# Streamed project work: Letting everyone rise to the challenge

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*Abstract: The main educational modifications used for gifted and talented students are enrichment and acceleration. These strategies are widely discussed in the literature in the primary and secondary education sectors. Where programs for talented or higher-achieving students do exist in the tertiary sector, enrichment is the most common approach with acceleration occasionally employed. Another alternative is the use of streaming or ability grouping, such as we find in the NSW state school system. We describe and discuss the merits of an approach which streams students according to their academic record, specifically the use of grade point averages (GPA) to allocate Information and Communication Technology (ICT) students into two separate final year compulsory project units. After presenting the differences and features of the advanced stream versus the basic stream we also consider two main issues that ability grouping raises: homogenous versus heterogeneous groups and the Australian cultural value of egalitarianism.*

## Introduction

History bears testament to the failure of traditional education to meet the needs of gifted individuals. The ramifications of this failure are significant for society as a whole as the 'intellectually gifted have been recognized as a group responsible for progress in society' (Poncini and Poncini 2002). However, gifted and talented (G&T) children cannot be treated as one homogenous group, but just as with any other individual they may vary according to cognitive differences (Intelligence, Creativity, Cognitive/Learning style, Pace of learning, Concentration, Dependence/Independence) and Personality differences (Self concept, Locus of control, Level of aspiration and performance motivation). While factors such as pace of learning, creativity, locus of control, dependence/independence can be found in some approaches, performance motivation or achievement motivation is seen as a key factor in the success of gifted students (Herbert 2007).

This means that enrichment opportunities must be motivating, intrinsically and extrinsically, for the individual, not simply extensional activities. Furthermore the activity not only needs to be relevant to the student but also to the field of study. Providing science experiences, often extracurricular, are seen to be a key means of providing intellectual growth and improved academic success for students with scientific talent (Poncini and Poncini 2002). Similarly, mathematically gifted students also need a curriculum that is 'deeper, broader, and faster than what is delivered to other students' (Kim 2006, p.28). Techniques traditionally used for these students are those of acceleration which include grade skipping and vertical timetabling (subject acceleration). Based on a study by Lewis (2002), Kim believes that 'acceleration is appropriate in subjects that are linear-sequential, where there is a building up of previous knowledge and skills such as mathematics and science' (Kim 2006, p. 29). However, much of the wisdom on G&T concerns primary or secondary education and it can be difficult to apply or see the relevance to the tertiary sector. For example, in the school system it has been found that for acceleration to happen you need dedicated teachers (and often parental involvement) who need to be trained in gifted education to manage and deliver benefits to the child (Kim 2006). Parental involvement is not appropriate at the tertiary level.

Our particular area of interest is teaching strategies for talented students in the field of Computer Science and more broadly Information and Communication Technology (ICT). On the one hand, learning ICT is more like learning mathematics in that you use a formal language to solve a problem by designing/applying an algorithm or formula. The need to set up hypotheses and experiments, typical of science, is less common and the infrastructure or equipment needed (a basic computer or even just pen and paper) are more readily available or accessible. While group-based activities can promote learning, often the learning is at the individual level.

Another means for handling talented students is to use ability grouping (Rotigel and Fello 2004, Shore and Delcourt 1996). Ability grouping allows the teacher to target the learning content at an advanced level, providing more interesting content for academically capable students, and perhaps even more importantly providing the opportunity for students to bounce ideas off one another. Thus, for ability grouping to be beneficial the student must actually work with other students and receive teacher feedback. Ability grouping fails when there is no curriculum differentiation and when grouping results in the teacher leaving the gifted students to their own devices while attending to other groups. Also, within class grouping can be harmful for social self-concept of non-gifted students if they need to interact with the gifted group.

Attracting and retaining academically gifted students is a common goal of higher education institutions. As part of our strategy to increase the appeal of, and hopefully demand for, our Bachelor of Computer Science (BCompSci) by high achievers, we designed a program to enrich their experience through a year long industry and group-based project that would group, differentiate and stretch these students. We describe this program next and then review how the program was opened up and elements incorporated into other streams to allow all students to rise to the challenge.

