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Does a Multicultural Mix Bring an Extra Dimension to Software Engineering Design Teams?*

Alec L. Simcock
School of Communications and Informatics, Victoria University of Technology, PO Box 14428 Melbourne City Mail Centre, Melbourne, VIC 8001, Australia

Some difficulty may be anticipated when given a new subject to teach with a week's notice. Matters are not improved when the subject is allocated only one third of the usual time and no practical component whatsoever. Trying to teach *An Introduction to Software Engineering* to third year electrical engineering students in only a one hour lecture per week was going to be a challenge. Under these circumstances a little lateral thinking does not go amiss. To create an environment that would generate the enthusiasm necessary to give students a chance of a satisfactory and lasting learning experience, it was necessary to supplement the potential boredom and alienation of the one hour lecture disconnected from immediate practical application. To attempt to achieve this goal it was decided to use a team design project approach with some differences. This paper describes the project and the differences in objectives and organisation; it will outline the initial analysis of whether the desired goals were achieved; and will also detail some unanticipated, potentially beneficial, outcomes.

INTRODUCTION

In many cases the voice of the instructor has barely ceased before some students begin hammering away at the keyboard in an attempt to *write* the program that has just been given as an assignment. The need for students to receive immediate gratification for their programming efforts in the form of code entered into the computer can sometimes prove to be an irresistible force. This approach to *programming* can become a habit, especially for those students who do not intend to specialise in computer engineering, and who have reached their current level of *expertise* having only ever tackled straight forward, well-defined programming problems.

This *hands-on, only for immediate reward* approach to programming can indicate that these students have adopted a purely surface approach to learning, a problem that has been noticed already [1][2]. In response to a questionnaire in another subject, when asked:

> *If at the end of a class a lecturer told the class to do certain exercises before the next class...*

only 11% replied that they would do the exercises in order to learn and understand (with the probability that this knowledge would reap rewards in the end of semester exam), but 84% would do the exercises for the immediate reward of a mark [3].

Software engineering is more about planning, structure and long-term, rather than immediate, benefits, etc. For these and many other reasons software engineering can be a difficult subject to teach. Realising their program design using only paper and pencil requires discipline by the students to keep their hands away from the keyboard; it can be seen as merely an esoteric exercise and can be beyond the grasp of many. The lecturer needs to be able to demonstrate the concrete advantages of the *software engineering approach* in order to encourage students to forget the habits of a lifetime and to adopt a deep approach to learning instead.

Laboratories and tutorials are normally the places

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where the theoretical ideas from lectures are fleshed-out to give students the practical experience necessary to reinforce the concepts and to show how the theories work in the *real world*. Unfortunately, the author was allocated one hour per week of lecture time to teach an introduction to software engineering to third year electrical engineering students. Software engineering lectures without labs or tutorials can appear to be incorporeal. To create an environment that would generate the enthusiasm necessary to give students a chance of a satisfactory and lasting learning experience, it was necessary to supplement the potential boredom and alienation of the one hour lecture disconnected from immediate practical application.

Motivation is an essential force in the teaching-learning process. In a word, it was vital to motivate these students, because only through motivation would it be possible to get them to voluntarily direct extra time and energy into a subject that did not offer immediate rewards [3].

BROADER GOALS OF THE SUBJECT

In order to claim that our students are *educated* rather than *trained*, and that they are prepared to fulfil a life-long, meaningful role in society, it is necessary to consider the broader preparation of the student to meet the needs of society. Recent commentaries on Australian higher education, such as Discipline Reviews, the Aulich Report, publications by the Business/Higher Education Round Table and NBEET, note that employers are looking for graduates with more than subject competence [4]. They require people who are also analytical, creative thinkers, attuned to the need for life-long learning, flexible and good communicators who are also sensitive to social contexts [5]. A 1992 report by the Business/Higher Education Round Table, *Educating For Excellence*, stated that all graduates should ideally have:

> *... high order skills in the areas of written and oral communication, have well-developed interpersonal skills,* [and be] *numerically and economically literate...*

Engineering is a discipline with a particularly strong vocational flavour. The review of engineering education (the *Williams Report*) concluded that Australia had a fairly good system of engineering education, but that:

> *... engineering schools paid too little attention to developing the communication skills of their students...* [6].

The Higher Education Council commissioned a study in 1992 to analyse newspaper advertisements and categorise the top twelve skills and attributes sought by employers. The results are shown in Table 1 [7].

Table 1: Skills and attributes requested by employers.

