Incentivising students to pursue Computer Science Programmes

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Abstract – **Statistics show that the number of students enrolling in technology based degree programmes has dropped dramatically in the past number of years. There are many possible reasons for this, including misconceptions on the nature of the discipline and a media fueled perception of a lack of employment in the field.**
This paper reports on the design, realisation and assessment of an event designed to encourage Transition Year (Grade 10 equivalent) students to consider Computer Science as a viable career choice. It documents how the event was planned and implemented, reports on the staff and student experiences, and provides both objective and subjective assessments of the event and its outcomes.

Index Terms – K-12 outreach, Recruitment, Lego, Mobile Communications

INTRODUCTION

In common with institutions in many other countries, Irish universities are experiencing a decline in the number of students enrolling in technology based degree programs. A key difficulty in addressing this problem is the challenge of finding ways to motivate K-12 students to even *consider* a career in computer science or engineering.

Many students associate technology based degrees with the stereotype of an isolated individual who spends their day coding at a computer terminal. This is reinforced by the widely held belief among second level students that the core component of a computer science degree is computer programming and, moreover, that computer programming is an extremely dull and uninteresting pursuit. It is clear that if technology based degree programmes are to recover from a catastrophic decline then highly motivated students with an aptitude for the discipline need to be attracted into the field.

The Computer Science Department in Trinity College Dublin set out to address this challenge through a highly structured, carefully coordinated programme of events. These provided Transition Year (Grade 10) students with the opportunity to get hands-on experience of some of the technologies which make Computer Science the innovative and exciting discipline it is today.

Over the past two years, in excess of 100 students drawn from 12 selected schools in the University's catchment area participated in a three day event where they:

- Explored and developed teamwork, technical and critical analysis skills;
- Investigated new technologies and innovations in computer science;
- Overcame misconceptions about computer programming;
- Gained an appreciation of the structured approach needed to tackle new problem domains;
- Interacted with staff from high-profile technology companies and gained an insight into their latest innovations;
- Experienced daily life on a University campus.

Participants undertook two practical projects. In the main project, students worked in small teams to create a Lego MindStorms[1] robot to satisfy a predetermined project specification. For the second project, augmented GSM cellular telephones and mobile positioning technologies were used to explore how location based services could be provided within the University campus.

Students also attended a number of short talks; these included presentations from high profile technology companies, as well as from those involved in academic research in the field.

MOTIVATION AND OBJECTIVES

In recent years engineering accreditation bodies such as the US Accreditation Board for Engineering and Technology (ABET)[2], the UK Institution of Electrical Engineers (IEE)[3] and Engineers Ireland (EI)[4] have actively encouraged academic institutions to view the development of teamwork, leadership and decision making skills as fundamental to the educational formation of engineers and computer scientists. Indeed, ABET identifies the "ability to function on multi-disciplinary" teams and the "ability to design a system, component or process to meet desired needs" as essential outcomes of any accredited degree program. Moreover, ABET state that graduates should recognise the "need for, and have an ability to engage in, life-long learning". These skills are of benefit to the practicing computer scientist and engineer on both an individual and professional level. This philosophy is a key element in the design of many courses in the Department of Computer Science in Trinity

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College Dublin, and we have sought to extend these principles to our Workshop for Transition Year Students.

The *raison-d'être* of the event is self-evident – it is a recruitment initiative that aims to increase student intake into our undergraduate degree programs. In order to maximize the return on our efforts, an extremely strategic, highly focussed approach was adopted. Firstly, we considered the gender balance of our existing student cohort. This shows a significant male bias – increasingly so over the past five years. Thus, our event had to be capable of strongly appealing to, and engaging with, male second level students with a predisposition towards the disciplines of Computer Science and Engineering. Secondly, as ever, we wish to increase our intake of female undergraduates so the event should specifically target this student grouping also. Thirdly, we need to positively influence the potential undergraduate cohort at an early stage – ideally before their parents or their career guidance teachers have engendered strong career perceptions in their charges. Fourthly, we sought to identify, and counter, any negative perceptions that explicitly and implicitly cause students to forego our undergraduate offerings. Finally, the event had to be fun and interesting – both for the potential students, the postgraduate demonstrators and for the academic staff involved.

