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In at the Deep End: An Activity-Led Introduction to First Year Creative Computing

E.F. Anderson and C.E. Peters and J. Halloran and P. Every and J. Shuttleworth and F. Liarokapis and R. Lane and M. Richards

Interactive Worlds ARG, Coventry University, UK

Abstract

Misconceptions about the nature of the computing disciplines pose a serious problem to university faculties that offer computing degrees, as students enrolling on their programmes may come to realise that their expectations are not met by reality. This frequently results in the students' early disengagement from the subject of their degrees which in turn can lead to excessive 'wastage', i.e. reduced retention. In this paper we report on our academic group's attempts within creative computing degrees at a UK university to counter these problems through the introduction of a six week long project that newly enrolled students embark on at the very beginning of their studies. This group project provides a breadth-first, activity-led introduction to their chosen academic discipline, aiming to increase student engagement while providing a stimulating learning experience with the overall goal to increase retention. We present the methods and results of two iterations of these projects in the 2009/2010 and 2010/2011 academic years, and conclude that the approach worked well for these cohorts, with students expressing increased interest in their chosen discipline, in addition to noticeable improvements in retention following the first year of the students' studies.

Categories and Subject Descriptors (according to ACM CCS): K.3.2 [Computers and Education]: Computer and Information Science Education—Computer science education

1. Introduction

When applying for a university degree in computing the computing disciplines [Ass06], relatively few potential students have a fully accurate conception of what their chosen degree may entail. Many may believe computing or computer science to be an extension of the use of office suites that they are familiar with from ICT (information and communication technologies) courses at school, confusing the degree programmes with basic computer literacy [BM05]. This problem appears to be exacerbated by current teaching practices in schools [Roy10]. In other words, school or college learners may not be aware of the differences between ICT, based on the use of computing technology, and Computer Science with its emphasis on problem solving and the production of solutions which often involve programming. As a result, many students are disappointed when they enrol at university and, to their dismay, discover their mistake. This is reflected in the observable decline of retention in computing programmes, and to remedy this, it has been suggested to modify degrees to become "more fun" and to offer "multidisciplinary and cross-disciplinary programs" [Car06] that will keep students interested in the subject. Unfortunately, retention problems are not restricted to traditional computing courses, but also extend to some of the multidisciplinary and cross-disciplinary degree programmes, such as creative computing degrees. In these, there is the potential to find a completely new set of misconceptions, where potential students confuse programmes such as multimedia computing, for example, with more vocational training courses for content creation software packages or web design. These applicants often demonstrate very strong expectations that their courses will predominantly feature artistic and creative content production topics, usually at the expense of more low-level technical topics such as mathematics, computer architectures or programming. Furthermore, the complexity of undergraduate computing degree programmes tends to be greatly underestimated. Once students become aware of this,

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they often disengage from the subject matter, often resulting in assessment failure or in the worst cases, withdrawal from their degree programmes. Consequently, retaining computing students remains a serious problem, one possible solution for which is to deepen the student's engagement with the subject.

Following the adoption of a new pedagogic model by the Faculty of Engineering and Computing (EC), Coventry University (UK), the solution of the Creative Computing subject group to address this problem has been the development of an integrative, interdisciplinary learning experience, providing new students with a breadth-first introduction to their chosen academic discipline. Newly enrolled students embark on a subject-spanning group project dubbed the "Six Week Challenge" (see http://vimeo.com/neophyte/pressplay), that encompasses the first six weeks of their first year at university, replacing the regular teaching schedule and combining various aspects of the courses that make up the first year of the creative computing degree programmes. This project, which is not formally assessed, aspires to confront students with a challenging and ambitious task requiring them to take on a proactive role in problem-solving and to use their own initiative if they want their 'product' to succeed. They are encouraged to "learn by doing", assuming responsibility for their student experience in the process, aiming to engage them closely with the subject matter of their degree programme while improving cohort cohesion, engagement and retention.

In this paper, we first present (see Section 2) the background details of Activity-Led Learning, which has been adopted as the educational methodology in the six week group project. In Section 3, we describe how the group project engages students with activities integrating software and hardware development with usability evaluation, viral marketing techniques and academic writing. We present the results of an evaluation of the methods, based on student surveys, in Section 4 and discuss implications of the results as well as insights gained and issues for further consideration in Section 5, with concluding remarks in Section 6.

2. Activity-Led Learning (ALL)

One of the goals of higher education is to prepare students for life by enabling them to become independent learners. Independent learning does not come easy to students who have adapted to being passive participants in the learning process, where they are presented with all of the required learning material, a learning style that many of them acquired during their secondary education. The students of this "Plug&Play Generation" [AM06, AM07] are sometimes described as suffering from shorter attention spans and impatience with the expectation to achieve quick and effortless results. However, "active involvement in learning helps the student to develop the skills of self-learning while at the same time contributing to a deeper, longer lasting knowledge of the theoretical material" [MK02]. This is a key reason why our faculty has adopted Activity-Led Learning (ALL) [WM08, IJP*08, PJB*10], a student-centred approach that has its roots in problem-based learning (PBL) [SBM04]. PBL is a constructivist instructional method [SD95] that provides a "complex mixture of a general teaching philosophy, learning objectives and goals" [VB93].