	Skills Requested	Attributes Requested
1	Oral Communication	Motivation
2	Written Communication	Initiative
3	Managing	Commercial Awareness
4	Analytical	Creativity
5	Leadership	Energetic
6	Computer	Ambitious
7	Interpersonal	Self Starter
8	Teamwork	Enthusiasm
9	Research	Hands on Approach
10	Supervision	Innovative
11	Organising	Results Orientation
12	Negotiating	Flexibility

As well as attempting to meet the immediate needs of the introduction to software engineering subject, it was felt that it would be appropriate to try to make the students more aware of some of these broader, non-technical skills required of a professional engineer in society. In order to attempt to achieve some of these goals, it was decided to use a team design project approach with some differences or novel aspects, the reasons for which are outlined below.

A well structured project can develop and exercise many of the skills that it would be desirable for our students to possess: oral communication, teamwork, managing, leadership, written communication, interpersonal, supervision, organising and negotiating. Add to this the fact that it is a computer-based topic and you have almost all the skills required by employers shown in Table 1.

The concept of using team-based projects to develop generic as well as specific skills is not new. Schlimmer *et al* describe similar goals in their paper *Team-Oriented Software Practicum* [8]. The environments in which the projects took place were, however, considerably different; they had considerably more resources with respect to:

- Curriculum hours: several hours per week for four years vs one hour per week for one semester.
- Manpower resources: one staff member plus two graduate students for nine students vs one staff member for 24 students in the first year of operation and one staff member for 45 students in the second year of operation.

THE PROJECT

In the first year that the subject was under the author's responsibility, the students were given a semester-long project to produce a *Requirements Specification Document* (RSD) as a major assessable component of the course. This particular year there were 24 students in the subject, and they formed four groups or project teams of six per team. Each team was given the same outline of the User's Needs, a summary of which follows:

> *A certain university lecturer (who shall remain nameless) is having terrible difficulty keeping computer programs and files classified in an organised way. The lecturer has nearly 1,000 floppy disks, both 31 and 53 inch, in both double and high density format. To compound the problem, these floppy disk archives occur for several different formats, ie MSDOS, MS Windows, OS/2 and UNIX. The disk files contain original commercial programs (some duplicated over several versions), backups of the originals, freeware programs, shareware programs, the lecturer's own programming files (usually organised with respect to the subject for which they were originally intended), Internet news articles, mail articles and various text files. The programs were written in various programming languages representing the lecturer's interest therein, but also included are games of various types, word processing, spreadsheets, database files and images in different formats, eg GIF files. All of these various files etc are for teaching, research or private purposes.*
>
> *Your task is to help to solve the lecturer's problems by conducting a requirements analysis and specification for the problem. Remember that if you do this job really well, it may have commercial possibilities.*

The tasks were allocated in the first week of the 13 week semester. Teams were required to hand in a one or two page preliminary design in week 9, and were required to make a co-ordinated, formal presentation of their design in week 12 or 13. Every team member was required to deliver part of the presentation. Individual contributions to each team's presentation had to be comparable in time span and complexity.

Novel aspects during the first year of operation

All teams started on an equal footing, each was given the same simple statement of User Needs. Teams were told that designs should be considered as submissions for a tender, and that there would be competition between the teams for the best design. A second novel aspect was to let students experience both sides of the customer/contractor equation. This was designed to ensure that students saw the transformation of a simplistic statement of User Needs into an RSD from two different viewpoints. Each team had to act as the customer for another team who were acting as the contractor, eg team A was the customer with team B acting as their contractor, and team B was the customer with team C acting as their contractor etc. At the time of the presentation each team had to prepare a *Customer Report* for their own contractor on whether or not the customer's needs had, in fact, been met. They knew what they had done to meet their customer's needs, but had their contractor done enough to meet their needs as a customer? This hand written one page report was handed in on the day after the presentations, and formed part of the assessment of the subject. The contractor's submissions were eventually ranked from first to fourth, and marks allocated accordingly.

Novel aspects during the second year of operation

In the second year that the subject was run, ie with a new cohort of students, there were 45 students in the class. They were again formed into four teams of roughly the same size. This time the project involved taking the RSD, ie the tender submission document, from one of the previous year's project teams, and producing a Design Document from it. Teams drew lots to decide which RSD they would be working from. This time the teams did not start on an equal footing as some of the RSDs from the previous year were better than others. There was no customer/contractor interaction this time because each RSD was different. Each team, however, would have to completely understand their own RSD before being able to transform it into a Design Document.