## An advanced stream

The 'Systems Engineering Project – COMP340' was designed in 2001 as a program to create alliances between our top computing students, academics and industry to the benefit of each party. From the student's viewpoint, the objective of this program is to assist students in taking responsibility and initiative for their own learning and to prepare them for a career in ICT, which will primarily involve working in project teams to deliver ICT solutions. To meet this objective, the students manage their own projects and present a lecture series to their peers. From the project sponsor's viewpoint, the objective is to provide sponsors with students that have a firm foundation in the fundamentals of computer science and an ability to apply and adapt that knowledge to solve a real business problem. Benefits to the university are the provision of an industry-relevant experience to students and the development of a bridge between academics and industry partners.

COMP340 seeks to provide both a theoretical and practical learning experience by including a fortnightly one-hour lecture stream within the unit. Students are required to give a 20-minute presentation addressing an issue related to the text and pre-specified by the lecturer. The student leads the discussion with the whole class. This design seeks to ensure that students:
- keep up with the theoretical content of the course and do not leave reading the textbook until the examination period;
- engage with the material and one another to improve their understanding of the concepts;
- are concurrently modifying their own theories and practices by working on both at the same time; and
- practise and improve the presentation skills necessary for the final project and as an assessment task.

Part of the assessment criteria for the presentation is evidence of wider reading beyond the textbook and identification of key issues and solutions. A study conducted by Waite, Jackson and Diwan (2003) has found this 'conversational classroom' style of learning improved overall class performance by up to five standard deviations larger than the historical value for the same unit. Our experience has been that students tend to achieve a distinction or high distinction in COMP340, which is above the GPA entry requirement to the unit.

Students also have greater autonomy and ownership of the project. In contrast to most industry-based projects, the COMP340 groups are responsible for all aspects of the project including the

selection of an appropriate process model; design architecture and developing their own project plans. Decisions made regarding the various design and management choices must be justified and be based on the environment they are working within. Students typically find understanding the business and its goals to be the most time consuming and challenging tasks. In many other project and industry based courses, individuals are incorporated into teams within the organisation and given junior positions with little or no autonomy or authority. In COMP340, the teams work as standalone units and are treated and expected to behave in a professional manner as any other team in the organisation. To ensure that each team member gains the most from the experience, the roles within our teams are rotated; significantly everyone must have a turn at being the project leader!
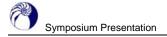
The greatest challenge for the unit convenor and industry supervisors is knowing when to step in to reorient groups that are not functioning properly or that are falling behind. It is the goal of both the academic convenor and the industry sponsor to make the experience as realistic as possible; this is typically achieved by creating projects that are of real value to the organisation and by having the groups follow the organisation's procedures and policies.

Each team has three to six members and is supported by two or three within the hosting organisation. One primary supervisor is assigned, who is generally supported and by a top-level manager. Others may provide some technical assistance within the organisation and at times discussions are held with broader stakeholder groups to clarify requirements and to place the student team within the larger context of the project and the business goals. For example, in one company the project team consisted of in excess of 60 people. The Student Team had five people. The overall project was scheduled to take approximately two years, with the Students' component taking seven months. No actual money changes hands, but some organisations include the time spent and resources used by the group and supervisors so that data is collected to assist management of the project and for estimation purposes of future projects. In the words of one participating organisation, 'from our perspective it has been beneficial working with the student group in several ways:

- provides resources and a commitment for our project;
- enables us to work with students in providing innovative IT solutions; and
- enables partnerships between administration, academics and students. This project definitely strengthens our relationships'.

