Designing Project-Based Courses with a Focus on Group Formation and Assessment

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The value and the pitfalls of project and group work are well recognized. The principles and elements which apply to projects in general, apply to project-based courses. Thoughtful and detailed planning, understanding of the stakeholders and their needs, a good design, appropriate testing, monitoring and quality control and continual management can maximize the benefits and minimize the negatives. In this article we draw together the literature to consider key design choices of project-based courses considering: type, length, size, management, participants, and content with a particular focus on the composition of groups and the issues surrounding assessment.

Categories and Subject Descriptors: K.3.2 [**Computer Milieux**]: Computer and Information Science Education—*Computer science education, curriculum, information systems education, literacy, self-assessment*

General Terms: Management, Measurement, Documentation, Performance, Design, Human Factors

Additional Key Words and Phrases: Group-based courses, assessment, group formation

ACM Reference Format:
Richards, D. 2009. Designing project-based courses: With a focus on group formation and assessment. ACM Trans. Comput. Educ. 9, 1, Article 2 (March 2009), 40 pages.
DOI = 10.1145/1513593.1513595. http://doi.acm.org/10.1145/1513593.1513595.

1. INTRODUCTION

"Learning by doing" is a sound pedagogical approach dating back at least to the early 1900s [Grant 2002], lying at the heart of project-based courses, and supporting both the constructivist and constructionist views. According to constructivism [Vygotsky 1978] individuals, in ways unique to them, use interactions such as activities and discussions to build on their current knowledge and construct new knowledge. Constructionism [Harel and Papert 1991] additionally places importance on the construction of personally meaningful artifacts which can be shared and reflected upon. Even when conducted within a group setting, project-based learning offers "considerable individualization of

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curriculum, instruction and assessment—in other words, the project is learner-centered" [Moursund 1998, p. 4].

Project-based courses are common in computing education. As a method within the problem-based learning toolkit, projects can be used at any stage within a degree program to explore alternative and often more complete solutions to a given problem allowing the theory to emerge as necessary. Further motivation for and uses of project-based work for cooperative education in information technology (IT) are presented in Fincher et al. [2004]. In an earlier book, Fincher et al. [2001] present numerous composite case studies and specific case studies describing types of projects (e.g., final year individual, research-type project, project with client, design-and-build project, etc.). The insights provided are the result of the collective experience of a UK computer science consortium. Somewhat similar to the use of design patterns in software design, Fincher's book offers summarized bundles of good practice for troubleshooting project related problems. Similarly, Clear et al. [2001] raise questions and offer advice on a number of issues, such as project deliverables, sponsors, financial, legal and ethical matters, and administration, related specifically to capstone units. Other less prescriptive literature reports results of studies testing, for example, a certain method for assigning groups [e.g., McConnell 2006] or a discussion of a specific subtopic such as the benefits of peer assessment [e.g., Orsmond et al. 2000].

This article is the result of searching through the literature, such as the above resources, to get ideas for how best to redesign our final year capstone project units for each of our named degrees. The units aim to tie together the learning in previous units and prepare the student for application of their knowledge to the workforce (spanning at least seven of the 11 project categories in Fincher et al.'s [2001] case studies). In these units the project is the key activity and the project itself is both a learning vehicle and outcome. While many interesting specific results, pearls of wisdom and practical examples could be found in the literature, we could not find one source to assist us with the redesign of our final year project units discussing the range of issues of interest to us. For example, often a solution was offered to a certain problem but there was insufficient discussion or motivation to explain the reasons for or issues related to the choice. To address this shortcoming, this article draws together a body of work by providing pointers to and discussion of the findings based on the collective experience and experimental studies of others and ourselves over the past decade.

This article is structured using the following design questions which were of great interest to us and relevant to many group-based projects and which were raised, but not explicitly or fully answered, by Grundy [1997]:

—Should such a course use industry or "made up" projects?

—Should project work be group-based, individual, or a combination?

—Should groups be self-selected or organized by the lecturer?

—How long should projects be—a whole year, one semester or part of a semester?

—How should projects be managed—by students or the lecturing staff?

—Should such courses have lectures and tutorials, and if so what material should these cover?

—Do students need preceding or subsequent "theory" courses to prepare them for or build upon their project course experiences?

—How can project work, particularly group work, be most effectively and fairly assessed—by the lecturer, by peer-review, by industry clients or a combination?

In addition, we asked:

—If groups are selected by the lecturer, on what basis should they be formed? Should they be homogenous or heterogeneous?

—What is the optimal size for groups?

The initial answer to each of these questions, except for the last one, is "it depends." Below, we have sometimes provided pointers and other times more detailed description of the technique or study. We include some of our own experience and data and also describe new strategies and measures we have implemented this year with some preliminary results. Group formation and assessment are given greater consideration as we believe they are key choices to get right and there are many options to consider.