2.1. Advantages

The problems that students are required to solve in PBL are usually much broader and more extensive than the relatively small, self-contained and well-defined exercises used in more traditional teaching sequences [BFG*00]. Furthermore, in PBL and similar approaches, such as ALL, educators take on the role of facilitator, guiding the students' learning and monitoring their progress [HS04], which some studies on the subject have concluded may be superior in some aspects over more traditional methods [VB93]. Such activity based educational approaches are supposed to work especially well in group projects, as they take advantage of group members' distributed expertise by allowing the whole group to tackle problems that would normally be too difficult for individuals [HS04], including other students in mutually supporting roles, as well as tutors and faculty [AM93].

PBL has gained some acceptance as an effective approach within a variety of disciplines in higher education environments [YG96, Fel96, BFG*00]. This may be attributed to it providing an environment where the student is immersed, receiving guidance and support from fellow students and where the learning process is functional [Per92].

ALL and PBL not only lend themselves to the teaching of computing [BFG*00] and computer graphics [MGJ06], but the use of computer graphics itself offers the possibility of defining interesting problem-based learning scenarios while also enabling collaborative or mediated learning activities that could lead to better learning [Tud92]. Learning occurs through multiple interactions within the learning environment [SD95, Cam96] and thus a potential added benefit of using computer graphics in combination with PBL scenarios is that learners engage with these using different senses, helping them to fully immerse in the learning situation [Csi90] which could be expected to result in learning gains [CGSG04].

2.2. Pitfalls

This type of student-centred education is not without problems, however. It has been criticised due to the amount of guidance given to students [KSC06], relying on the use of 'scaffolding', i.e. close guidance of the learner's discovery, which some consider a simple improvement of a fundamentally ineffective approach [SKC07]. Finding an adequate balance for the amount of guidance given to students is one of the challenges of this type of educational approach [BBA09], as students might become too dependent on the provision of guidance, defeating one of the main aims of this type of approach, i.e. to create independent problem solvers. It has been suggested that one precondition for the success of activity centred instruction is that participants need to already be highly motivated, well educated and possessing some degree of base competency in the subject area before engaging in activities [Mer07] and that the success of PBL approaches may depend upon the ability of students to work together to identify and analyse problems and to generate solutions [Cam96].

The use of scaffolding is not universally seen as a negative, and it has been suggested that the idea of PBL implies a "minimally guided" form of education is wrong [HSDC07]. Our experience has been that to be useful it is far from minimally guided, but also that this does not imply that the students are encouraged to become dependent on constant guidance from staff. The staff time requirements, however, are significant in comparison to traditional teaching.

2.3. Creative Computing in Coventry University

The Creative Computing subject group of Coventry University's EC faculty delivers degree courses which aim to produce graduates and computing professionals capable of working in environments where art and technology meet. Our courses have a strong Computer Science core, balanced with studies in design theory, game development, programming, graphics and content creation, pervasive and sensing technologies, usability and video and sound production. The teaching team strives to develop a strong interdisciplinary environment integrating content from these distinct domains.

Computing curriculum recommendations state that "the breadth of the discipline should be taught early in the curriculum" [Tuc96]. This is realised in a breadth-first computing curriculum, where students are exposed to the computing domain through a broad introduction to the major areas of Computer Science [VW00], allowing them to gain a more comprehensive understanding and appreciation of the discipline. They are able to gain "a holistic view of a topic before they learn about more complicated details" [DG06] that empowers them. Important concepts are touched upon early on to provide students with the basis for a much larger range of activities than would be possible in more traditional/conservative teaching sequences. This is because students experience the tasks that they embark upon in the wider context of the computing discipline, rather than as isolated subject matter. While to many students this may seem intimidating at first, it nevertheless tends to result in much deeper understanding.

In line with a faculty driven move towards more activity-led teaching and learning, the Creative Computing subject group has developed a six week group project. The project aims to immerse first year students in an engaging activity designed to address some of their apprehensions, while introducing, in microcosm, the entire spread of topics in the 1st year curriculum. The design of the project is described in more detail next, in Section 3.

3. A Six Week Challenge – Learning by Doing

First piloted at the start of the 2009/2010 academic year [SEA*10] (see also `http://vimeo.com/neophyte/pressplay`), the activity for our creative computing degrees, including Multimedia Computing and Games Technology pathways, integrates software and hardware development with usability evaluation, viral marketing techniques and academic writing. In its refined second iteration at the onset of the 2010/2011 academic year, the software development aspect focussed on computer graphics, resulting in the students' creation of a computer graphics application with a physical hardware interface. Our creative computing degree programmes are heavily reliant on modern multimedia concepts and technologies. "Multimedia – while embracing computer graphics – describes the foray of other disciplines into the digital realm" [Gon00] and through their projects our students not only "learn computer graphics", but also "learn through computer graphics", effectively making our students' learning experience a hybrid of both aspects of teaching computer graphics in context [CC09].

The purpose of a Six Week Challenge is to allow students to evaluate the flavour of the course they are about to embark upon, addressing a number of issues in the orientation of new students whilst promoting high levels of engagement, which aim achieve to both deep learning and increased retention. Next we describe the our rationale for finding a suitable challenge (see Section 3.1) and the details related to running one (see Section 3.2).