THE PROJECT TEAMS

With guidance on maximum and minimum numbers, students were able to select their own teams. For the purpose of this subject we can define several broad ethnic categories as follows:

1. Southern European
2. Northern European
3. Middle Eastern/North African
4. South-East Asian

Table 2: Ethnic mix of the design teams.

Team	Category			
	1	2	3	4
A	4	1	0	1
B	0	1	0	5
C	5	1	0	0
D	0	0	2	4
E	7	5	0	0
F	4	5	1	3
G	0	0	0	10
H	0	0	0	10

In the first year of operation there were four teams (A to D) and a total of 24 students. In the second year there were again four teams (E to H) and a total of 45 students. Table 2 shows the ethnic mix of the teams across the two years of operation of the subject.

There was no particular intention to investigate the effect on team performance of ethnic mix when this particular subject was first developed, although the author has had the opinion for some time that ethnic and cultural integration, rather than ghetto-like segregation into single culture groups, would be more beneficial for the vast majority of our students. From Table 1 it can be seen that the majority of skills required by employers relate directly to, or rely upon, students' fluency in English. In culturally diverse groups, English would probably be the only common language. (This is not restricted to groups of any particular background, as in another subject one team comprised one student of Cambodian descent who speaks only Cambodian and English, and one of Vietnamese descent who speaks Vietnamese, Chinese and English.) The need to communicate to other team members would therefore require students constantly to practice their English skills, and, as the old saying goes, *practice makes perfect*.

It would appear that team A was the most culturally diverse, but in fact the one student in category 4 was an Australian student of Chinese descent whose family have been living in Australia for three or four generations. He has a very *Australian* outlook on life and has no language difficulties at all. The most diverse team was actually team B. The one category 2 member was a strong individual, as were a couple of the category 4 members, and this, it was later revealed, resulted in the occasional healthy exchange of views. While they were not exactly rivals, two of these three were *natural* leaders and, as can be seen from the results indicated in Table 3, the group benefited from the healthy interaction of these two team members. They led by joint example and both insisted that all team discussions should be in English.

In the second year, teams E, G and H were almost mono-cultural (each in its own way); while team F was very diverse indeed.

THE PROJECT ASSESSMENT

Students sometimes learn very effectively from interaction with others, as in a team project. Some are better than others at certain things and if *group mentoring* occurs, this can help to develop a similar level of expertise in the rest of the team. The opposite can also occur however. Some students can hide behind the expertise of others and not learn for themselves. Sometimes the better prepared students will try to *protect* their less well-prepared colleagues from individual and, thereby, team embarrassment by attempting to intercept assessment questions and answer on behalf of the team.

For the reasons noted above, the project assessment was designed to encourage full participation by all team members, team collaboration, confidence within the team and competition between the teams. The following criteria were actually used to assess the presentations:

1. Introduction
2. Full team participation
3. Quality and use of visual aids
4. Breakdown of workload
5. Consistency
6. Individual presentations
7. Time management

In addition to these standard features, two more criteria (8* and 9*) were used, and these were different for each year. In the first year the assessed components 8* and 9* were as follows:

8*. The other team's mark

9*. The inclusion of cost information

In the second year of the project the assessed components 8* and 9* were:

8*. Adherence to their own RSD

9*. Fixing oversights/incorporating changes, ie correcting and updating the RSD from which they were working

Table 3 shows how the teams fared with respect to the assessment criteria. (Note: the sheer numbers involved in the second year of operation made comparisons between the two cohorts of students very difficult as it obviously affected work breakdowns, time management, etc. For this reason, direct comparisons between team performances have been kept, as far as possible, within each year, with relative compari-

Table 3: Results obtained vs assessment criteria.

	Assessment Criteria								
Team	1	2	3	4	5	6	7	8*	9*
A	B	A^-	B^+	B	B	B	A	B^+	D
B	B^+	A^-	B	B	B^+	B^+	A	B^+	A
C	B^-	A^-	B^+	B	B^+	B	B	C	A
D	B^-	A^-	B^-	C	B^-	C	C	C	D
E	C	C	A^-	C^-	C^-	A	A	A	C
F	C	A	A	A	C	C	A	B	C
G	A	C	C	A	C	A^-	C	C	A
H	B^+	C	B^-	C	C	C	C	B^+	A

sons of general trends across the years subsequently made.)

A quick analysis of the results shown in Table 3 suggests that in the first year (ie teams A to D) team B looks to have performed best overall, and in the second year (teams E to H), team F has achieved a similar overall advantage with respect to their peers.