2. INDUSTRY VS. MADE UP?

This question is often answered pragmatically. Are industry sponsors available (not only willing but also accessible) and do the students have the necessary skills to succeed so that all parties will be satisfied? Fincher et al. [2001] suggest the parties and process by which topics are negotiated or found for each type of project. Clear et al. [2001] discuss sponsors particularly with respect to the importance of managing client expectations. Moving along a spectrum (no sponsor, that is, instructor acts as sponsor, internal sponsor, non-profit organization, profit-making organization), Clear et al. [2001] note that increasing robustness is required by the sponsor of the end product and increasing commitment of the sponsor to the students, to ensure the right product is delivered. Similarly, we note that more commitment on the part of the student is required along this continuum with increased learning benefits and growth in personal maturity which follows from the added responsibility.

To ensure that our students are up to the challenge and the reputation of our program and university are not compromised, we restrict participation in an industry project to students with a grade point average (GPA) of 2.75 (out of 4) or above. As anecdotal evidence of our past students' perceived value of the industry project, this year three out of five industry groups are hosted by alumni who had themselves participated in our industry group project. However, for other students we offer an internal project to provide a significant group and project experience for all of our named degrees. We note that the learning outcomes (see Section 9) for the industry and internal projects are identical, however the industry projects are able to achieve a higher level of authenticity in learning Outcome 2. As a viable addition to Clear et al.'s [2001]

abovementioned spectrum (fitting between internal sponsor and nonprofit organization), where possible for the internal projects we have brought in someone from industry to provide a real world problem (for example, a student management system for the NSW Therapeutic School of Massage or disability support system for a rehabilitation center) and to provide occasional clarification and comment on solutions developed. Both our industry and internal programs fall under what Fincher et al. [2004] have termed a cooperative education halfway house because in both cases students are not fully immersed in industry but are enrolled in up to four other units concurrently each semester.

In project-based courses, the project is what is assessed, regardless of whether the process and/or product are the major focus. Thus answering the industry versus made-up question can be tackled from the viewpoint of conducting assessment. Biggs and Tang [2007] recommend that the general emphasis when conducting assessment should be on:

1. "Authentic" as opposed to "performance" assessment—that is, an active demonstration of the knowledge in question rather than thinking or writing about it.
2. Contextualized rather than decontextualized tasks—applying contextual information rather than entirely abstract solutions.
3. Divergent (in at least some respects) rather than entirely convergent tasks—allowing students to expand, create, and explore unintended learning outcomes.

These criteria suggest a preference towards an industry based project which involves a real problem to be solved, a rich context which includes the client, company and team and problems which require the students to experience uncertainty, risks, and change.

We can further differentiate project content (the actual curriculum implementation) on the following bases [Grundy 1997, p. 173]

1. Theoretical versus practical.
2. Relationship between previous courses.
3. Software choices (CASE tools, development environments, etc.).
4. Lectures versus laboratories versus tutorials.
5. Reference materials (texts, lecture notes, examples).

These bases can be used to determine the appropriate type of project. For example, if certain theory is to be used, or certain previously taught content needs to be reinforced, then it might be necessary to "make up" a project which nevertheless offers a problem as real and contextually rich as possible. Similarly, students may not have acquired sufficient knowledge to complete a project, such as not having learned project management skills, and thus may need lectures and/or a textbook to run in parallel with the project. Project scope will also vary considerably based on these factors. For instance, Combs et al. [2005] have identified four types of projects that could be conducted for the same general problem of course scheduling.

Fincher et al. [2004] identify professional and academic complexities in defining the nature, context, and construction of the IT discipline. The particular academic view (tool, ensemble, algorithm, or proxy) and the professional perspective (IT-specific disciplines, IT-intensive disciplines, and IT-supportive occupations) will have a bearing on what project is most suitable and potentially necessitate the need to bring groups from different degree programs together to complete a given project (for example, we bring our BIS and BIT students together into teams to contribute different skills to the their capstone unit projects). Other programs such as the Genesys student-run software house at the University of Sheffield, the Educational Technology House (ETH) at the University of Colorado (Boulder), and the R&D Project at the Auckland University of Technology also draw disparate students together (even freshmen, sophomores, juniors, and seniors in the case of ETH) to gain a wide range of skills according to the needs of projects as they arise.