3.1. Finding a Suitable Challenge

To meet our goal of engaging the students with the creative computing discipline we had to face our own challenge of finding a suitable set of integrative activities for students. In the development of such activities it is important that they are meaningful to the student [Cun99], and appropriate for the intended student group, which in our case are absolute beginners embarking on their first steps in higher education. The activities designed for the six week group project would have to be related to the degree programmes of the students, complex enough to appear challenging, yet achievable within the set time-frame. At the same time the problem that "students ... expect to see immediate (and spectacular) results, often before they have learned enough to achieve anything remotely spectacular" [AM07] needs to be addressed by enabling the students to achieve results that appear 'spectacular'. We first delivered a Six Week Challenge in the 2009/2010 academic year, and did so again in the

Week	Theme	Section
1	2D graphics programming	3.2.1
2	3D graphics programming	3.2.1
3	hardware design & interfacing	3.2.2
4	usability evaluation	3.2.3
5	viral marketing	3.2.4.1
6	academic communication & reporting	3.2.4.2

Table 1: *A Six Week Challenge consists of six sub-challenges, or themes. Each theme adds a new element to the overall project and can be completed by students within a week.*

2010/2011 academic year. The student cohorts, staff numbers and tasks set for both years were as follows:

- The 2009/2010 cohort consisted of 56 students, with 6 faculty members and one graduate intern involved, of whom only 4 faculty members were actively delivering content. Students were tasked with developing a hardware controlled media player (see [SEA*10] for more details).
- The 2010/2011 cohort consisted of 54 students supported by 6 faculty and 2 teaching assistants. The students were tasked with the development of a graphics application based on the popular *Etch A Sketch*® drawing toy by the Ohio Art Company (http://www.etch-a-sketch.com), the computer implementation of which would not only involve graphics, but would also provide an interesting exercise in user interface design and evaluation [Bux86]. To provide students with an additional challenge, we extended the basic concept of a 2D drawing toy to the third dimension: a 3D etch-a-sketch-like graphics application with turnable knobs as inputs for drawing on the three axes.

In the 2009/2010 and 2010/2011 challenges, *Processing* [RF06] (http://www.processing.org) was chosen as the development environment for the task. This is a Java-derivative language for computer arts creation, which lends itself well to introductory programming and computer graphics education [PBTF09] and also interfaces with the Arduino micro-controller [Sto09] (http://www.arduino.cc/) that we chose for the development of the hardware interface. The Arduino is an Open Hardware design that has been successfully employed as an educational tool [FW10], which allows the easy creation of input devices for computers. The kits we used were ideal for our purposes as they did not require any soldering, allowing the hardware to be simply slotted together.

Our careful selection and presentation of topics was aimed to provide students with the opportunity to quickly evaluate the flavour of the course they were about to embark upon, addressing a number of issues in the orientation of new students and attempting to promote high levels of engagement, deep learning and increased retention.

3.2. Running the Challenge

Since the Six Week Challenge is a group project, the 2010/2011 cohort of 54 students was split up into groups of 6 to 7 students. For the duration of the project normal delivery of teaching was suspended entirely whilst the teaching team worked collaboratively with the student groups to develop their products.

The task of creating the 3D etch-a-sketch-like graphics application with a dedicated hardware interface was broken down into six sub-challenges, or themes (see Table 1), that each added new elements to the overall project and that each could be completed within one week, including:

- graphics programming and software control, consisting of 2D and 3D graphics programming in the Processing language and the mapping of manipulation functions to keyboard controls (see Section 3.2.1).
- hardware interface, concerning the construction of a hardware interface with the Arduino micro-controller for the 3D etch-a-sketch-like application (see Section 3.2.2).
- usability evaluation, to consider usability aspects of the controller – this gives the students their first experience of what it means for software to not just be correct, but be accepted by users, a topic that is particularly important on the degrees for which this programme was developed (see Section 3.2.3).
- dissemination (see Section 3.2.4), consisting of a viral marketing campaign (see Section 3.2.4.1) and academic communication (see Section 3.2.4.2).

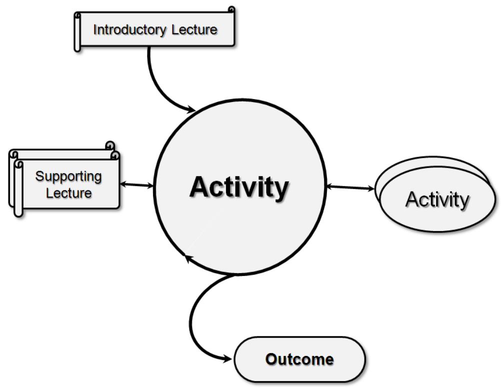

Figure 1: *The Activity-Led Instruction cycle. The main* activity *is introduced through an introductory lecture to subject-specific aspects of the students' task, which they then solve independently; this may lead to further* activites *and additional lectures that are based on students' needs/demands.*

We employed an activity-led instruction cycle [AP09] (see Figure 1) in which students were first, in a Monday morning briefing at the start of each week, introduced to the sub-challenges. Important subject related information was covered in a short introductory lecture, followed by a variety of guided learning activities that focussed on the challenge for the week which the students participated in. The students were then left to work out how to solve each of the sub-challenges, being allowed to organise their remaining time as they saw fit. Teaching staff were available throughout the week to provide encouragement and additional guidance when requested and, depending on the student groups' progress, to run additional sessions to cover subject areas that the students discovered while working on their projects, with these support sessions timetabled from Tuesday to Thursday.

A special 'show and tell' session consisting of a gathering of all of the students and lecturers involved in the project was organised for the end of every week (see Section 3.2.4.3). This provided an opportunity for students to demonstrate their work to the whole cohort, as well as to members of the faculty.

