the Battleship exercises and completed the searching algorithm games successfully.

4 Conclusion and Future Work

According to teachers interviewed this first time experience of computing was engaging and fun for students. “Having Fun with Computer Programming and Games” offers a positive and exciting experience to computing novices. To address the issue of students losing attention during particular lessons, we made modifications to the materials during the summer of 2009. For example, we added more detailed steps and guidance in the nested loops lesson and we added a two player Traveling Salesman Problem game in the computational thinking module to include a competitive element.

Because the materials were designed for teachers that do not normally have a computer science background, extensive training is not required for teachers wishing to teach the modules to transition year students. This allows us to roll out the materials nationally to all schools in Ireland in September 2009. Lero has formed partnerships with CIO Ireland, a group of senior ICT executives, and the Institute of Technology Tallaght (IT Tallaght) and the Irish Computer Society (ICS) to support the national rollout.

In terms of increasing the uptake of computer science undergraduate courses, transition year students that participated in the pilot project will be making their university choices in August 2011. At that point we will know if “Having Fun with Computer Programming and Games” has had an impact on student choice of course at third-level. In the meantime we plan to survey students that complete the course. We hope that the uptake of the materials will increase nationally as we move from the pilot phase to a national rollout and that new students and teachers will have a similar positive experience to students and teachers involved in the pilot project of 2008-2009.

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