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On Summer Schools, Building Student Teams and Linking Undergraduate Education to Research

K. A. Hawick **H. A. James** **C. J. James** **C. L. James**

Computer Science
Institute of Information and Mathematical Sciences
Massey University, Albany
North Shore 102-904, Auckland, New Zealand
Email: {k.a.hawick,h.a.james}@massey.ac.nz

Abstract

We report on summer student programmes and activities we have run, or contributed towards, for undergraduate students at Universities in the UK; in the USA; in Australia and in New Zealand over the last 16 years. We discuss the aims and objectives of such activities - based around bootstrapping research projects; introducing undergraduates to the research process; and seeding new outreach and collaborative processes from research centres. Looking back, we are able to compare outcomes and different approaches in different research cultures in different national settings. We believe these activities are not so hard to initiate at any University and that they deliver some very worthwhile short-, medium- and long-term outcomes for computer science. We summarise our thoughts on such programmes and provide some advice on how to manage similar programmes.

Keywords: research culture, research training, extramural programmes; seeding enthusiasm.

1 Introduction

Often we have heard students complain that there is little 'real-world' component to their Computer Science education. We have found, in four different countries now, that summer scholarship programmes are an ideal way of providing a small number of students a taste of what it is like to be involved in either a research programme or a goal-oriented development programme. In this paper we describe the organisation and execution of our different summer scholarship programmes and the various factors that we believe have made them work successfully. We also discuss the relative merits of these programmes to staff and students.

The authors see the outcomes of running and participating in summer scholarship programmes as being mostly positive from a number of different viewpoints: two of the authors are academics and one of us is an administrator who had the responsibility of organising and day-to-day running of our programme in the UK. The academics saw a definite result from the programmes in the quality and focus of new Honours students, while the other authors saw a definite period of personal growth in the student participants.

When one considers organising and running a summer scholarship programme, one must carefully consider the reason for actually wanting to do so. Simply employing a student (or group of students) over the summer vacation does not make a summer programme: this is employing a research student. Nor does organising a number of students to work on on-campus or remote industrial projects constitute a summer programme. We believe that a real summer programme should result in a number of non-academic outcomes to both the student participants and also the staff who are involved. We believe that students should not only be exposed to advanced or state-of-the-art computing technologies but also be exposed to people from industry and required to learn how to talk intelligently about the work they are doing.

Primarily we have run summer programmes as a way of growing the research foundations in newer departments where, while there may already be a lot of research already, there is little in our areas of interest. We used the summer programme in the UK as a way of 'bootstrapping' the computing research culture (Hawick and James 2003) in the department that, in our opinion, was sadly lacking. By running summer programmes we have also tried to "scatter the bread-crumbs" over many students in an effort to seed their enthusiasm for not only our areas of interest but also in research as a worthwhile pursuit in itself. We have found summer programmes as a useful way of pre-vetting students before entering an Honours programme under our supervision and also as a way of raising awareness in the wider undergraduate community of the department's research activities.

One of the significant challenges we have faced in each summer programme is attracting and retaining the students that we wish to target. Sometimes, with the more business-oriented students, it is not an easy task to convince them of the immediate benefits of participating in a summer programme that will pay only slightly more than they would earn flipping burgers all summer when they could be earning far more (but having far less fun) in Industry. This is a definite trade-off for the organisers of a summer project: you can't pay peanuts and expect not to get monkeys working for you!

This paper is organised as follows: in section 2 we first describe the summer research programmes that we were originally involved with, and drew inspiration from. We discuss the different departmental and environmental cultures in which each of the programmes were run. In section 3 we discuss the positive outcomes that have happened to the student participants since their involvement with the programmes. In section 4 we discuss the issues and present a checklist that must be considered before embarking on a summer research programme.

2 Some Historical Programs

In this paper we focus on a discussion of our programmes at Adelaide (Australia), Bangor (UK) and Massey (New Zealand), but we first outline two major programmes from which many of our ideas grew: those at the Edinburgh Parallel Computing Centre and Syracuse University.

In this section we describe the way these two larger programmes were set up and run, and how experiences of these initial programmes lead us to make design and administration decisions when we ran the subsequent programmes in Adelaide, Wales and New Zealand. The main difference in the way that the larger programmes were run was in the level of funding available to participating students.