A number of spin-off benefits were generated within two years of the unit being launched. The success of projects in earlier years has led to an increased confidence from the industry partners in the high quality of our graduates and our commitment to meeting the needs of industry. As a result a number of communication channels have opened up. These include:

- guest lectures provided by sponsors to students in other units;
- development of a new monthly evening *Technology Trends* seminar program in 2003 aimed at bringing industry and academia together to hear about the latest developments in IT. Attendance ranged from 28-40 in its inaugural year and the seminars are ongoing on a monthly;
- investigation of possible research collaborations such as ARC Linkage Grants;
- development of industry-based projects for Masters and PhD;
- a range of industry-sponsored scholarships to support undergraduate students;
- a number (4) of industry cadetships;
- distribution of a questionnaire to industry partners seeking their input into our current curriculum redevelopment;
- students not in the BCompSci were asking for special permission to participate;
- more companies are asking us to announce employment opportunities to our final year students; and
- in 2003, COMP340 won runner-up in the Business Higher Education Roundtable Awards for Outstanding Achievement in Collaboration in Education & Training.

## Extending the program

A number of factors have occurred resulting in the extension of the program to a wider and less elite group of students. These factors include the following internal and external influences: demand from industry for student teams each year is higher than our supply; students in our other degrees have asked to be allowed to participate; an overall drop of 40% in the numbers of ICT enrolments within Australia between 2003 to the present; and a change in student preferences towards computing degrees with less technical and theoretical content (including reduced programming and mathematics). In 2008 as a result of these factors we only have one COMP340 team comprising 5 students. To address these factors and also to continue the program due to the benefits it has delivered, from 2007 we have personally invited students to participate in an *industry project* (Stream 1) who meet a minimum grade point average (GPA) and who are enrolled in one of the other two 'capstone' third year project units: *COMP345 Software Engineering Project* for the Bachelor of Technology (BIT) or *ISYS346 Information Systems Project* for the Bachelor of Information Systems (BIS) students. The learning goals of all three project units overlap. Students completing any of the three project units should have: experience with the entire system development life cycle and how to work effectively as part of a team; the ability to specify a problem and design a computer-based solution to it; improved communication and report writing skills, project management experience (including time, resource, quality and risk) and improved technical skills through application of the skills learnt in other units, supplemented with new skills acquired to solve the problem at hand. All units commence in February and run for the duration of a year (two semesters). Students enrol in one project unit in their third year along with three or four other units each semester. In 2007 and 2008, expanding access to industry projects resulted in four additional teams and organisations involved in Stream 1. Overall, since 2001 we have had seventeen companies sponsoring one and occasionally two teams each year. In most years we have two or three companies from previous years and two or three new companies.

When COMP345 and ISYS346 were created in 2004, taking over from a one semester project unit that had existed for about a decade, each had a different goal. ISYS346 was to provide a project that was database, modeling and business oriented. COMP345 was more focused on the latter end of the system development life including design, coding, implementation and testing. In the first two years of these units we ran them separately with different projects according to the unit focus. However, recognising that delivering a quality software product would a more holistic view and to give students experience working in teams with diverse people with disparate skill sets, we have combined teams from each unit to ensure each team has a mix of students and skills.

Currently, the minimum GPA requirement has been set at 2.75 for participation in Stream 1. In our university, each type of passing grade is given a certain number of points (conceded pass =1, pass=2, credit=3, distinction/high distinction=4). To find the average one divides the total grade points by the total number of units taken. Thus, for example a GPA student of 2.75 is a student who for every three out of four units achieves a credit and one pass OR two passes, one credit and one distinction. Approximately 30% of our students would fall into this category, thus our current advanced stream project is not focused so much on providing an elitist or exclusive program, but on providing programs that the two cohorts (those with GPAs of 2.75 and above and those below 2.75 GPA) will be able to achieve. Those students below the GPA cutoff or who do not accept our offer of an industry project (often because they already have industry experience or do not have the additional time which the industry project demands) form another cohort of project students involved in the *inhouse project* (Stream 2). Table 1 shows the key differences between the two streams.