Overall, this mode of delivery allows students to actively influence the direction of their learning, as they are given some level of control of the delivery of subject-specific information, i.e. while students receive an introductory lecture to subject-specific aspects in support of their activities, any additional teaching sessions (lectures and/or tutorials) are dependent on the students' needs and/or demands.

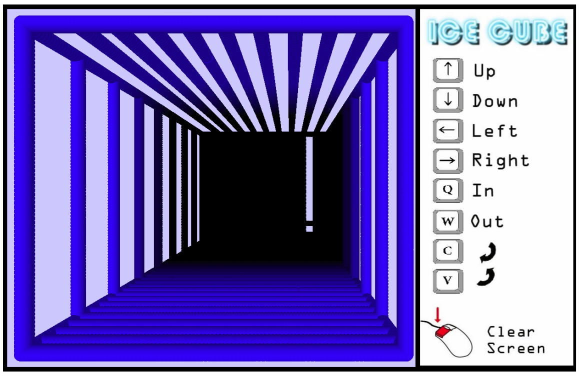

Figure 2: *One of the student-created 3D drawing applications. Keyboard controls allow the turtle to be moved in three dimensions and enable the screen to be cleared.*

3.2.1. Graphics Programming and Software Control

The first set of tasks for the student groups concentrated on the development of the graphics application. This required for each team to develop, using the 'new to them' Processing language, know-how in the creation of the graphical elements required to create the etch-a-sketch-like application. It consisted of:

- Implementation of the drawing environment itself, commencing with the drawing of simple 2D points, and progressing to lines, squares and more complicated 2D shapes. A primary goal here was the understanding of how objects could be created for display on the screen, particularly their specification using vertices, edges and faces. Some experimentation took place with simple 3D objects.
- Placing newly-created objects within the drawing environment in 2D and 3D. Developing an understanding of basic affine transformations in 2D and 3D (i.e. translation, scaling and rotation). In many cases, this led to animation attempts that required an exploration of aspects related to the composition and redisplay of scenes, such as single- and double-buffering.
- Definition of a changeable camera/view. The need for knowledge about the camera naturally arose from incidents where objects unexpectedly disappeared from view for some groups, either due to being placed outside of the viewing area of the window or outside of a poorly-defined view frustum during 3D experimentation. Some groups also wished to be able to move the camera around in a manner similar to popular first person shooter games, motivating them to learn more about camera parameters.
- User interaction, to allow the program to process input from the keyboard and mouse. This involved a basic understanding of event handling and the event processing loop and was initially based on predefined keyboard input (i.e. controls that allow a user to limit movement to X, Y and Z), while students grasped the relation between the event loop, user input processing and scene redisplay for animation. Basic mouse control was also introduced.
- An appropriate graphical user interface design, building on topics learned during user interaction, but going somewhat further to consider the ease of use for the user and performance issues.

All of the student groups achieved at least a basic implementation of the features and demonstrated prototypes capable of drawing to the screen in 2D and 3D, and allowing the screen to be cleared subsequently. Most groups exceeded the basic requirements (see for example, Figure 2) and included diverse additional features. Many of these related to the selection of different drawing colours from a predefined palette, either by manual selection or, in some cases, automatic schemes that accounted for the drawing depth by changing some of the colour characteristics. A number of implementations also featured the use of 2D shapes as brushes with which to draw.

As students experimented with shapes and drawing in 3D, important questions arose. For example, technical issues relating to camera set-up, object and scene rotation, and 3D object positioning using transformations, all arose naturally as the task was feature-driven. Furthermore, in cases where groups redisplayed the scene each frame, they also required a means for storing and updating previously drawn lines or shapes so that a full sketch could be displayed each frame. This represented an interesting and challenging problem for the students, who investigated a number of data structures and methods to do so. In this way, students discovered for themselves the need to understand these concepts, which might otherwise have seemed obscure or unimportant.

Students were also encouraged to investigate different interaction schemes, for example, by mapping different keys onto controls and considering mouse movement. In particular, they were tasked with attempting to control the application using the minimum number of keys possible and to create novel mouse-keyboard methods for control. This added an extra challenge beyond the more obvious 1:1 mapping between keys and functions, and additionally helped raise important issues for consideration during the modelling of the physical controller (see Section 3.2.2) and in the usability evaluation (see Section 3.2.3). A number of groups succeeded in enabling more advanced interaction control by combining both the mouse and the keyboard. This proved to be very useful when the groups were subsequently asked to design user interaction tasks for usability studies.

3.2.2. Hardware Interface

Once the basic graphics application was developed, teams were asked to integrate their application with a dedicated hardware interface and then to evaluate the hardware prototypes. For the hardware task, students used the Arduino prototyping platform, which allows users to quickly construct devices ranging from simple flashing lights to autonomous spy-planes and hand-held consoles. Online resources were provided to the student groups, including eBooks and hardware tutorials. In addition, students were given instructions on how to create a blinking LED device using resistors and potentiometers. Resistors were used to protect the circuit and the potentiometer to control the speed of a LED 'Scanning Light' effect. At the end of the task, all of the groups had created circuit diagrams for their etch-a-sketch-like applications and many students created solutions with three potentiometers for controlling the drawing, similar to the Digital Airbrush by Batagelj et al. [BMTM09]. Some of the most important keyboard functions that were assigned to hardware buttons included: change of colour, drawing speed change, background colour change, clearing the screen, restoring the screen, precision mode, camera movement, zoom in/out, and the provision of a help screen. Some groups also decided to provide a combination of two or more button pushes to perform a particular action, solving the problem of having too many key assigned features.