Finally, even when units of study are based within industry, different objectives can be emphasized. Costley and Armsby [2007] distinguish between subjects that treat work-based learning (WBL) as a mode of study (characterized as subject curriculum, knowledge based, university is knowledge provider and assessor) or a field of study (characterized as work-defined activities, practice-based, university-is-knowledge catalyst, work-based assessment). Our WBL units primarily take a field of study view; however, we do include some subject curriculum as needed, an exam at the end worth 25% and the industry deliverables are marked by the academic supervisor for quality control across groups.

3. GROUP-BASED VS. INDIVIDUAL VS. COMBINATION?

Project work does not necessarily involve a team effort. Fincher et al. [2001] defines the *Final Year Individual* project. This type of project is common in degrees with an industry internship or practicum, though we note that often these individuals are placed in teams within the host organization.

Some disadvantages of group work have been identified. Barker [2005] forewarns that simply requiring students to work in groups does not necessarily lead to improved learning outcomes. The climate within a typical computer science classroom has been found to be defensive resulting in students who are reluctant to collaborate [Barker et al. 2002]. Other reasons preventing a positive attitude to group work include fear of plagiarism, freeloading, ego, effort, assessment, legal requirements, communication overheads, and technical support [Bower and Richards 2006]. Similarly, Salomon [1992] describes several group phenomena, especially social loafing and freeriding that compromise team effectiveness, further examined by Houldsworth and Mathews [2000]. Bourner et al. [2001] found that negotiating and working with other people underpinned the top three reasons for not liking the groupwork project. On the basis of their survey of UK computing departments, Lejk et al. [1997] report a general feeling of caution and uncertainty among academics about group assessment (as opposed to group learning).

Table I. Survey Questions and Student Responses

Statement	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I learned more by working in a group than if I'd done the assignment on my own.	5	9	53	33
2. I enjoyed working in a group.	5	7	57	31
3. It was easy to get the group to work together.	10	22	48	20
4. It was easier to get the task done by working in a group than if I'd done the assignment on my own.	11	18	44	27
5. I would like more assignments to involve group work.	14	21	45	20
6. Everyone in my team did an equal share.	5	17	55	23
7. Most people in my team did an equal share.	3	9	56	32
8. I think programming and testing works well with groups.	4	18	43	35
9. I think training to work in groups is needed.	3	13	36	38
10. I think choosing our own groups is best.	1	2	41	56

Despite the pitfalls, there is a need for students to be able to work in a team to meet professional accreditation requirements and employers' demands (Fincher et al. 2001's *Professional Bodies View* project type). For this reason and the various benefits that group work can deliver [Grant 2002] project-based units, including ours, primarily involve group-based experiences and assessments.

Increasingly, we have been using group work in nonproject-based units for a small proportion of the assessable tasks. This has given us the opportunity to see whether students found the experience worthwhile as they are able to consider and compare the advantages and disadvantages of group, individual, or mixed activities within the same context. Also, learning to work in teams should be a gradual process [Hogan and Thomas 2005], rather than a sink or swim experience in the final year. The results reported in Table I were collected in 2006 in a second year unit which provided approximately 119 students with their first introduction to Object Oriented Programming using Java, after learning C++ in their first year. Only the second assignment was group-based. To ensure that each person understood the basic ideas, the first assignment was an individual task. A third assignment allowed individuals to explore the material at a level of their own choosing. The survey was administered at the end of the semester after all assignments had been completed and thus the answers reflect their experience with Assignment 2 as compared to 18 months of individual assignments in this and other units. The responses to questions 1, 2, 4, 5, 8, and 9 indicate a strong preference for the use of group work over individual work. We will revisit some of the other responses as they relate to other sections. In the assessment section we discuss mixed individual/group approaches to assessment.

4. SELF-SELECTED VS. ORGANIZED BY THE LECTURER?

Selection of group members by students can allow more harmonious groups to be formed but often skews group ability levels with more capable students

grouping together [Grundy 1997]. One of the motivations for allowing students to form their own groups is based on the stages of group development relevant to group success as identified by Tuckman and Jensen [1977]:

—Forming—setting clear, worthwhile, and compelling goals.
—Storming—a thrashing about stage where members develop relationships.
—Norming—setting objectives, establishing operating rules, identifying training needs.
—Performing—the team works together to complete the project task.

Redmond [2001] points out the following problems with student selected groups:

—Students tend to choose partners who are like them in gender, ethnicity, knowledge, and ability. This claim is supported by Rutherfoord [2001].
—There are often issues related to groups that are too small or large, or unallocated people.
—Students learn less about how to work with unfamiliar people, which is usually an intention of groupwork projects.