2.1 EPCC

The summer student programme at Edinburgh Parallel Computing Centre (EPCC) has its origins in ideas by Wilson and others for an outreach programme that would involve other academic departments at Edinburgh University in the work of the then very new centre (Wilson, MacDonald, Thornborrow and Brough 1994). Actually the original programme goes back a bit further in EPCC history to the Edinburgh Concurrent Supercomputer project and the group of individuals led and inspired by David Wallace, that were to form EPCC. The environment was of a group of researchers and graduate students deeply interested in parallel computing before it really became an acceptable mainstream discipline. In particular, most involvement came from computational physicists rather that the computer science department. the summer programme was one attempt to redress this balance, involving the recruitment of undergraduates and potential academic supervisors and co-supervisors into a set of activities that would spread the word on the then exciting but unwieldy parallel computing technology. One of us recalls supervising one or two of these enthusiastic undergraduates each summer the programme ran, on projects that included diffusion limited growth; spin models; and parallel simulations projects that tied in with the then nascent Numerical Simulations commercial projects group at EPCC.

The work was of enormous appeal to the summer students - it was something near state of the art to work on and a bullet point for their CV's. For some it led to employment as EPCC grew from around six post docs to over eighty staff in the space of a few years. Hawick's group grew to around a dozen researcher's and four of these were "summer programme recruits".

In later years the summer programme took on a life of its own, it grew in scope and number of students. It took on projects that embraced new non-traditional parallel computing applications and supervisors and co-supervisors from outside EPCC and indeed outside Edinburgh University. A number of enthusiastic EPCC staff took on the mantle of summer coordinator after Wilson, most notably Neil McDonald, Chris Thornborrow, Colin Brough and Elspeth Minty and the programme has gone from success to success in terms of spreading the parallel computing word. In later years grant funding was obtained from schemes such as European Human Capital and Mobility programmes. EPCC has always had strong commercial funding foundations and Hawick recalls the summer scheme also obtaining some specific sponsorship from industrial and commercial partners of the centre in exchange for some specific project suggestions. For the most part, many project ideas came from EPCC staff or from its immediate collaborators. The original model was of a collection of relatively brief project outlines being matched against the background of various student applicants. The general philosophy of seeding a broad variety of projects was followed, albeit tempered from time to time by the funding and political special initiatives within the centre.

In general the outcomes of the EPCC scheme were mostly in terms of student-supervisor development rather than pushing back particular frontiers of science and engineering. While all students were encouraged to "write up" reports it has to be said that the quality varied enormously - as might be expected from any student cross-section. Nevertheless some projects had great impact on the centre and were either continued on in subsequent years or had input into mainstream research or commercial projects undertaken by the centre.

Hawick recalls EPCC and this scheme with great fondness and much of the thinking for the programmes we report on in this paper had their origins in the EPCC scheme.

2.2 Syracuse REU

The Northeast Parallel Architectures Center (NPAC) at Syracuse University was set up by Geoffrey Fox and also ran various summer student activities. Hawick joined NPAC in 1993 and also participated in the NPAC programme as a project supervisor. The NPAC programme was sponsored by a National Science Foundation funding programme known as "Research Experiences for Undergraduates" (REU) (Fox and McCracken 1991) and was successfully run at NPAC by Fox, Nancy McCracken, Paul Coddington and Ed Bogucz amongst others. The grant funding made this a more formalised affair than the original EPCC scheme, and NPAC's parallel computing facilities were somewhat more lavish and varied in the early to mid 1990s. Generally the age of NPAC summer students was lower than EPCC students. The NPAC programme was aimed specifically at undergraduates whereas the EPCC scheme was perhaps slightly more embracing. More group level activities were therefore necessary - and fundable at NPAC. Hawick recalls an English writing group during the NPAC programme run by English literature faculty in Syracuse University. This was certainly necessary and had a perceptible influence on the quality of student written reports at the end of the summer.

The NPAC programme involved some very high quality applicants from across the USA and had a good effect on spreading word on parallel computing throughout other institutions. NPAC was part of the umbrella organisation - Centre for Research on Parallel Computation (CRPC) involving other institutions across the USA including Caltech, Argonne

National Lab, University of Tennessee and Rice University. There was an exchange of ideas on running summer programmes of this nature and some good collaborations resulted.

The NPAC programme made use of high performance parallel computing resources such as the Connection Machine; IBM SP2; and the then novel broadband networking technologies such as ATM networks of compute clusters. Around this time the World Wide Web was being discovered and a particularly successful strand of work was on novel HPCC applications that could be accessed "on-demand" via a web interface. Several REU students will have had their first "web server experience" through this programme.