PARTICIPANT SELECTION

The identification of candidate schools is, again, a highly organised and focussed process. Information about all undergraduate entrants to Trinity College Dublin is held by the Admissions Office. This Office can, upon request, provide a demographic breakdown of the number of entrants to each course, the number of points they achieved, and the second-level schools they originated from. All school leavers are awarded points based on their aggregate grades in the state examinations. Thus, it is a simple matter to identify "feeder" schools that have sent us a large number of students in recent years, as well as allowing us to identify the schools that have sent us the highest point scoring students.

This information is used to form our initial target list of schools for the event. Each school is approached, ideally by a staff member or current post-graduate student who attended the institution and the nature and benefit of the event is explained to them. The event is targeted at transition year students in second level institutions. Transition year is "designed to act as a bridge between Junior Cycle and Senior Cycle by facilitating the smooth transition from the more dependent learning of the Junior Cycle to the more independent self -directed learning of the Senior Cycle" [5].

Some transition year students have very clear ideas of the career they wish to pursue, but others are less certain. Thus, focussing on transition year students satisfies our third criterion for the event.

Having established contact with our target schools, each school is invited to send us 4 students that have expressed an interest in the fields of Computer Science or Engineering. Once eight schools have committed students, we arrange the event and liaise with the schools.

EVENT ORGANISATION

The event was organised by three full time members of the academic staff supported by two technicians and six postgraduate laboratory assistants. In order to ensure the smooth running of the event two induction sessions were held for this grouping. At the first of these, those new to the event were introduced to the laboratory environment and required to familiarise themselves with the tasks that the students would undertake. The second induction session involved the whole group and focussed on the general organisation of the event including the methods to be used to support the students within the laboratory environment. The potential risk of students disengaging from the set tasks was highlighted and the authors described their previous experiences in this regard [6]. Preventative approaches and stratagems were formulated and specific roles assigned to key individuals. Finally, as the students taking part in the event were all legally minors, the key child protection and legal requirements were summarised.

Immediately prior to the event the students were organised into their event teams of four. All students in a team must be from different schools, and no team can contain a lone male or female student.

The event was run over three full days, starting at 10am and finishing at 4pm each day. A 30 minute induction session was held on the first morning. At this session students were introduced to the staff members involved in running the event. They were then provided with an event timetable, location details and information on the procedures to be followed in the event of an emergency. As part of the latter they received a brief talk on safety and hazard awareness in a laboratory environment. Finally the students were given detailed information on the tasks they would engage in, what was expected from them and the intended learning outcomes.

Each day started with an introductory session where the plan for the day was presented together with any other organisational or administrative items. The students were then brought to the lab where they joined their pre-assigned groups and started work with their Lego MindStorms kits.

At 12.30pm each day, prior to the serving of lunch, the students received a short presentation from representatives of leading Irish technology companies. Google, Microsoft and Havok were amongst the companies that participated in the 2005 event. The company representatives receive a prior briefing as to the suggested length, nature and tenor of the proposed presentation, in tandem with a request for a dynamic and engaging speaker. The talks provided a challenging, but inspirational, snapshot of working life with some of Ireland's largest and most dynamic technology employers and helped counter some of the negative perceptions of the Computer Scientist = Programmer stereotype.

Over lunch, the event staff and students mixed sociably before the second laboratory session began at 1.45pm. At 3.30pm the students again returned to the seminar room where they received their second talk of the day from an industry representative, prior to departing at 4.00pm

All students also undertook the Mobile Communications task. Each group spent one of the scheduled laboratory

sessions exploring the university campus and learning about Mobile Communications networks and positioning technologies. For safety and supervision reasons a maximum of two accompanied groups engaged in the mobile communications task at any time.

On the afternoon of the last day, a Lego sumo basho took place - a wrestling/pushing contest between two or more robots in a ring, or dohyo. The objective of the challenge was to push the opposing robots out of the ring, or otherwise disable them. Robots were categorised as lightweight or heavyweight, with each robot competing against others in its division. The emphasis was on fun and spirited competition, with marks for style, technique and destructiveness – as well as victory. The event concluded with a final session where students were given a brief overview of the degree programs offered by the department and encouraged to consider one of these as a possible career choice. A survey was also administered to gather feedback and aid us in the execution of future events.