**Table 1.** Differences between the two streams at a glance

| Requirement/Strategy/Task/Activity | Stream 1 | Stream 2 |
|---|---|---|
| GPA requirement | GPA ≥ 2.75 | GPA ≥2.0 |
| Rotate leadership role | Yes | No, one leader appointed by the group at the start |
| Peer Assessment | Presentation of theory/lecture material | Demonstration of product |
| Student Presentations | 1.Lecture material, 2.Project progress, 3.Final presentation to industry, peers and academics | Demonstration of product at end of each semester to class |
| Set own time lines | Yes, except project plan due date and final presentation and product delivery date | No |
| Set own deliverables | Yes, except as above | No |
| Maintain Blog (personal journal) | Optional | Mandatory |
| Contribute to Discussion boards | Optional | Mandatory |
| Groups formation and duration | By lecturer – year long | By lecturer – swap in S2 |
| Sponsor/Client | Industry-based | Sometimes industry-based usually an academic |
| Nature of problem | Industry, real world, complex, different for each group | Simplified real world, same for each group |
| Determine project | Group and sponsor | Lecturer |
| Problem Focus | System and Organisation Relevant Solution | Software/Product |
| Examination | Yes, same as Stream 2, worth 25% | Yes, same as Stream 1 (25%) |

Some (perhaps temporary) changes have been made to the current and previous offering to accommodate the greater diversity of student ability such as the provision of some lecture content by the convenor, rather than the delivery of a lecture stream and associated advanced textbook content by the students. Also, recognising the challenge associated with self management and delivery of a useful product to the industry client, a number of controls have been added to monitor groups more closely. Within both streams the groups are also of mixed ability (spread of GPAs) and there is opportunity to take up challenges and extend oneself beyond the group or basic project definition.

## Potential issues with streaming and conclusion

As described, we have found many benefits in offering an advanced program. However, support and the case for streaming versus not streaming are not always apparent. We raise some questions for further consideration: is it better for students to be in homogenous or heterogeneous groups; is this form of segregation ethically or culturally acceptable?

Many researchers believe that heterogeneous groups will tend to function better than homogeneous groups (Barker 2005; Nicolay 2002; Rutherfoord 2001). There are several factors by which academics can choose groups, including gender, prior classroom experiences, work experience and race (Rutherfoord 2001). McConnell (2006) favours instructor chosen, heterogeneous groups because they allow the instructor to shape the nature of the group and avoid the pitfalls of student self-selected groups (segregated based on ability, placing top students with top students; and bottom students with bottom students). In a controlled experiment examining groupwork in a second-year systems analysis and design subject, Lejk, Wyvill and Farrow (1999) found that high ability students obtained considerably lower grades in mixed-ability groups than in streamed groups (when members of each group received all the same grade). On the other hand, lower-ability students received higher grades when placed in mixed ability groups than in streamed groups. The study also indicated that lower ability students perform better in subsequent examinations after having worked in mixed-ability groups than in streamed groups, whereas the reverse is true for higher ability students. This study indicates that mixed ability groupings relatively disadvantage more capable students. Laughlin and Branch (1972) who conducted a study with 1008 college students, found that group performance is correlated to the group-member with the highest ability level. In response to these findings and due

to an increase in incidences of dissatisfaction in some our teams in 2007 (typically concerning equity issues such as commitment, contribution and ability of other team members), we are currently experimenting with alternative strategies to group formation which we will report in a future study.

The results of these studies raise an ethical issue: should high achieving students be placed in groups with low ability students, potentially at the expense of their own performance (compared to if they were placed in a group with people of similar ability)? The prevailing view is that heterogeneous groups provide a greater benefit for below-average students than they impose a detriment on high-ability students. This view may be influenced by the Australian cultural value of egalitarianism and what is known as the Tall Poppy Syndrome. In the field of science the term Tall Poppy is used to 'refer to outstanding scholars who deserve to be publicly acknowledged for their work' (Peeters 2004, p.1). While this may sound like a positive attribution, Australians are renowned for 'cutting or lopping tall poppies down to size or bringing them back a peg or two' (Peeters 2004, p.8). The NSW Selective High School system has received criticism since its inception on a number of grounds. On the one hand the argument in favour of selective schools is that G&T students have particular needs not met in a comprehensive system even by specific programs within the school such as special classes: this view is supported by parents who are voting with their feet (Watson 2006). A key negative of selective schools are the potential negative effects on students' self-concept, known as the big-fish-little-pond-effect (BFLPE) and the negative affects this can have on academic achievement (Marsh 1991). Further support for non-streaming and even classes with mixed ages can be found in a study conducted in an independent school in NSW which consistently achieves outstanding results in science and technology (Dow 2003).