Hawick also recalls supervising one outstanding "REU" student at NPAC who went on to work on computational physics applications in her PhD. Other notable outcome of the scheme were collaborative projects with other academic department such as the prestigious media studies school at Syracuse. NPAC projects were chosen much like EPCC's from staff suggestions and current research directions of activity. NPAC made a more concerted effort to publish a collection of student reports and these are still available on the Web, describing the student projects outcomes (Bogucz 1994, Coddington 1995).

2.3 Adelaide

The Distributed and High performance Computing (DHPC) and later DHPC Research Group at the University of Adelaide in Australia came about through funding from the Research data networks Cooperative Research centre and management coordination from the Advanced Computational Systems CRC. Research staff at Adelaide like Hawick and graduate students at Adelaide like James were funded through the CRC. There was unfortunately no budget items for an undergraduate summer programme at Adelaide and it was necessary to generate commercial revenue for one. Revenue from teaching commercial programming courses and some industrial project sponsorship from local businesses and government agencies such as the Defence Science and Technology Organisation (DSTO) and Department for Environment, Heritage and Aboriginal Affairs (DEHAA) were however forthcoming and in 1998 and 1999 Hawick ran a two-year undergraduate research experience programme for groups of around six to eight students working specifically on DHPC related projects (Hawick 2000). The staff working on the summer programme were completely DHPC-funded staff. James became a project supervisor in the second year of the programme.

The programme included project such as:

- to use the fibre-optic ATM Experimental Broadband Network (EBN) connecting Adelaide and Canberra using IPv6;
- open-source prototype virtual reality systems using stereo graphics head-tracking hardware;
- the use of virtual reality modelling language (VRML) to develop models and manipulation tools;
- Java-based image manipulation libraries for a Government department;
- to implement prototypical Web-services interfacing high performance compute and storage resources for applications
- to construct Web interfaces to integrated image and relational data bases
- to experiment with the then novel Linux operating system and its potential for running large scale Beowulf clusters
- to experiment with advanced 3D graphical technologies like Java3D for Virtual reality engines and interfacing with simulations and collaborative systems.

A great deal of this work was closely integrated with the work of the DHPC research group on metacomputing and Java middleware for Grid computing. This was before the "grid" word was widely used and the field was still known as "metacomputing."

Other, broader-based projects involved the early use of Lego Mindstorms (Lego 2004a, Lego 2004b) kits to build simple robots and experiments into their use for education in AI.

Many of the students involved in the Adelaide programme went on to further study at Honours level and indeed Doctoral study (e.g. (Bastian 1999, del Fabbro 2000, Zschech 2000). Several also followed us to Wales and became involved with a commercial concern , using Java and Web technologies and graph theory to build data management systems.

It was easier to obtain leveraged funding for the second year of the programme following its first year of success. Students were effectively employed at a not unreasonable pay rate for two to three months over the southern hemisphere's academic summer/Christmas holiday period. The student cohort was small enough that they could all work together in a single laboratory and could be group supervised with minimal individual direction. As one might expect, some produced more than others but the general ethos of introduction to a research environment and the opportunity to play with VR walls; supercomputers; compute clusters; broadband networks and Lego robots was a serious draw and the programme was considerably over subscribed with applicants.

As well as providing a new experience for the student participants the programme also provided an opportunity for junior and recent academic and research staff to have an opportunity of supervising and managing a small project. It has been our experience that this is a very valuable training experience and that the sooner in their careers academics obtain it and learn lessons from it the better.

2.4 Wales

We decided to run an eight-week week summer school at our new department in Britain. In contrast to other summer schools, we made a conscious decision to not simply restrict entry to the summer school to the academically best students, but open it up to all who were interested. We argued amongst ourselves that the reason for this is that achieving excellent grades does not necessarily make for a good researcher.

Before instigating the summer school we were fortunate enough to receive a small amount of funding from the Welsh Development Agency (WDA). We developed a budget, with enough funds to pay the students for their time, and also enough to purchase some equipment that would be used during the summer programme. This equipment comprised of a number of Java-enabled Tini boards and also a small number of PDAs, used for mobile computing experiments. We paid each student GBP1000 for the eight-week programme, a sum that, while certainly not extravagant, was more than they would have made working at the local fast-food restaurant over the Summer.

This quickly became an over-subscribed programme. We recruited 18 undergraduate students, from first-, second- and third-year level. We had previously arranged for the third-year students to either start PhD programmes with us or to take up employment with us as research assistants. These students we nominated 'super summer students': they received slightly more pay and in return were nominally in charge of a group of students.