TASK DESCRIPTIONS

The tasks are designed to encourage students to learn how to develop and function as a coherent, effective team – cooperating with others to attain mutually beneficial goals. Each task encompasses a variety of challenges. The teams must analyse the task in hand, decompose it into subtasks and assign responsibility for these to specific team members. Time and project management issues impinge on this process. For example, in the main task it is not possible to test a program for the Lego robot if the robot is not already assembled. Similarly, it is not possible to produce code for the robot if a team strategy for competing in the basho has not been formulated. The team's programmers must contend with the restrictions imposed by both the Lego kits and by the programming tools available. Similarly, the team's builders cannot build or construct their robot without knowing the number, and type, of sensors the programmers expect. For the subsidiary mobile communications location task all team members must understand what they are going to do, the hardware required to achieve this, and how to meaningfully interpret the data collected.

The students are explicitly told about the skills they should be developing at the introductory session. During the event the laboratory demonstrators not only provide feedback and assistance, they also encourage the groups to work as a team and engage in the critical analysis of their robot design. The students are constantly encouraged to talk to each other about how their group is operating and at the end of each day are asked to reflect on what they have learnt about working with others in a multidisciplinary team.

I. Lego MindStorms Project

When they first enter the laboratory the students assemble in their predetermined teams of four. They are then set the task of designing, constructing and programming a sumo-wrestling robot using Lego MindStorms technology. Each team will be evaluated on both the quality of the robot they produce, their performance as a team, and the design of their robot.

Lego MindStorms differs from "traditional" Lego by using a microcontroller (small computer) built into a Lego brick ("RCX") to control the robot. The computer can be programmed to perform actions via external interactors, such as moving forward, turning or changing speed, and respond to sensor inputs, such as bumping into another robot or crossing a line on the ground.

Computer programs to control the RCX are created using a standard PC and downloaded to the RCX memory. As most students have little or no programming experience they initially use a graphical "drag-and-drop" interface to quickly start creating sophisticated programs. Students with previous programming experience are encouraged to control their robots using programming languages such as C or Java. One of the stated aims of the event is to address and counter the negative perceptions of computing that incoming students may have. One such perception is that programming is difficult, tedious and largely static. The Lego MindStorms environment ensures that students discover that programming and technology can be straightforward and fun – as well as providing the capabilities to interact with and influence the world around us.

Each team must overcome a number of practical constraints in designing and programming their robot. For example, the RCX can only react to a limited number of sensory inputs and can only control the robot using a limited number of outputs. Students must factor these "real-world" limitations into all aspects of their design and construction, forcing each team to prioritise certain tasks and behaviours to ensure successful completion of the project.

To emphasise the "fun" element of the task, the authors elected to introduce an additional, novelty-based competition category. Known by the students as the "Pimp my Pusher" category, this seeks to recognize, and reward, the most creative, but pointless, extensions to a team's Lego basho robot. The "add-ons" should neither contribute to, nor interfere with, the robots functionality. This category encourages all team members to contribute towards the construction of the robot - regardless of their individual or collective attitudes towards the task.

II. Mobile Communications Project

The event team considered it extremely important that the students gained not only an appreciation of both the breadth and ubiquitous nature of the discipline of Computer Science, but also that they considered the social, ethical and moral consequences of new and emergent technologies. Therefore, a secondary task was created to address this need. This task was firmly anchored in the mobile cellular telephony and ubiquitous computing arena. The authors, and their Department, have a strong background in research and teaching in these areas and sought to leverage their experience in these fields. A further incentive was the high level of cellular phone penetration in Ireland, and the rather invidious

attitude of the Irish Government towards the privacy of personal digital data and records [7].

The subsidiary task goals and outcomes were defined as:

- Highlight the dependence of virtually all modern technologies and disciplines on Computer Science and Engineering.
- Emphasise that innovation, adaptability and creativity are amongst the key skills required from a modern Computer Scientist;
- Instil an appreciation of the social and ethical considerations and dilemmas that can result from modern computer science innovations.