The survey results to Q10 in Table I indicate that, at least for these second year students involved in a short-term (six weeks) group project, allowing students to choose their own groups is best. As a caveat, for the past three years in this unit (including this cohort) and another second year modeling and analysis unit also using group work in one assignment, roughly only 50% of the class have chosen to form their own groups, even if 97% claim to prefer to have the choice. In all offerings students were advised four weeks earlier that they will need to form groups. With a number of reminders, only approximately 25% of the class notified the lecturer of their group by the specified date. The lecturer then formed groups with the remaining 75% and advised the class of the groups. Another 25% of the students then contacted the lecturer with their excuses asking for permission to form their own group. Amusingly, this pattern (dance) has been observed each year. Also, every year there are some individuals who contact the lecturer at the start to ask to be put in a group and don't want the problem of finding other team members.

For the final year projects we follow the advice of the consensus of the literature recommending and describing lecturer formed groups. In our yearlong projects, as one of our strategies for developing software engineering teams in line with the recommendations of Hogan and Thomas [2005], and to facilitate storming and norming we run "Working in Teams" hands-on workshops in weeks three and four which they attend with their lecturer-allocated team members. Speck [2003] emphasizes the need to train students how to be successful collaborators in terms of executing effective leadership and conflict resolution skills, as a means of creating effective group functioning. In Question 9 in Table I, we see that our students agree. Similar to the activities of McConnell [2006] we use icebreaking activities to promote group interactions and understandings. While the phases of group development can be

expedited by allowing groups to self-form, this quote from the blog of a capstone unit student reinforces the challenges of "working with friends."

> *Working with friends or someone I know is not easy. Further, the relationship and/or friendship can break at some point. It's not easy but I need to kill my emotion first and I had to think once more before I wanted to say something to my friend which is my team member. And I have to let him/her know, it's nothing personal but it's something I have to do/say to do our project. and I had to keep reminding him/her it's for me, us and him/her to pull her/his weight.*
> *When I got really angry of his/her laziness, I just kicked my teddy bear on my bed or I was writing comments on contribution form. That helped a lot. [female, 2008].*

5. HETEROGENEOUS VS. HOMOGENOUS?

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] favors 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 (which tend to be segregated based on ability with top students with top students and bottom students with bottom students). McConnell [2006] used GPA as the primary criterion for streaming groups (for example, for five groups a GPA ordered class list with 1234554321123 .... would be used to form the groups). After this, manual checks are performed to ensure no strong personality clashes (in conjunction with other staff if necessary), and no isolation of women or minority groups. Until this year, this has been our main approach but also first grouping according to day or evening availability for meetings. To avoid the common situation where one or more teams are formed later than the others (and as a consequence tend to comprise the less organized, motivated, or capable students), we form groups in week three and use weeks one and two for class meetings involving lectures and discussions about managing people and resources, personality types and decision-making styles, project management issues, the project problem domain, and the project's milestones and expectations. We also gather any specific needs and preferences of the students such as availability or locations they are not able to travel to (which precludes some industry sponsors).

McConnell [2006] formed groups on the basis of a student survey at the start of semester. The survey instrument asked students for their GPA, major, minor, whether they like solving logic problems, are patient when solving problems, enjoy the process of solving a problem more than finding the answer, enjoy group work, and dislike asking for help. Groups are then balanced not only on the basis of GPAs, but also based on answers to the other questions. Items asking students for their preference between dogs and cats, vanilla and chocolate, comedies and dramas, coffee and tea, and Coke and Pepsi were also asked in order to mask the intent of the questionnaire.

In a controlled experiment examining groupwork in a second-year systems analysis and design subject, Lejk et al. [1999] found that high-ability students obtained considerably lower grades in mixed-ability groups than in streamed groups (when members of each group received 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.

In a similar study investigating the effect of group ability composition on group processes and outcomes, Webb et al. [1998] found that group composition had a major impact on achievement and group discussion. Their results were based on 445 eighth-grade science students across five schools, and showed that groups with above-average students produced more accurate and high-quality answers and explanations about how to solve the test problem than groups without above-average students. This led to below-average students who worked with above-average students showing higher achievement than below-average students who worked without above-average students. On the other hand, high-ability students generally performed better when they worked in homogeneous groups than when they worked in heterogeneous groups [Webb et al. 1998]. The fact that the group performance is correlated to the group-member with the highest ability level is supported by Laughlin and Branch [1972, cited in Webb et al. 1998], who conducted a related investigation using a test-retest experiment involving 1,008 college students.

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)? Webb et al. [1998] note that in their studies heterogeneous groups provide a greater benefit for below-average students than they impose a detriment on high-ability students.