AN ASSESSMENT OF THE ASSESSMENT

As the presentations and reports produced by teams A to D were being marked, patterns appeared to be developing. For the less diverse teams, it was difficult to identify the real contribution of individual members of the team. It was easier to identify the originator of separate components from the most diverse team. Team B's presentations appeared to be individual efforts that had been co-ordinated and channelled towards satisfying the team's goals. During assessment in the second year, this type of *directed individualism* was particularly looked for.

In the second year, one team originally scored very well in category 5, *consistency*, in the presentations. The presentations from this team actually appeared to be almost homogeneous; they were slick, with great cohesion and singularity of style. There was some lack of individualism in their presentations however, the reason for which became apparent later. Their mark had to be adjusted afterwards when it was revealed that one team member had virtually prepared scripts for the other team members to use in their own presentations.

As observed above, as far as language and communication skills are concerned, the more practice the better. At Victoria University of Technology, figures show that up to 40% of students are from non-English speaking backgrounds, and that many of our students come from the *disadvantaged* western suburbs. It has been the author's experience, however, that the better students do not wish to hide behind the tag of *disadvantaged*, and would rather take every opportunity to become self-sufficient and able to compete with their peers on an equal footing. For them it is a matter of pride to be seen to have *done it* for themselves and not to need favours. It is easy to see, therefore, why students with language difficulties would benefit from working with students with a greater degree of language proficiency. The benefits for the latter group are relatively obvious when one takes the time to think about it.

It is very easy to sound as though you know what you are doing, while, at the same time, hiding behind the technical jargon of a subject. It is only possible to strip away the technical facade, however, and present a topic in a very simple, easy to understand fashion when you really *do* know what you are doing. In this team-based project, with all team members willing and eager participants, all students had the need to communicate their own part of the project to the rest of the team. To do this it would be necessary to replace the jargon and simplify the topic to ensure that all could follow.

Within the team, students would be seen as role models and experts on their own parts of the overall project. Since students usually wish to impress and not disappoint or fail their peers [3], and without even being aware of the fact, they would have to adopt a deep approach to learning rather than a surface approach [1]. A surface understanding of the topic would not permit the summary, rewording, simplification and alternative explanation strategies necessary to communicate efficiently within a more culturally and technically diverse team.

After the project presentations, in the second year of operation, it was decided to interview some members of some teams (F and G) to get feedback on the team-based project idea as a whole, but more specifically to gain a better insight into factors such as:

- Each team's mode of operation
- Communication within the team

- Reasons for electing to be in that team, or for a team to allow an individual membership of the team
- Interaction within the team and between teams, etc

Another objective was to find out if any of the learning experiences noted above actually occurred, and if they, or any other factors for that matter, had had any significant bearing on why some teams (ie the more diverse ones) had performed better than others.

Interview with team F

The informal interview with team F may be summarised as follows:

- Team membership was work related, not just because they were friends.
- Individuals had confidence in their team mates because the team members had similar work styles, attitudes to completion and all wanted to contribute.
- Sub-teams were formed and tasks allocated, and sub-teams assisted other sub-teams that were dealing with overlapping topics when their own tasks had been completed.
- Decisions and workloads were allocated democratically, then one person co-ordinated the team.
- All team members contributed equally, except in one sub-team, where one person tried to act as the spokesperson, but was not allowed to do so by the rest of the team.
- They all stated that they had learned something from their team mates.
- The team as well as the individual became a focus for success.
- All were aware of the competition between teams, but one person divulged team information to another team. This was particularly unpopular with *all* the other team members.

Interview with team G

The informal interview with team G may be summarised as follows:

- Team membership was mainly because they were friends and they wanted to help each other, and they were very comfortable with team work.
- Many immediately resorted to their native language, rather than English, for team discussions, while others tried to insist on the use of English.
- Many used a very *hands-on* learning style, with their success being attributable, in some part, to a trial and error approach.
- A team leader was elected, who thereafter allocated workloads (as it turned out, to a much finer level of detail than he should have done), co-ordinated the team and made most of the decisions.
- Some team members were very active and contributed wholeheartedly to the project, several others were exceptionally passive, showed no initiative and would only do exactly what they were told to do, and then only after considerable pressure had been applied.
- Some had tried to form teams with non-Asian students in order to enhance their own English skills, but had found that many *European Australians* were not patient enough to cope with students who had language problems and wanted to practice their language skills.
- Some thought that they worked extra to overcome their language limitations (though not necessarily on English itself), and that this heightened work ethic might encourage others to work harder so as not to be embarrassed.