To allow us address these requirements, we created a mobile positioning/geolocation task for the students to perform. This was structured in the form of a "reverse treasure hunt". In a traditional treasure hunt, participants are provided with clues that allow them to iteratively localize their position until they find the treasure. In the reverse treasure hunt, students are taken to the target location and must take measurements, readings and observations to allow them identify their current location from amongst the complete set of "clues" for all locations visited. Thus if eight locations are to be visited, students are provided with a master list of eight sets of clues. They are then brought to each possible clue location where they take measurements and observations that allow them identify the relevant clue-set for that location on their master list.

For the purposes of the Mobile Communications task, the clue information is provided in the form of visible Cell-ID's and associated signal strengths for a number of the cellular telephony networks detectable within the College campus.

The task has three distinct segments. Initially students are given a brief talk to explain to them what the session is about, what they will be doing and the communications phenomena they will encounter. They are also told about the buildings and infrastructure they will be seeing around the Campus. Each group is then equipped with a GSM cellular telephone with Engineering mode enabled. Finally they are given the master list of clues which give the Cell ID's and signal strengths at eight unnamed locations around the campus. In Engineering mode, the cellular phone provides a list of visible network cells and their corresponding signal strengths as determined by the phone. The students are then brought on an informative, guided tour around college by academic staff members. They are given a brief history of the various sights and buildings en route. At eight separate, and distinct, locations around the College campus, the groups stop and measurements are recorded from the cellular telephones. This information comprises a list of visible Cell-ID's and associated signal strengths at the location. The students attempt to correlate this against the master list they have, and are also required to explain any discrepancies. The sites are carefully chosen to highlight a variety of mobile telecommunications phenomena – such as frequent handover, attenuation of signal strength, multipath reflection, different antenna structures, congestion etc. The academic staff provide guidance and assistance and encourage the student groups to formulate and rationalize their theories and justifications for the results they are getting. After the tour and hunt are complete, the group returns to a seminar room where they share results, findings and theories. The academic staff postulate on the uses of such location and positioning information and highlight some of the potential uses of this information. Students opine on, and debate, the pros and cons of a future world where the individual has little, if any, personal digital privacy. The whole process is intended to encourage collaborative learning and teamwork while fostering a sense of critical analysis, questioning and discrimination in the young students.

EVALUATION AND DISCUSSION

The Transition Year Event described above has been refined and enhanced since a pilot event was held in 2004. This pilot program involved students from a single school and it was found that not all of the initial student group had an aptitude for, or interest in, computer science. This led us to reduce the number of student participants from each school to just four and to focus on attracting those students most likely to consider Computer Science as a career choice.

To gauge the effectiveness of the Transition Year Event, information gathered from individual students as well as global statistical data gathered from the group was considered. Results of a student survey together with observations from the staff and postgraduate assistants form the basis of this section. The data presented relate to a sample of 66 students who took part in the event in November 2005. Quantitative data was gathered for four specific purposes:

- Obtaining background information on the students computer experience and usage
- Assessing if the objectives of the course had been achieved
- Gathering data on the number of students who are considering taking a technology based degree programme.
- Ensuring the laboratory environment, staff and postgraduate assistants were effectively contributing to the success of the event.

Qualitative feedback was also obtained from the questionnaire. This addressed issues such as:

- State three things you liked/enjoyed over the past few days
- State three thing you disliked/did not enjoy over the past few days
- What do you think could be added to improve the event?
- Are there any other comments you wish to make on your experiences over the past three days?

Figure 1 graphically depicts the students' perceptions of their prior experience of computers. It can be seen that most students rate themselves as experienced or very experienced with Computer Games, Word Processing and the Internet. Disappointingly, but unsurprisingly, most students have had

very little exposure to Computer Programming Languages and Computer Graphics.

More positively the qualitative data collected shows that while the students have had very little exposure to computer programming, many are quite eager to learn. Unprompted, over 16% of the students recommended that the event include more programming languages (Many of these asked for Java and C++ specifically). Others expressed an interest in learning how to write games programs.