Lejk et al. [1999, p. 12] propose a solution to the problem:

> *The dilemma can be overcome by assessing students individually on the learning they have undertaken in an extended group project. There is no reason why peer assessment should not be included within the groupwork but this would act as formative feedback to the student and not be used in any way to arrive at a grade.*

Speck [2003] provides nonability-based criteria upon which professors might consider grouping students for problem based learning purposes, including "students' interest in a particular topic, personality types as identified by the Myers-Briggs Type Indicator [Collins 1989; Jensen and DiTiberio 1984; Spiegelhalder 1983], compatibility of students' schedules for out-of-class meetings [Summers and Redmen 1989]" [p. 60]. Speck [2003, p. 60] also discusses the role of gender in group formation:

> *. . . opinion is divided about whether student groups should be homogeneous [Tebeaux 1991] or gender balanced [Rehling 1996]. Lay*

> *[1992] and Sirc [1991] say that men and women have different communication styles, and literature on collaborative groups recognizes that gender differences can be the source of group difficulties, such as stereotyping women as secretaries and men as experts. Thus, women can become, de facto, secretaries for a group's work. However, differences in communication styles between men and women can be a means of benefiting all members of a group [Atwood 1992; Burnett and Ewald 1994; Chiseri-Strater 1991; Lay 1989].*

Speck [2003] recommends gender-balanced groups as a means of preparing students for industry where gender-mixed teams will be the norm. He suggests that class discussion regarding Markel's [1998] assertion that "women's communication patterns are more focused on maintaining the group, and men's on completing the task" might help a professor to raise issues about respect for and appreciation of individual differences.

Cultural differences also require consideration in team formation. Speck [2003] discusses how behavioral differences may result from a person's culture, for instance how some nonnative English speakers may be reluctant to criticize the work of others. As well, the background culture of team members may influence writing and reporting abilities, and thus to form teams with the same (non-English speaking) background together would be to group people with the same weaknesses. Lejk [2008] provides a comprehensive 96-page report drawing together research into the effect of cultural dimensions such as individualism, collectivism, concern for face, power distance, and communication styles on learning with a particular focus on their effect on group work and cooperative learning.

Personality types can also be used in the selection process. Rutherfoord [2001] describes an experiment that was conducted to gauge the effect of basing groups on heterogeneous personality types as opposed to homogenous types. The Keirsey Temperament Sorter instrument[1] was used to established each student's Myers-Briggs personality type. The four dimensions of the Myers-Briggs scale are Extrovert versus Introvert (E/I), Sensing versus Intuitive (S/N), Thinking versus Feeling (T/F), and Judgment versus Perception (J/P), forming a total of 16 possible personality types. Other factors such as industry experience, gender, and ethnic background were spread evenly between groups as far as possible. Rutherfoord [2001] found that the heterogeneous groups functioned more effectively and experienced less frustration than the homogenous groups.

Nelson and Bass [1994] describe a "Managed Group Formation" process that they use to form groups in their policy courses. Their process involves:

1. Obtaining a value profile of the students (the 80-item Personal Value Profile instrument by Nelson [1990] is used, containing 16 dimensions and taking less than 20 minutes to complete).
2. Partitioning students into homogeneous clusters of between four to seven students using Breiger et al.'s [1975] CONCOR clustering algorithm.

[1]Similar instrument is available from http://www.humanmetrics.com/cgi-win/JTypes2.asp.

3. Having all groups solve and present a short case (one lesson followed by a 5-10 minute presentation of recommendations and their justification).
4. Having heterogeneous groups solve and present a case (formed by scrambling the homogenous groups).
5. Discussing with the class the implications of group homogeneity and heterogeneity for group performance, being sure to point out the benefits of group diversity in ensuring a greater sum total of knowledge and approaches to a problem. At the same time discussing the fact that group cohesion, which facilitates group development and cooperation, is strongly favored by similarity, which in turn reduces the vision and creativity of the group.
6. Distributing the roll to class members with the request that they rank order the five class members they would most like to work with (anonymity guaranteed).
7. Using the CONCOR approach on student preferences to designate students to groups.

Nelson and Bass [1994] argue that this approach:

1. Exposes students to the effects of both homegeneity and heterogeneity in groups.
2. Sensitizes students to the biases and limitations of one's personal frame of reference.
3. Enables students to become acquainted with a large and diverse group of their classmates before forming final work teams.
4. Enables the teacher to acquire a sense of student abilities before final work teams are formed.
5. Permits students to express preferences for colleagues while allowing the professor to formulate balanced groups.
6. Allows students to "work into" group case analysis and presentation assignments in a relatively non-threatening way.

Interestingly, in noncomputing learning domains the benefits of heterogeneous abilities and personalities groups are less highly rated by some. Fisher et al. [2004] prescribe forming groups randomly to avoid preexisting cliques, or forming groups on the basis of the type of project or geographic proximity. Only in some cases do they feel a purposeful mix of students in groups on the basis of personal attributes (such as technological skills, leadership ability, and subject matter expertise) is necessary.