3.2.3. Usability Evaluation

The usability component of the Six Week Challenge involved students in designing a simple usability study focussing on one or two key tasks for their etch-a-sketch, running the study on four or five users, collecting data, and analysing it to develop an informed view on whether the interface to their graphics application was usable in terms of the tasks tested.

A classic, central approach in usability is 'lab-based' studies in which the setting, tasks, and measurements in a usability study are all pre-defined by the researcher and kept uniform across different users to allow comparability of results. This approach is what was experienced by students during the Six Week Challenge.

In designing their usability tests, groups were first instructed to define the core tasks required of users by the etch-a-sketch. To do this, it was suggested a simple task analysis was created, showing the steps and any substeps required to complete the task. This required students to think about scoping: what should the realistic limits of the tested task be? How long should it take? What should count as its beginning and end, and what is the necessary sequence of actions?

Following this, students turned to metrics: what aspects of the users' performances could and should be counted? This relates to a quantitative approach to data, where numbers are the basis for claims about usability. Students made sensible suggestions: for example, number of errors made, and time taken overall. This naturally led into the need for 'baseline' measures, i.e. benchmark performances with which to compare user performance, and how these should be established.

After addressing this issue, students were asked to prepare observational instruments (paper forms) they would use to record data, and to explain to tutors in advance how they would carry out data analysis, which led into consideration of individual and mean scores, variance, and representation, for example by bar charts. Crucially, students needed to be able to explain how they would make usability claims on the basis of their data. Most groups realised that the numerical scores they got from users needed to approach or equal baselines. In that case, it could be claimed that, in terms of tasks tested, their design was usable. Conversely, students were asked to consider what they could say about design revision if the numbers were further away from baselines, i.e. it was more difficult to claim usability. This issue links usability studies to technology design and is crucial to start negotiating early on in the study of human-computer interaction.

These methods and techniques, although elementary, are crucial to usability studies, but can be hard to teach. The most difficult issue is that students, while they may be able to perform aspects the practical work, are frequently not so clear on how to design it or why they are doing it in the first place. In the context of ALL, one goal of the usability week was to start to inculcate a scientific approach, where claims about usability are evidence-based, and the process is explicit, repeatable, and replicable. This was eased by the fact that the groups had a vested interest in showing the usability of their designs. This helped leverage understanding of these principles: in other words, it was important for groups to show that their claims were not just their own subjective opinion, but evidence-based according to scientific practice, in such a way that they would gain credibility. This is a crucial hurdle for students to clear, and the motivation provided by the Six Week Challenge undoubtedly helped (although developing a scientific attitude is not immediate). That there was general appreciation of this was clear from the end-of-week group-to-peer presentations (see Section 3.2.4.3) made at the end of the usability week.

Having developed their usability tests, students had to run them. This means engaging with users in systematic ways. In particular, instructions needed to be developed and kept consistent across users. Students had to learn not to interrupt or make hints to users, and crucially to keep their own behaviour discreet and uniform across users to control for any researcher effect. This resulted in tests being run in ways that began to approach professional practice. Many students worked out that in addition to the metrics they were using, they could add in other qualitative observational data, for example questions users asked, things they said, facial expressions they made, and so on. This spontaneous activity was the beginning of the important process of gathering both quantitative and qualitative data and looking for the complementarities between these, particularly how qualitative data can help explain numbers: for example, where time was slow, did the user ask a lot of questions? If so, this might indicate confusion, which helps explain slow times.

The main difficulties in teaching usability are usually that it is highly conceptual and often abstract. Typically it is taught by asking students to run studies on interfaces they may not have a personal interest in. The Six Week Challenge meant that students had a strong motivation to show their designs were usable. Personal investment in the work helped leverage engagement in many issues which can be a challenge to teach, in particular the forming of a research question for a usability study, the collection and analysis of different types of data, realistic and relevant scoping of user tasks, and the correct setting up and running of user sessions. The embedding of advanced usability material within the Six Week Challenge increased its accessibility: there was impressive work within a short period. Our activity-led approach in general can be claimed to ease the transition from pre-degree to degree education, particularly helping to ameliorate the feelings of dismay and difficulty we identified in the introduction (see Section 1).

3.2.4. Dissemination

An important further aim beyond developing students' technical abilities and team work was to develop their awareness of the importance of dissemination and how dissemination should be tailored to both target audience and goal. Students disseminated their work both internally and externally through group demonstrations, a viral marketing campaign and academic communication methods. The aims of dissemination were to inform the work of other groups, to provide them with the experience of presenting work to different external target-groups, highlighting the necessity of differing dissemination methods based on the target audience (e.g. academics, consumers), and to think about ways in which quantitative and qualitative feedback could be collected. In addition to internal demonstration, students also had to disseminate their work externally in two contrasting ways: through a viral marketing campaign (see Section 3.2.4.1) and in the form of an academic manuscript (see Section 3.2.4.2).