Each student had an individual project that was also related to a small group project. Groups were comprised of students who did not know each other well, from differing year levels. It was one of our stated aims to improve the communication and cohesiveness of the students from all year-levels. We believe this aim was the one that succeeded best of all.

We were also hoping to develop the leadership capacities of our graduating third-year students in the context of mentoring the younger and more inexperienced students.

We were well aware that several of the first-year students had only had minimal programming experience (let-alone life experience) so it also provided us with the opportunity to assess, in an informal setting, the state of the current first-, second- and third-year curricula as recommended by organisations such as Association for Computing Machinery (2004), Institute of Electrical and Electronics Engineers Computer Society (2004) and British Computer Society (2004) in their computing curricula (ACM/IEEE-CS 2001, ACM/AIS/IEEE-CS 2004, Shackelford et al. 2004). In fact, after completing the summer school, one of the authors completely rewrote the fundamental first-year programming paper to improve student outputs.

During the summer school we had students use many different programming languages and programming software/tools that they had not experienced during their 'normal' education. Arguably we encouraged the students to think harder than they had at any point in their undergraduate education: they were now required to not only apply their undergraduate learning, but to combine their knowledge of different subjects in order to solve their research problems. More than one student was overheard to remark that this thinking business is hard!

At the conclusion of the summer school we organised a staff-student retreat. This mini-symposium featured contributed papers and associated talks by the summer students and also all staff in our department. This gave the students excellent exposure to the staff research interests and also allowed the students to gain valuable presentation experience. Unfortunately there was a significant lack of "buy-in" by the staff who were not directly involved in the summer programme; we believe such a buy-in would have considerably added to the students' experience at the retreat.

2.5 Massey

Massey University's Albany campus is still relatively new and research activities in computer science were still nucleating until recently. Our Institute invested in a number of summer student projects as a way of helping this nucleation and growth process. We have been able to find enough funding to employ individual students wishing to remain in a more research-oriented environment over the summer, to complete small research projects for us. This has been quite successful, allowing us to explore different avenues of our research, and to perform more speculative research projects than would have been possible by ourselves.

Computer science student researchers are able to fit into a broader community of research students in the information and mathematical sciences across the greater institute and we therefore have not felt the need to run specific summer student group activities. Individual projects have focused on making use and spreading expertise on cluster computing. We anticipate continuing this general direction. One recent noteworthy project made use of the Helix cluster supercomputer (The Allan Wilson Centre and Massey University 2002) and some ideas in software library development to produce a package of parallel iterators(Gan-El and Hawick 2004) using C++ and MPI. The core idea is for writing high level programs using library components that are close in style to that of the C++ Standard template Library, but which abstract over message passing parallelism for commonly encountered programme idioms. The student involved has since found employment as an advanced software engineer. Other student summer projects have included: novel scheduling algorithms for cluster systems; computational scientific simulations; and software development for swarm robotics systems.

Although these students generally worked closely with one or more supervisors, they had the challenges of shared adversity in coming to grips with a collection of apparatus and systems not normally available to the general undergraduate population. This experience seems to have a significant maturing effect on students and anecdotally has been reported as a plus for job interviews and early work experience.

These Massey projects have been funded from departmental budgets and other internal university funding schemes. There do appear to be commercial sponsorship opportunities to be had from local industrial interests, but it has been useful to us to identify specific technical developmental directions we wished to pursue without commercial pressures, while the computer science group's research directions are still in early growth.

3 Benefits and The Future

Of the approximately thirty students who have completed summer research programmes with us, we occasionally hear from a third. Several have later become professional research scientists; many are currently employed as professional software programmers, and others have pursued higher degrees in semi-related areas. A small group of students we supervised in Adelaide followed us to Bangor to take up jobs in a local software development. Spending a significant time with students over a summer also means supervisors get to know their students quite well – typically we hear from ex-summer students when they want a reference!

We would assert that completing a summer research programme gives the students a certain edge over those who have not. In the first place, these students have completed an extra-curricular programme in their chosen area of study that others have not. Secondly, the research component of the programmes give the students extra things to talk about during interviews – and seeing that most graduates have not had that much experience worth discussing, the fact that they *have* had some interesting experiences hold them in good stead. Extra exposure to industry throughout the summer programme also helps in raising student awareness of careers that they may have not previously considered – and sometimes helps students decide on career paths they *don't* want to take. We believe we have, in some small way, helped the summer students in their careers, hence the reason for this article.

We have also found participation in a summer programme leads students to be better informed about what is involved in an Honour-level student project. As summer projects are typically on a wide variety of project themes, we have also found that students who participate in the programmes are more aware of the different areas of research in the department. We have discussed the positive effects of student projects and the benefits of tailoring student projects to individual interests in (James, Hawick and James 2005).