Pragmatic issues may also be taken into account when selecting groups. Redmond [2001] believes that student timetable availability is a critical matter to determine groups. As well as background experience and project preference, Redmond uses student availability times in his computer program to select student teams. On a general level, Nicolay [2002] recommends waiting two weeks before making group assignments. This caters to late arrivals or class members who drop the course, as well as providing the opportunity for any personality issues to be identified so that groups can be selected more sensitively.

Table II. Questions Asked in Group Formation Survey

1. Gender: Male/Female
2. How many full years have you lived in a country where the main language spoken is English?
3. Preferences for holding groupwork meetings: Like Day (Y/N), Like Evening (Y/N)
4. How would you rate your programming ability relative to your peers? (Low/Medium/High)
5. How would you rate your programming experience relative to your peers? (Low/Medium/High)
6. What grade are you aiming for in this subject? (HD/D/Cr/P/PC/F)
7. If you had to guess, what grade would you expect to achieve in this subject? (HD/D/Cr/P/PC/F)
8. How many hours per week on average do you aim to allocate to this subject?
9. Given other demands in your life, how many hours per week on average do you expect that you will be able to allocate to this subject?
10. How much of an intravert/extravert are you? (Very Intraverted/Intraverted/Moderately Intraverted/Neutral/ Moderately Extraverted/Extraverted/Very Extraverted)
11. How would you rate your ability to work in teamwork situations? (Very Poor/Poor/Moderately Poor/Neutral/Moderately Good/Good/Very Good)
12. How would you rate the average ability of other people in your course to work in teamwork situations? Scale as above
13. How would you rate your confidence in working with others? As above
14. How would you rate your enjoyment of working with others? As above

Based on the literature, our experience and the desire to make the process pragmatic we have created our own survey. The questions are shown in Table II. Many interesting results can be found in the responses. In a future article we intend to present greater discussion of the survey questions, a statistical analysis of the data, and the effects, if any, of using the survey for group formation. For now we note a few interesting observations involving 74 students (56 male and 18 female). All students, with the exception of two male introverts, rated their own ability to work in teams higher than others' ability to work within a team. Higher GPA students overall rated themselves higher on the introvert/extrovert scale (that is, more of an extrovert). Only 1/18 females rated their programming ability as high compared to 14/56 males (a disparity not supported by the grade achieved by gender in prior programming units). Surprisingly, there was no obvious link between the number of hours a student expects to spend on the unit, the expected grade, or current GPA. For some of the top GPA students, the number of hours they planned to spend on the project were less than half those of some students with GPA's 1-1.5 points lower.

In previous years we have used the following rules of thumb: first divide into day and evening availability, sort within these two cohorts by GPA, create groups of four or five, include either zero or two/three females so that a female (or male) is not the only one of their gender in the group. In recent years the reduction in students interested in the more theoretical, technical and/or mathematical degrees or units has resulted in some teams without a good blend of skills. For example, one group last year had only one team member claiming programming proficiency. To avoid gender stereotyping as observed

by Speck [2003], in the past we have advised groups not to leave the documentation to the females in the team and not to rush into the implementation phase. Now members are fighting to take on the documentation and don't want to know about implementation!

Thus this year in addition to the criteria we have used in the past, we have ensured inclusion of at least two technically competent/programming oriented team members (by combining BIS and BIT capstone unit students), a mix of introverts and extroverts, and balance of English proficiency. Further, in our experience, a key cause of student dissatisfaction is the perception of inequity. While this clearly relates to fairly assessing group work, assessment is not the only issue. From the complaints we had received from students, it seemed important that groups were homogeneous when it came to when they were able to meet and their expectations with respect to grade and hours of effort. A similar sentiment is expressed in the following blog (personal journal) entry:

> *All-night assignments are a part of University life, but to see that someone else is willing to work through till 4 a.m. to help the team effort is something special — it's more than just working for your own assignment, I can't think of a better epitome of teamwork than that. [male student, 2008]*

We look at our initial results in the next section following some discussion about group longevity.

6. LONGEVITY OF GROUPS?

McConnell [2006] points out that when a group is formed there is a portion of time during which the group is less effective because they are learning about one another. Only as students begin to trust each other and understand how to best communicate with each other does their teamwork become more effective. McConnell [2006] believes this process can take four to seven weeks depending on the frequency of group interactions, and as such group membership should stay fixed for a relatively long time (at least a semester). We have observed similar time requirements for our teams to go from forming to performing. In 2001 we commenced year-long industry-based projects to allow a more substantial project to be undertaken (with the possibility of learning and employing alternative processes, techniques, tools, and technologies) and to recognize the significant amount of time required just to establish a sense of group belonging and understand the problem and problem domain. We can also facilitate team development by providing communication opportunities by scheduling rooms and times into the students' timetable.