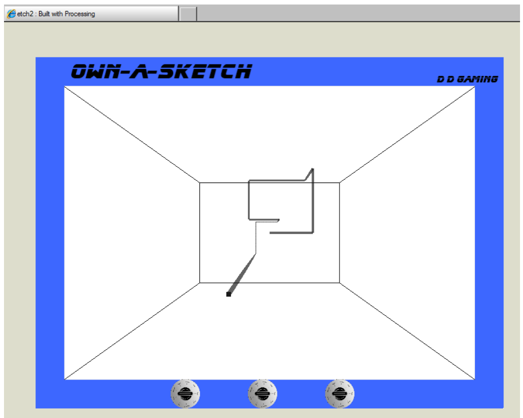

Figure 3: *Example of a student group's graphics application embedded in their website. Control knobs on the interface allow the user to create a sketch interactively in three dimensions.*

3.2.4.1. Viral Marketing Campaign This challenge involved student groups generating publicity for their products by creating web-pages for presenting their programs and gathering usage statistics, as well as an online viral advert linked to their product to tempt back a set minimum number of users to their groups' product homepages. The stipulation of numbers was an important inclusion as students would need to solve the problem of digital verification and customer tracking. A suggested operational strategy for the week was to upload their source code to an open source repository, upload their executable to an online storage site or a hosted product website. Students were encouraged to create a video or other promotional device and to disseminate this through social networks. For visitor tracking we demonstrated the use of Google analytics software [Cli10] and tracking code.

This task allows the students to work in media that most of them are familiar with already: blogs, on-line videos, social networking sites and so on. Rather than simply allow them to demonstrate their familiarity and facility with these media, however, the marketing task asks them to think more critically about what they can achieve through them, how they might be applied in their studies or careers and ensures at least a basic level of skill in the minority of students who, before coming to university, have not had any experience in this area. The students, who we might describe as "digital natives" [Pre01], do not always have a great deal of skill in transferring their skills [KJCG08] or realising how they might be of use in their studies or careers. The goal of this media week component of the challenge was to get the students to think about the context under which their future productive activities may take place, and how to shape products and messages for a particular audience. Whilst presented in a light-hearted fashion, the media week provided opportunities for discussions about the nature of digital goods, ethics and piracy, copyright, open source and creative commons solutions to intellectual property rights problems.

We found that many students published their work by placing interactive demonstrations of their graphics applications on their web-pages (see Figure 3) and loading prerecorded videos on YouTube [BG09]. The Processing system provided the necessary facilities for allowing students to do this themselves, as it allows interactive graphics programs to be embedded in websites. Most of the student groups successfully completed the website integration of their applications and interfaces, while some groups chose to provide downloadable executables of their applications instead. Unsurprisingly, very few of the students exhibited any difficulty with the technical components of the week's challenge: Producing simple web pages, embedding JavaScript tracking code, uploading video content and accessing analytic data. The students performed particularly well during this week, being able to share their existing knowledge of how to resource web activity for free and they welcomed the opportunity to proudly demonstrate their achievements to their friends on social networking sites. The graphical nature of the work seemed particularly amenable to such sites, as a means for attracting interest from peers and potential employers, and also serving as a starting point for the creation of a graphics programming portfolio. In fact, in hind-sight, we probably set the 'number of viewers' stipulation too low, as between them each group could possess over one thousand contacts on social networking sites. The more interesting learning outcomes of the week occurred in the conversations that the tasks entailed. Some students worried about how to protect their products from piracy (even though they were free) and then had to consider this in light of the fact that the tools with which they had made them were free also. Students were encouraged to read about copyright and creative commons solutions to the problem of intellectual property. Similarly, the mechanics of viral marketing were a topic for discussion during the week, leading students to examine what makes an individual share a link with their friends on the internet and which content was most likely to trigger exponential sharing. This also helped raise an awareness that the dissemination method must account for the target audience, which may also include potential employers.

This week's activities also served to raise the question of feedback, by looking at ways in which qualitative and quantitative data could be collected. This involved accounting for simple metrics, such as tracking the number and types of comments and views that their work attracted. The issue of feedback is sometimes underestimated from the students' point of view. Graphics work published on the web may be a very useful way for attracting comments from more skilled graphics practitioners from around the world, as a way for students to obtain broader formative feedback on their portfolio work from a diverse audience.

At the end of the week presentation all of the groups had met their viewing targets, a few were able to share customer's comments' and one group had even 'monetized' their website and were deriving an income stream.

3.2.4.2. Academic Communication The academic writing and research component deals directly with the process of critically evaluating students' own work and the work of others, reading academic texts, synthesising arguments and presenting information; skills that will be used and developed throughout any degree course, yet are not necessarily obviously critical to students beginning a technical degree.

The task involved preparing a short paper (3-4 pages of collaborative academic writing) providing background information to their projects and stressing the relevance of this research to their product. Each student group was presented with a different research question. Many of these were related to the graphics techniques they used and that they were tasked with describing in their short papers. For this the groups had to:

- engage with a number of academic texts, providing them with a basic understanding of academic writing (language and style), some of which [LR88, Lar09], originating from the computer graphics community, were provided to them;
- adopt appropriate strategies for finding and evaluating relevant textual sources [Gri09], including the use of citation databases;
- learn to organise information in a logical manner, suitable for presentation in written form, as well as for oral presentation [Ger04].