STUDENT INTERNATIONALISATION

David James wrote:

> *This world does not need more statements, and it does not need more communications that travel in only one direction. Rather, the world needs communications that are received, understood and returned with goodwill and the promise of continued interaction* [9].

These comments were related to trade within the global marketplace, but they are equally applicable to scientific, engineering, political and social communications as well as business interactions. How can one adopt the philosophy of *When in Rome ....*, if one is unaware of what the Romans actually *do*?

Some cultures developed in an introspective and isolationist atmosphere. Modern transport and telecommunications have meant that these cultures must now face dealing with the rest of the world. Other cultures have evolved in a travel and international trade environment. The first step to being able to handle cross-cultural interactions is to accept that differences exist. Only then is it possible to try to identify the specific differences and modify your own behaviour accordingly. Mixing and working with people from a culturally different background is one step to overcoming cultural barriers that many students may not even be aware of. This is a multidirectional learning experience through which students from all cultural backgrounds can benefit.

CONCLUSIONS

Preparing and presenting new subjects is always somewhat of a challenge, but it need not be seen as an insurmountable problem. One of the keys is to capitalise on the naturally sharing nature of many of the students, and to develop an environment in which *group mentoring* is likely to result, so that the total of the knowledge received by each student exceeds the accumulated sum of the knowledge transmitted by the lecturer.

In the conduct of this subject it appears as though the teams with the greatest multicultural diversity did, indeed, perform better than the more monocultural teams. Many students appeared to subconsciously replace long-standing surface learning approaches with a deep learning strategy so that they could create half a dozen explanations for their own aspect of the project in order to help team mates. Students with language limitations were helped by colleagues, usually in a positive way, so that they would become more independent as a result of the assistance rather than relying on assistance in the future.

Students with a cultural propensity to a *collectivist society* helped the *individualist society* students to develop their team spirit and loyalties [10]. *Individualist* students helped the *collectivist* students to be able to express their *directed individualism* within the confines of the team project. For many students from collectivist societies, academic achievement has much higher social significance that for students with individualist backgrounds. For this reason they are more prepared to forego other activities in order to achieve academic success. It is also possible that the more highly tuned work ethic shown by some Asian students may help others to diminish the Aussie *she'll be right, mate* attitude of many other students.

Education is a more global activity today than it has been in the past. Australian students venture abroad to be educated and overseas students attend Australian universities on a full time, part time, full fee or foreign exchange basis. The mix of cultures, education methodologies and experience styles that seems to be necessary to create a type of education mobility appears to be satisfied by this type of *multicultural* project approach.

Increasingly, our engineers and computer specialists are taking opportunities to work overseas. Many employers now operating in Australia are part of multinational organisations. Working overseas and discussing contract details with local negotiators can be a challenge for the most seasoned engineers, let alone new employees [11]. Students who have developed a better appreciation of the different approaches that might be expected by overseas clients or contractors could offer this knowledge as an additional skill to potential employers.

While it is not suggested that deliberately creating culturally mixed project teams is appropriate in all, or even most, cases, it may be appropriate in some, and should, therefore, at least be considered as an alternative to more conventional groupings. The cultural interaction within the more diverse teams really does appear to have provided many mutual educational and learning benefits above and beyond those anticipated at the outset. Students could, as a matter of course, be made aware of the potential benefits before they make their decisions on team composition.

The occasional success, as achieved with the team-based project idea used in this subject, especially when accompanied by some unexpected (and hopefully exploitable) learning situations, can provide the fillip necessary to encourage future educational experimentation.

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BIOGRAPHY

Alec Simcock is a senior lecturer in the School of Communications and Informatics at Victoria University of Technology. He graduated from the University of Kent in 1972 with a BSc (Hons) in Electronics, and then worked for twelve years for the Procurement Executive of the Ministry of Defence in the United Kingdom. During this period his major research interests were in digital circuit design, digital data switching, computer controlled communications systems and the use of embedded microprocessor systems to replace hardware. In 1984 he joined the then Footscray Institute of Technology as a lecturer in communications, circuit theory, computer programming and digital systems. He has been course director, year supervisor, section leader, selection officer, etc. While doing all of this he obtained a Master's of Engineering in 1990.

He currently teaches mainly in the areas of computer systems, embedded systems, microprocessors, computer technology, community-based project applications and the wider impact of the use of *computers in society*. His main research interests are in the fields of alternative teaching tools, teaching effectiveness and ethics and morals in computer usage. His technical research interests are in neural network applications, decision support tools and super system support.