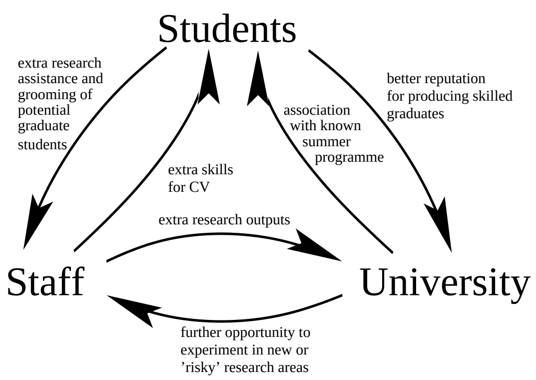

Figure 1: Benefits to major parties involved in summer scholarship programmes

Students are not the only group to have beneficial outcomes from the summer programmes. The other two parties with significant investment in the summer programmes are the staff who are directly involved with the programme and the University that speculatively spends the money to employ the students over the summer.

The staff benefit in some quite obvious ways: they have students working with them on projects they feel personally involved with. The staff member is able to have a student under their direction make headway on their project, leaving them to work on another project. However, sometimes this is a double-edged sword – it has happened in the past that a promising student totally fails to fulfil their potential or the project uncovers considerable gaps in the student's knowledge, requiring a greater-than-average investment of time by the supervisor in that project. Furthermore, working closely with a student over summer means the staff member can get to know them – and whether they could work together in a year-long Honours project or even longer on a post-graduate project.

The University also benefits from the programme in two ways, one tangible and one not: any research outputs of sufficient quality can be written up in scholarly journals or presented at conferences as papers or posters. Intangibly, the University also benefits from the students who have completed the programme and come away with positive experiences. The University also benefits from the Industry links that are forged through the summer programme – these also serve to raise the University's reputation in the eyes of local industry. In our experience Industry likes the contact with the select group of students – some of our students joined these companies after graduation.

However, as previously stated, there is a definite cost to both the staff and University. Most obviously, the University must spend money to keep the students during the summer period. Sometimes it is possible to get research funding from an external body, but in our experience this is difficult to come by. The University must also accommodate the group of summer students, and we have found it socially beneficial to the summer students and staff (and involved Industrial representatives) to hold weekly morning teas – just to get everyone involved together.

The staff involved in the programme must understand the level of commitment they must make to the programme: they must remember that the typical student entering a programme will be of second- or third-year level – that is, they cannot be expected to be an expert programmer, nor aware of many project subtleties that the academic is aware of. The staff member will most likely need to put in a fair amount of time, on a daily basis, to help the student. Thus, when organising a summer programme, it is best to get a firm "buy-in" from all supervisory staff *before* the programme is advertised – the extra burden placed on those staff who do participate is quite large is other staff pull out.

4 Common Summer Programme Issues

From the outset we have tried to design and run our summer programmes to maximise the research experience of the student participants. Part of this experience is allowing the students to come to their own understanding of what is involved with their research project; another part of the process is their time management; and the final part has been to invite local researchers, software developers, and associated Industry professionals into the summer programme to talk on a wide variety of subjects centring on what it is like in the real world. Inviting local industry or researchers into the summer programme had the added benefit of fostering industry linkages, not only for the summer programme, but the degree programme as well. This is especially useful in the UK where it is accepted practice to have a group of local industrial partners who provide oversight on degree programmes.

We suggest an approximate schedule for the operation of a summer programme in figure 2. The following subsections describe the relevant aspects of designing summer schools that pertain to this figure.

4.1 Results and Expectations

It is crucial to have a realistic expectation of the results that will be produced by the summer students: they are unlikely to produce any earth-shattering results from individual or group projects (although you may be lucky!). There will be a range of results commensurate with the variation in latent student abilities. Most projects will proceed to some sort of 'good' result. Some will achieve more than originally expected and others will falter at the first hurdle, either due to a student-project mismatch, staff-student mismatch or some other reason. We have already men-