The introductory lecture for the academic communication week provided students with an overview of academic writing, i.e. the academic writing style and the structure of academic texts, which students were exposed to in a light-hearted manner [Sch96], as well as considerations of good academic conduct, including issues of proper citing of sources. Students were then introduced to literature search strategies, as well as the LaTeX document preparation system [Lam86] to ease them into the practice of preparing consistently formatted documents. Students were then directed towards the compilation of a comprehensive reading list of academic articles that appeared relevant to their set research questions, providing the basis for their short review/survey paper. Throughout this activity, students were repeatedly briefed on the principles of academic honesty to prevent problems like plagiarism.

The resulting short papers showed an unexpected level of

Improvement	SD(%)	D(%)	N(%)	A(%)	SA(%)
Problem solving	0	5	17	71	7
Team-working	0	7	8	46	39
Communication	0	0	15	56	29
Time-management	0	7	27	29	37
Self confidence	0	2	34	49	15
Analytical & critical abilities	0	2	35	56	7

Table 2: *Student responses to the prompt "Taking part in the six week activity has helped improve my ...". Results are based on the responses of 56 students from the 2009/2010 cohort and displayed as percentages, where SD = Strongly Disagree, D = Disagree, N = Neutral. A = Agree, SA = Strongly Agree.*

maturity, rarely seen in students in their first year at university. The students also developed a much greater appreciation for the academic writing style, contrasting it to the much more informal communication forms they were familiar with before (see Section 3.2.4.1).

3.2.4.3. Group Demonstrations Over the course of the Six Week Challenge, a special 'show and tell' session consisting of a gathering of all of the students and lecturers involved in the project was organised for the end of every week, so that students could demonstrate the week's results to the other groups of their cohort, as well as to members of the faculty. This was primarily a student-driven activity: while lecturers had the opportunity to provide feedback on the work of the students, the student demonstration sessions focused on students commenting on the work of others. Most importantly, it allowed groups to demonstrate any innovative features that they had implemented over the course of the previous week. We believe that the fostering of this type of friendly and constructive competition between groups was a major contributing factor in motivating them to seek new and interesting features to be demonstrated the following week.

4. Evaluation

The previous sections all have an evaluative aspect, in indicating the gains accruing from the Six Week Challenge for the teaching of the discipline represented in each week. This suggests that ALL has definite advantages over more traditional teaching methods. In terms of overall evaluation, a range of surveys were carried out, and the Six Week Challenge was also externally evaluated, concluding that the Six Week Challenge "potentially represents one of the most interesting developments in PjBL across the UK" [Gra10]. The external expert "was particularly impressed by the extent of the students' awareness and understanding of the active learning approach that had been adopted. Hearing them reflect on their own learning, it was clear that this awareness was an important element of their development through the 6-week activity" [Gra09].

In an internal student survey of the activities offered by the 11 subject groups in the EC faculty, conducted at the end of the 2010/2011 group project, our group's project was found to have received the overall best feedback from students [WM11].

The survey asked some key questions to students concerning the relevance and importance of their learning to their futures; how far ALL challenges are achievable; if students felt part of a learning community; and whether the workload was right. All these questions met with high average scores of the order of 4 out of 5 (on a 5 point Likert-type scale), indicating high satisfaction. Thus, it appears that, despite the potential disorientation that computer science students can face at degree level, discussed in the Introduction, students generally felt what they learned was relevant and important, reported a sense of belonging, and believed the workload was feasible.

Students were asked more specifically about the learning: whether the ALL experience had developed their subject knowledge; how far the teaching staff encouraged them to learn effectively; and if there were sufficient opportunities to learn from others. Responses to such questions are important to gauge, to see whether the passing of initiative and direction to students that ALL implies results in any difficulties compared to traditional alternatives. The average response scores for these questions were all of the order of 4.3 out of 5, which again indicates high satisfaction.

To complement the questions about learning questions were also asked about teaching: the extent to which students were satisfied with how they were being taught; how far tutors were available informally; and whether the group size and teaching environment were right. Again, these are important questions to ask, especially concerning the more agile, ad-hoc tutor responsivity required throughout an ALL process, and whether this works compared with the more formal traditional alternatives. Again, the responses are of the order of 4 out of 5, indicating high satisfaction.

These scores are gratifying and indicate that students were happy with the teaching and learning that took place during the Six Week Challenge. Importantly, there seems to have been a sense of engagement and involvement which could help mitigate attrition rates, which, as we saw in the Introduction, are a key problem in degree-level computing education. Graphics is a tough area of computer science, but the Six Week Challenge indicates that if an ALL approach is taken, graphics plus linked relevant disciplines can be effectively taught with high satisfaction at this level.

The results of the EC faculty survey have been very similar to a survey that we conducted of the students of the 2009/2010 cohort in our subject group for which the students' responses were also highly positive. We have been particularly concerned to track how students reflect on their own learning during the six week period, particularly in the absence of traditional lectures and tutorials (see Table 2) Asked if they would recommend this type of learning to other students, 98% of our 2009/2010 cohort agreed that they would.

> "The Six Week Challenge began as difficult and uncertain but the results showed our potential. This was a triumph" (Student feedback on the 2009/2010 activity).

5. Discussion

Our student-centred, activity-led introduction to creative computing through the development of a simple, yet intriguing interactive computer graphics application, certainly appears to have achieved its aims. Over the course of the six weeks, we have observed the transformation in our students from 'nervous and unsure' to 'confident and proud' as they have become increasing capable communicators. The group presentations at the end of each week especially were an arena where the groups competed in terms of the features and capabilities of their product. Indeed, we believe that this competitive atmosphere was crucial to driving student effort and engagement, allowing us to forego assessment as a means of motivation.