However for our internal projects, this year we are trialing an alternative so that we can evaluate the benefits of changing teams each semester and alternative algorithms for allocating groups. Last year few group problems arose in the first semester. The real problems raised their (ugly) heads in second semester. At the end of Semester 1, 2008, we asked students to individually notify the lecturer if they preferred to change teams or stay in the same one. In response, 22 of the 55 students said they preferred to stay, four preferred to

change, five didn't mind, and the remainder did not contact the lecturer with their preference. However, since in only one group all members contacted the lecturer to say they wanted to remain in the same group and that group was achieving the best results, the original plan at the start of the year to change groups went ahead. Within the first few weeks of Semester 2, students were reporting in their personal blogs and in the discussion boards that they found it much easier to get started and many were excited by the challenge of putting the team skills they had learned (either through success or failure in the first semester) into practice with a new bunch of people. It is interesting to note some of the comments made by students regarding this question:

> *We have a limited time to complete a project in a semester and I feel that most of it will be taken up just trying to know each other rather than just working on the assignment at hand to achieve the best result based on what we already know of our group members. [male student, 2008]*
>
> *Main downside to a change would be the getting-to-know-new-people overhead. Just getting everyone networked and a schedule worked out could take ages. [male student, 2008]*
>
> *I hope we do have new groups next semester, because I think we have different quality in standard in our group, especially when 2 of our group members can't program and don't have good English. [male student, 2008]*
>
> *I would probably prefer to work with different people, as I feel I would enjoy a project more if I had more to do with the programming of it. In this group, it felt a little like our main programmer didn't want to delegate any of the programming, and this made me feel a little like I wasn't doing my best, and I could do better. [male student, 2008]*
>
> *I wouldn't mind staying in the same group or changing. Staying is good in that we all know our team members fairly well, and do not have to re-adapt to new team members. This means that we can work more efficiently with the next project. Changing groups can allow us to meet new people, assist in dealing with different people and working in different teams. [female student, 2008]*
>
> *I think that whoever wants to have a team change can form a pool so they can pick a new team and whoever does not want a change can stay to have the same team. It is important because in the real world environment, good team spirit means good productivity and no boss on the earth would separate teams that have good spirit to risk the productivity. [male student, 2008]*
>
> *I'm really scared about which group I end up with next semester because by the looks of it everyone seems really serious and a bit off. . . i don't know. . . like my group was full of jolly n happy people . . . they were serious but more to the nice side. . . so ya. . . lets see what happens. [female student, 2008]*

All this talk about switching up the groups is making me nervous. Not because new people scare me, but because I don't want to go through the whole storming, forming, norming, performing stage again since this is supposed to be my last semester. I've normally had bad luck during my group assignments but this time it has worked out very well. For those people who havent been placed in a group which works, well I guess it's a chance for them to taste the bitter before the sweet and practice at making things work by applying the knowledge we are learning at university.
UNLIKE the outside world, there is no real incentive to perform in a group, u cant kick someone out or u cant fire them or u cant reduce pay etc etc. You are stuck with them and i guess i want to be stuck with a team which inspires me to perform!
Please don't change the groups! [male student, 2008]

Overall, the group has been OK, but I would like a change in groups for next semester due to be able to work with a different selection of students, which I think will be good. [female student, 2008]

Changing group's Pros will be - learn to form group again - Save time from making same mistakes. - Apply something learnt from previous group/mistakes

Cons will be - comparing current group with previous group (this is worst I guess, without trust, people cannot make work done). [female student, 2008]

Although I felt very confident with my other team members, knowing each other's characteristics very well, I do think that working with different group in the next semester can allow us to gain more experience as to how to manage a team more effectively. [female student, 2008]

At the end of Semester 2, after having experienced the change, we asked students if they thought next year's students should stay in the same group or change halfway. We are pleased to report that 24 said change (and thus our decision was validated), three said stay the same, seven said it didn't matter due to benefits both ways, and one said let the students decide over December/January winter break before starting the unit. The discussion board thread was headed "One or Two Groups?" and many responses were along these lines.