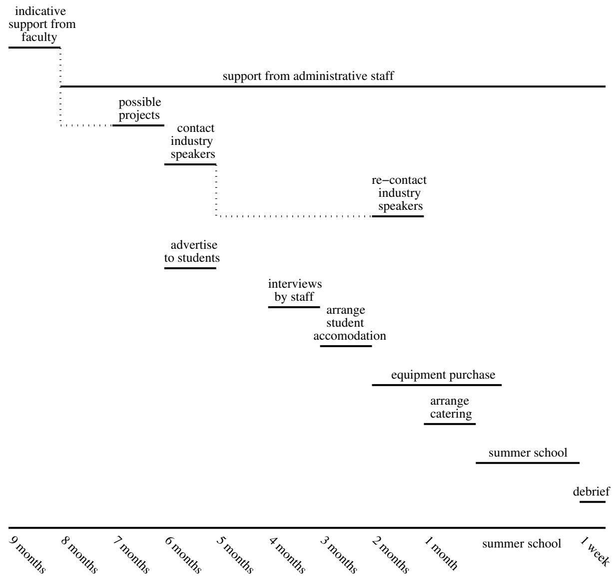

Figure 2: Gantt chart showing the rough timing of events required to run a summer scholarship programme

tioned that one of the valuable outputs of a summer programme is some sort of semi-public research forum at which the students are required to present either an oral paper or poster (e.g. (Toon 2002)). After the programme, the supervisor and student can dissect the work completed and make a decision whether to submit it to a conference as a paper or poster.

Some major milestones in the summer programme are important to focus student and supervisors on what is actually to be achieved. Presentation sessions, poster sessions, and a semi-formalised practice conference at the end of the scheme were all useful. Its important to remember just how little is typically achieved on a daily or weekly basis but how surprisingly much can emerge over 10-12 weeks. We found that the poster material from summer programmes could be used to brighten the departmental corridors and could be re-used as valuable publicity material over the following year(s). Institutions often have publicity budgets - it is worth considering applying for a contribution from your institution's PR budget to a summer programme. It may well lead to better value for money than some of the other uses to which such funds are sometimes put.

We are fond of the maxim "If you didn't write it up, it didn't happen!" and believe it is valuable to attempt editing some sort of proceedings from a summer programme. It may be in practice that some projects will lead to normal publications, but even if not it is certainly useful to have **all** the projects produce a short technical or working note. The writing experience can of course be built into the student programme and forms, we believe, a valuable part of the apprenticeship. We have found that it is a useful learning experience for students to see past years technical notes - they soon learn what is deemed to be a good one and therefore the standards to which they should aspire. In the present enlightened times in which we live, it is relatively easy to archive such material on the Web and doing this does give students valuable CV and job-application material.

4.2 Funding

Possibly the most fundamental difficulty one faces when organising a summer programme is that of funding. Remember students are hungry for CV items; accommodation and minimal cash may be all that is required. What is enough for them to avoid working in a bar or burger joint? However, some money is still required. The financial resources for the programmes we have described vary enormously due to different national and cultural circumstances. Table 4.2 shows the approximate number of students that participated on the various programmes we have been involved with, and the relative budgets.

In general for all the schemes the key resources were staff time and student stipends. The former generally has an opportunity cost attached to it but with the exception of the USA environment usually does not need separate cash to be obtained as staff time will typically be covered through the normal operations of the university or academic institution. It is nevertheless important to consider how much of your own time and your colleagues' time will go into a scheme and that everyone involved does feel it is worth it. We typically found that one average at least one staff day of input was needed per summer student per week for the 8-12 week summer programmes we describe. Less might be feasible with more coordinated group supervision activities and particularly if team activities that can be self supervised by the more experienced students or participants. These are we emphasise not insignificant amounts of staff resource for an institution to invest.

The biggest obstacle for most colleagues who might wish to run similar programmes is obtaining cash for student stipends. While it might be feasible for some better off students to participate in a scheme without a stipend, we believe this will typically be unfair and disadvantage many potential applicants. On the other hand it is not necessary to pay lavish wages either. Our experience has been that good schemes, with competition amongst applicants, need only offer stipends comparable with those great student institutions - wages working in a bar or in the supermarket. In some institutions and circumstances it may be possible to arrange discounted or even free university accommodation. Availability of university accommodation in the vicinity of the Snowdonia mountains was a serious draw for applicants at Bangor. The Syracuse programme had applicants from all over the USA and therefore accommodation arrangements were also important. The attraction of Edinburgh as a city were a draw for applicants across the UK and Europe for the EPCC scheme. The Australian and New Zealand student cultures do tend to encourage stay-at-home-city students and accommodation was perhaps less important in these two cases. As we have described the number of places you can offer can usefully range from just two or three to over twenty. This will be the major financial item to consider.