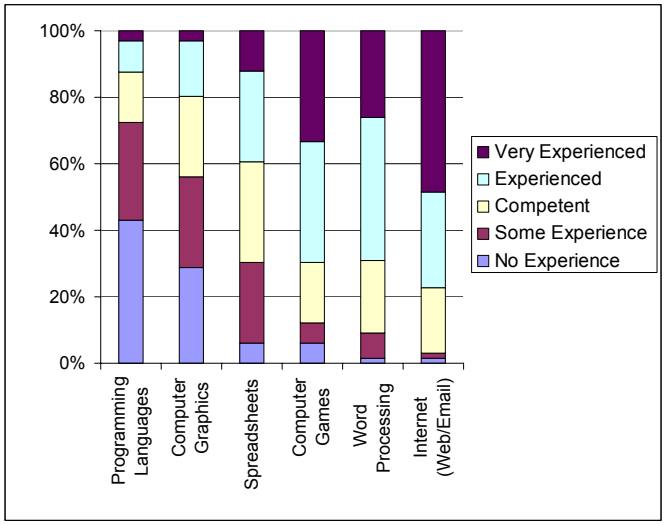

FIGURE 1
A SUMMARY OF THE STUDENTS PRIOR EXPERIENCE

With the goal of assessing the effectiveness of the event, a series of questions were asked to see how well the objectives were achieved. These are presented in Figure 2. It can be seen that at least 60% of the students agreed or strongly agreed that all of the objectives had been achieved, with 86% expressing themselves as confident in their ability to program the Lego.

We were pleased to find that 58% of the students expressed the intention of pursing their undergraduate studies at Trinity College, with 20 students from the group of 66 saying they were strongly considering majoring in CS.

Qualitative feedback from individual students included the following comments:

- "I enjoyed working with the other students and the college grads."
- "I made loads of new friends, it was great"
- "It was great fun but it should be longer."
- "Learning how to build and program was really good fun"
- "We didn't really cover any true aspects of programming"
- "The industry talks, especially Google and Havok were brilliant"
- "Some of the lectures pretty boring (1 boring, rest OK)"

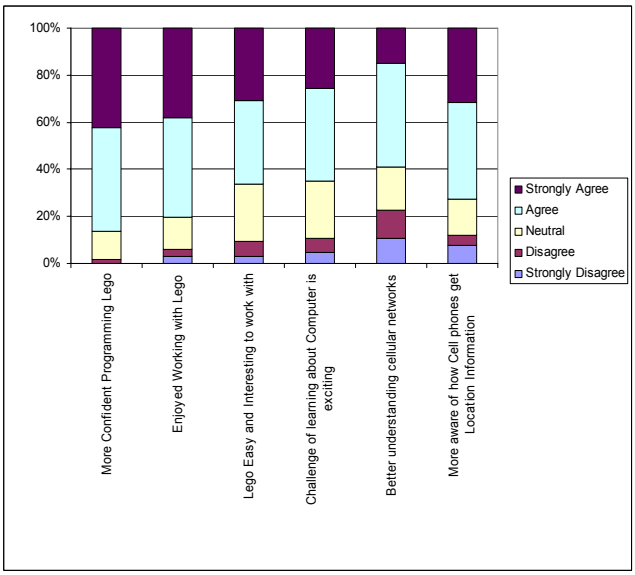

FIGURE 2
A SUMMARY OF THE QUANTITATIVE EVALUATION DATA

All the student participants had at least one personal cellular telephone and were extremely interested to learn more about their operation. Equally all were unsettled by the potential uses of, and opportunities for exploitation off, data arising from routine mobile telephony activities.

While the organisers made a considerable effort to encourage schools to send potential CS majors to participate in the event, some schools sent their brightest and best students instead. These students engaged fully with the event but remained unchanged in their desire to study perceived prestige subjects such as medicine or law.

The academic staff, technicians and postgraduate assistants involved all found the event to be an enjoyable but extremely demanding experience in terms of both energy and time required. It is not clear how the workload involved could be significantly reduced without compromising the quality of the learning environment created through the use of intensive small group activities.

CONCLUSION

This paper provides a detailed description of the organisation, setup, delivery and outcomes of a recruitment event targeted at Transition year (grade 10 equivalent) students. We show that by adopting a highly focussed strategic selection methodology a strong positive impact can be made on the target constituency. As part of the event the students are confronted with some of the technical and ethical implications of emerging ubiquitous communication technologies.

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