With these various considerations in mind, the streaming of students according to academic ability needs to be handled carefully. In the development of our basic and advanced project streams we have sought to find a balance that provides each student with the opportunity to rise to the challenge and thereby achieve the intended learning outcomes.

## References

Barker, L.J. (2005) When do group projects widen the student experience gap? In *Proceedings of the 10th annual SIGCSE conference on Innovation and technology in computer science education*, Caparica, Portugal, 276–280.

Dow, K.L. (2003) *Australia's teachers: Australia's future: Advancing innovation, science, technology and mathematics. Main report.* Canberra: Commonwealth of Australia.

Fisher, M., Thompson, G.S. and Silverberg, D.A. (2004) Effective group dynamics in e-learning: case study. *Journal of educational technology systems*, **33**(3), 205–222.

Hebert, T. (2007) *Exploring the motivational trajectories of gifted university students.* The Free Library. Retrieved June 01, 2008 from http://www.thefreelibrary.com/Exploring the motivational trajectories of gifted university students.-a0162695205.

Kim, S. (2006) *Meeting the needs of gifted mathematics students.* The Free Library. Retrieved June 01, 2008 from http://www.thefreelibrary.com/Meeting the needs of gifted mathematics students: Sally Kim presents...-a0164525551.

Laughlin, P.R. and Branch, L.G. (1972) Individual versus tetradic performance on complementary tasks as a function of initial ability level. *Organizational Behavior and Human Performance*, **8**, 201–216.

Lejk, M., Wyvill, M. and Farrow, S. (1999) Group Assessment in Systems Analysis and Design: a comparison of the performance of streamed and mixed-ability groups. *Assessment & Evaluation in Higher Education*, **24**(1), 5–14.

Lewis, G. (2002) Alternatives to acceleration for the highly gifted child. *Roeper Review,* **24**(3), 130–133.

Marsh, H.W. (1991) The failure of high ability high schools to deliver academic benefits: The importance of academic self-concept and educational aspirations. *American Educational Research Journal*, **28**, 445–480.

McConnell, J.J. (2006) Active and cooperative learning: further tips and tricks (part 3). *SIGCSE Bulletin*, **38**(2), 24–28.

Nicolay, J.A. (2002) Group Assessment in the Online Learning Environment. *New Directions for Teaching and Learning*, **91**, 43–53.

Peeters, B. (2004) Tall poppies and egalitarianism in Australian discourse: From key word to cultural value. *English World Wide,* **25**, 1–25.

Poncini, A. and Poncini, L. (2002) A Qualitative Assessment of Gifted and Talented Students Undertaking Research Science Project. In W. Vialle and J. Geake (Eds) *The Gifted Enigma: A Collection of Articles*. Hawker Brownlow Education, Highett, Vic, Australia.

Rotigel, J.V and Fello, D. (2004) Mathematically Gifted students: How can we meet their needs? *Gifted Child Today,* **27**(4), 46–51.

Rutherfoord, R.H. (2001) Using personality inventories to help form teams for software engineering class projects. *Proceedings. 6th annual conference on Innovation and Technology in Computer Science. Education*, Canterbury, United Kingdom, 73–76.

Shore, B.M. and Delcourt, M.A.B. (1996) Effective Curricular and Program Practices in Gifted Education and the Interface with General Education. *Journal for the Education of the Gifted*, **20**(2), 154.

Speck, B.W. (2003) Fostering Collaboration Among Students in Problem-Based Learning. *New directions for teaching and learning*, **95**, 59–66.

Waite, W.M., Jackson, M.H. and Diwan, A. (2003) The Conversational Classroom. *SIGCSE'03*, February 19-23, 2003, Reno, Nevada, USA.

Watson, K. (2006) The Comprehensive High School: destruction of an ideal? *Metaphor*, **3**, 21–24.