4.3 Resources

In-kind resources such as computer labs and supercomputer or cluster access cycles will also vary. We have experienced considerable variation in what new specific targeted resources were available - it was particularly valuable to have the economic development resource s of the Welsh Development Agency brought to bear on our Bangor programme. At EPCC and NPAC it was relatively easy to make available machine cycles and compute resources. The Adelaide

Location (Country)	Students	Approx Budget	Budget Notes
NPAC (USA)	10-20	3^{+}yrs grant funded	stipend of a few thousand per student
Edinburgh (UK)	10-25	15^{+}yrs variable budget	stipend of a few thousand per student
Adelaide (AUS)	~10	2 yrs @ AUD15,000/yr	only includes stipend
Bangor (UK)	18	1yr @ GBP25,000	included stipends (18K), equipment (2K), catering and symposium (5K)
Massey (NZ)	4	2 yrs @ NZD	only includes stipend

Table 1: Location of each of our summer research programmes, showing the number of students participating and the approximate budget of each programme.

scheme involved a lot of research specific equipment belonging to the DHPC research group. The host department also generously made space and labs and terminals available without cost.

Like in so many lab-oriented endeavours it helps enormously to have a fund for sundries and small equipment items (components or software or consumables) that can make the difference between getting experiments and equipment delivering useful results in a short time-frame or not. We were able to use discretionary funds (untyped-money) from other research consulting work to finance these items. Some well-funded departments may be able to contribute directly to this.

When we ran the programmes in Australia and particularly in the UK we were essentially starting with no dedicated equipment for the summer students. Thus it was necessary to carefully pre-plan the project themes in order to purchase or borrow the required equipment. It took longer than we had first considered for some equipment to arrive, meaning that some students were not able to immediately start work on aspects of their projects. In Adelaide we used the results of the previous years' summer programmes to scope the following year in terms of lab set up and equipment ordering.

4.4 Administrative Support

It also helps to have good administrative support for a programme. A lot of the time consuming supervision work is actually connected with administration and logistics and can be carried out by non-academic staff. We believe it is important that such staff be included in the planning process and are given a clear idea of what the real objectives of a particular scheme is. Good support staff and good contacts in your local environment can also lead to a surprising number of in-kind contributions of time or other resources. We found that a concerted effort to grab leftover food from other university meetings for the ever-hungry summer students led to discussion and team building opportunities.

In fact, one of the significant hurdles that our friendly administrator faced when we organised the programme in the UK was that of student accommodation. In the UK most undergraduates move away from their family residence and stay in student accommodation. During the summer months most halls of residence are let out to visiting academics or conference attendees at a significantly higher rate than during semester time. Unbeknownst to us, we faced the problem that our summer students would not be able to afford to stay in halls at the rate we were paying them; it was up to us to put pressure on the accommodation management and we managed to secure a special rate for our summer students.

4.5 Project Design

On an organisational front, we have trailed two distinct types of summer project: individual and group projects. In Australia and New Zealand we ran only individual projects, while in the UK we used a mixture of individual and group projects. The decision was made after the initial interview through which the students were chosen for the programme: some students naturally prefer to work alone, while others prefer to work in small teams. As previously mentioned, we nominated some of the more senior UK students as 'super summer students' and gave them the additional responsibility of looking after a group of individual projects with a similar theme. Experience has shown us that the more junior members of the team are more likely to approach their team leader before the supervising faculty. Of course, it is necessary to motivate those older students to take on the extra responsibility of nurturing more junior students: extra money often helps, together with a reminder that this is in some small way "project management experience" that will look good on their CV.

It has been our observation in all the programmes we have described that a team experience, either planned or emergent, has been a significant outcome for many students. Shy undergraduates who would not otherwise have had the opportunity to work in a team of peers or in an established research team of older more experienced colleagues have commented on this value. Indeed particularly at Bangor and Adelaide where we had the opportunity to mix students at different levels it was clear that it helped may mature and develop considerably. Professional bodies in the UK and elsewhere are pushing for accredited degree programmes to include some sort of team project experience. We endorse this with the recognition that it is not always easy to shoe-horn material into an already packed curriculum. Summer programme activities where the team and project experiences are not necessarily formally assessed towards a degree result can be, we believe, even more beneficial towards the real education (rather than assessment) process. Our feeling is that if the summer programme were to be made an academically-assessed part of the undergraduate or Honours curriculum, it would significantly change the tone and culture of the programme: we fear that it would no longer be viewed by the students as 'fun' or 'a privilege', but instead yet another form of assessment.