We have found that:

- By introducing students to all components of their course in a concentrated short term exercise, they are better able to assess quickly what the coming three years will involve in terms of content and approach.
- By working in small groups alongside, and supported by, the teaching team, students are rapidly introduced to our academic community. This is further enhanced by social activities which help to develop a strong sense of cohort identity.
- By focussing on activity and production, students are introduced to the practical nature of their subject and, by example, realise that their learning will be active, rather than passive, and that the production of technically sound artefacts will be a predominant feature of their course.

One reason for the success may be the novelty effect of our approach, which Vernon and Blake believed to be a possible factor of the success of PBL, as "participating in something new and different ... may create positive attitudes by psychological mechanisms that are unrelated to the theory, content, or learning objectives" [VB93]. However, a review conducted by the EC faculty of the six week project designed by our group has led to our project being characterised as a "true 'high impact' activity" [WM11] as described by the US National Survey of Student Engagement [Nat07], which could explain the success that this project seems to have had with the participating students.

5.1. High Points

We have experienced a number of other positive outcomes. Our first year students have retained a significant degree of group cohesion throughout the year, organising social events and often speaking with one voice on issues that affect them. The early use of group-based activities, which can provide a social support structure that helps to retain students who might otherwise consider leaving their degree programme is likely to be one factor that has influenced this apparent success. Furthermore, many students have retained some of the good habits they learned in the six week group project, particularly in academic writing, and assessments submitted by the students so far appear to be of a better quality than previously observed. Furthermore, the students appear more amenable to challenging material and tasks than in previous years. Finally, the introduction of the Six Week Challenge has coincided with a significant improvement in first year student retention. In the 2010/2011 academic year we have suffered no early withdrawals and at the end of this academic year we expect year 1 retention to be over 90%.

5.2. Issues for Further Consideration

The Six Week Challenge is highly resource intensive both in terms of staffing, accommodation and technology.

One important observation that should be taken seriously is that despite our approach's expectation that the students should demonstrate initiative and solve the set challenges on their own, this does not imply reduced responsibility or workload on behalf of faculty involved in preparing the challenges and developing teaching materials for the sessions that are led by an instructor. In the 2010/2011 Six Week Challenge, the project involved 6 academics and 2 teaching assistants working with a cohort of 54 students and it is unclear how well this activity would 'scale up' for larger cohorts, especially as the instructors need to closely monitor the student's progress to ensure that the learning goals are met. As the student groups have freedom in the way in which they approach any task, their solution may very well miss a specific aspect of vital importance to the outcome of their activities and instructors must watch for these 'wrong turns' and if the need should arise, make the students aware of potential problems with their chosen approach.

One of the more demanding aspects of the Six Week Challenge for the support staff (besides the physical requirements of extensive ad-hoc student support) was ensuring that each member of the student groups was participating as much as possible, and it was not uncommon to find some students trying to avoid doing parts of the tasks they did not enjoy by taking a back seat. Generally this could be rectified by engaging these students and trying to get them to think about the problem faced by the group and to provide input. Additionally due to the problem-based, self discovery structure of the Six Week Challenge, support staff would often find the demand for guidance from the students would fluctuate throughout the week depending on the overall complexity of the task.

One issue that did become apparent during the programming element of project was that we found that within the groups a minority of the students had previous experience with programming, resulting in these students tending to take on the majority of the workload in this area. This often caused a divide in the group and would further isolate the students who were new to computer science. The main solution to this was for staff to encourage the students to share knowledge with the group, but despite these efforts, some students did become disillusioned during this activity. This could be addressed by running optional programming orientation sessions for students who are completely new to computer science.

Finally, we have found that student expectations are significantly higher at the end of the Six Week Challenge, in terms of pace and direction of their degree programme. Management of these expectations can be problematic as the students return to more traditional classroom formats. The delivery of the latter has also been affected by the Six Week Challenge, as a side effect of the suspension of regular teaching activities for the duration of the project has been the need to redesign courses which started after the project which now have to run within a shorter time frame.

6. Conclusions

Our mode of delivery has very much followed the concept of activity-led instruction, which in this context refers to the instruction of students on how to embrace the Activity-Led Learning process. At the introduction for every sub-challenge (see Section 3.2), exemplar-based activity sessions were organised with the primary purpose of familiarising students with the process, rather than the task's content *per se*. Students were thus provided with a concrete, real-world example of the processes involved in addressing the challenges, eventually turning them into pro-active problem solvers who were not 'afraid' to face new problem domains. In this respect the weekly 'show and tell' sessions were also highly useful, as the competition they instilled between the different student groups prompted many students to independently investigate different techniques, which they then disseminated among their peers – effectively students themselves took on the role of instructors. The evaluation of the students' experience during the Six Week Challenge suggests that students have reflected on themselves and their learning and the reasons for which they enrolled at university, which in itself is a positive outcome of the six week group project.

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The screenshots shown in this article show the projects of three of the student groups. Figure 2 shows the program developed by the student group *Clumsy Penguin Entertainment* (Sareena Hussain, Sennel Ionus, Charnjeet Kaur, Jaipreet Panesar, Shaun Richardson, Anthony Rickhuss and Sarah Wardle). Figure 3 shows programs developed by the group *DDG* (Ahsan Ahmed, Sean Bhadrinath, William Brady, Thomas Bridger, Constantin Cercel and Ian Evans).

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