At Bangor and Adelaide a key outcome for us of part of the summer programmes was to establish and equip laboratories for cluster computing and swarm robot systems. It was fascinating to involve the summer students in this process and we believe it was an unusual opportunity for such students to have input into equipment purchase and scheduling. It was insightful to see comparisons between our prejudices and pre-conceptions about what a well equipped lab ought to have and what the students thought was important. We believe the involvement of the students saved us some money and made for more rapid progress and improvisation than would otherwise have occurred.

It was a fascinating experience to watch older students teaching younger ones to solder circuit boards, to install operating-systems kernels, to configure network switches and generally pass on general experiences that do not always neatly fit into modern lab based curricula. We recall ourselves the computing terminal room experience where we ourselves learned so much by "osmosis" from the greater student community. It is a symptom of curriculum pressure and laptop-equipped students who work mostly at home that this learning from your community experience now has to be deliberately nurtured rather than expecting it to happen spontaneously. We believe summer programmes such as we describe can go some way towards this planned nurturing.

4.6 Convincing the Academics

The summer student vacation is often seen by academics as being "their time" in which they can do research unfettered by the demands of undergraduate students. So, it was interesting to see the effect that running these programme had on the authors. We must admit that, while supervising the students did cost us a significant amount of time over the summer, some of the work that was done by the students was useful as a partial research output, and also in some cases, lead to other research programmes in themselves.

What does this investment of time and effort (not to mention money) buy the staff on the programme? Firstly it gives us a set of research assistants for the summer period. The downside to this rather attractive proposition is that we have to train them (sometimes a little, sometimes a lot) in order to get them to a point where they become productive. It's no good just taking the brilliant students (even if they will stick around) because many 'average' students simply have not had the chance to shine in an ordinary academic teaching environment.

If we have an average-to-good student, participating in the summer programme means we (the staff) are able to produce slightly more research output over the summer. Sometimes this is true, sometimes not.

The programme is also an excellent forum for the staff to get to know a core group of undergraduates, that might be mentored for an Honours programme, or considered for job placements during the semester breaks. As previously mentioned, many summer students use their supervisor as a job reference.

Lastly, it does let us know, through our day-to-day interactions with the students, where the holes in our own undergraduate curriculum are. Students have proved to be, once their trust has been gained, quite open (and brutally honest) about their undergraduate degree courses, areas of difficulty and shortfalls in programmes. This means we are better able to consider changes to the curriculum to cover those gaps.

5 Summary and Conclusions

We have been involved with, and have run summer research programmes in the US, UK, Australia and New Zealand over the past 15 years. Experience has shown us the summer schools are an excellent way of bootstrapping a research culture in a new area of research or to establish awareness of research activities in the undergraduate student population. We also see the inclusion of an annual summer student programme as being a key differentiator in today's Higher Education market where all degrees essentially cover the same subject areas. This is one way in which a University or department can show focus on the career paths of students.

Along the way we have learnt a number of quite valuable lessons. Firstly, it is critical to have a clear view of the expected outcomes of any summer programme. Spend some time mapping out possible projects or areas in which projects could be run with and without equipment. Secondly, it is necessary to have the active support of research-active staff who will be around over the summer period. It is also crucial to have an administrator (possibly 'enticed' with chocolate) who is willing and able to organise the non-technical aspects of the programme including student payments, advertising materials, accommodation, office space, morning teas, and presentation facilities for students. Thirdly, budgets must be sourced as early as possible so as to ascertain the viability of running a programme. Don't forget that some student projects will require new hardware, which must be purchased well before the summer programme is to be run.

We found uniformly across all our programmes that the best projects and student outcomes were closely correlated by how much staff-supervisor time and effort was put in. For this reason we believe it most important to undertake such a programme if and only if you and your colleagues really want to put effort into it and will therefore be able to project the necessary signals of enthusiasm for the student participants.

We have had experience running a programme where some of the lesser-involved staff pulled out at a late stage, thus increasing the burden on those staff who were involved. This was not good. It is also important to maintain a low student:staff ratio, so as to be able to devote an appropriate amount of time to the students on the programme.

Running summer schools, in their various guises, has been very beneficial not only to the students on the summer schools, but also to the academic staff that have day-to-day interaction with the students. Primarily, the students are being exposed to new ideas, methodologies and technologies that they would not ordinarily be exposed to. From a staff viewpoint, the summer schools have had a two-fold benefit: firstly they have allowed us to 'cherry-pick' the best students to later become graduate students, or at least maintain a watchful eye over, and secondly the interaction allows is to fairly accurately gauge the gaps in our own undergraduate curriculum.

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