Two Groups, reasons:

**Chance to meet new people - like people will have to do in the real world. They may have to work with someone they don't like.*

**A Chance to redo documents (I know its a pain) but its good practice. This subject will be the last time we actually do these types of documentation before going in to the real world.*

** The opportunity at an individual level to fix up mistakes made when in the first group.*

**A chance to do something different the second time around, e.g. you did documents in the first group, then you have the option to do coding in the second group*

**The strong points of group members will change.*

One Group:

** Good to maintain consistency in work over the whole year.*

** No need for team members to take time to establish communication between new group members which can take time from a week a few weeks.*

Overall I believe that two groups are better. [female student, 2008]

Being in two groups over the whole year provided a more diverse experience in my opinion. While some what stressful to begin with, I think changing groups twice provided the opportunity to develop other skills. On the other hand, had we stayed in the same group, I think we probably would have had better results. We would have been able to fine tune our work. While there was some scope for this in the second group, it was not as easy. [male student, 2008]

The second comment reflects that changing groups results in the development of softer skills, potentially at the expense of the final product. However, the product is a vehicle and even a failed product can achieve many successful learning outcomes. Clear [2007] notes "if the true role of learning is "transformation of the whole student," not commercial benefit to the institution or isolated individual, then failure is a legitimate and transformative educational experience" (p. 14). Contrary to the student's comment about poorer results, we believe that running a different project each semester resulted in prototypes produced at the end of each semester of similar quality to those usually only produced by the end of the year. We believe this resulted because there was less of a tendency to put off work and deliver a minimal solution in first semester. Interestingly, from swapping groups and introducing a new problem halfway, groups report being able to come up to speed in half or even a quarter of the time it took them in first semester since they had prior experience working in a team and familiarity with the project deliverables.

As many of our students identified, changing teams halfway mirrors the common situation in industry where people and projects change during the course of a project. Our team swap indirectly resulted in swapping of ideas, experiences, and artifacts from the first group experience (which raised some grey areas concerning plagiarism). Direct swapping of projects and project artifacts were trialled by Sure [2000] in order to motivate students to produce professional quality (consistent, complete, modifiable, etc.) documentation. Smith et al. [2001] ramped up the motivation level further by introducing a catastrophic change to the projects within a one semester software engineering

unit concerned with the modeling and documentation phases prior to system implementation. Before the disaster, the class were unwittingly prepared to be "run over by a bus" (ROBAB) through the reinforcement of the need for risk management and consideration of possible disaster scenarios. The actual scenario involved randomly swapping six of the ten groups and swapping the documentation for some teams. While initial reactions varied from anger and confusion to welcoming the challenge, when asked whether we "should run next year over with a bus," 72% were in favor, furthermore, 50% suggested that all groups should be affected.

7. STUDENT VS. STAFF MANAGED?

The issue here is not responsibility for learning or delivering a successful project experience but rather who is responsible for managing the group and the project. In most units the norm is for the lecturer to specify what will be done, assessed, when assessments are due and how many marks they are worth. The prescribed tasks act as extrinsic motivators and assist the student to manage their time and activities. In contrast to this and in line with Fincher et al.'s [2001] *Project with Industrial Involvement*, our industry projects require the students, in consultation with the industry sponsor, to determine what deliverables are required, when they will be delivered, and what percentage of the total project marks they comprise. This is similar to the approach taken by Bidois et al. [2004] in the design of assessment tasks in their Diploma of IT. The lack of given milestones and need for the student(s) to clarify the problem via the sponsor and wider investigation makes the project more similar to a research project than a coursework project, bringing with it new time management issues and the need for internal team-driven motivation. The high level of independence of the groups is a key reason why we require a minimum of a credit average (2.75 GPA) to be allowed to participate in an industry-based project.

Quite novelly, we rotate the role of project leader within each industry group ensuring each member has roughly the same time as leader. In industry team leaders are appointed based on experience, which is an inappropriate basis for leader selection in our student teams. Allowing a natural leader to emerge has many problems (what if there is no one or more than one in a group?) and also robs individuals of the opportunity to experience this role and also to experience what it means to be led. We have seen individuals transformed by having to be in both roles. Rather than the leader role losing any of its authority or responsibility by rotating it, it becomes a highly respected role as each individual grapples with how to fulfill the responsibilities and expectations of the role as set out by the group during the planning phase.

> *I took my role as the first team leader quite seriously. I felt it was my responsibility to establish good practices within the team and get the project off to a good start. I strived to set a high standard for future team leaders to follow. [male, industry group, Final Report 2008]*

> *Being the last team leader for our project, I had an idea of what to expect having seen my team members experience being team leader throughout the year. However, I still remain unprepared and lacking the skills that a team leader requires for a successful project. [female, (different) industry group, Final Report 2008]*

Internal groups had the choice of rotating leaders but were advised to have just one person. One group in first semester tried it and after they made the first rotation decided not to go ahead with it. About midway through semester 1, a thread started called "how to get rid of your team leader," which received quite a few postings containing complaints and criticisms and a few defensive responses from team leaders feeling that they were copping too much of the blame for poor team results. Just as learning to work in a team needs to be taught, it is clear that the role of leader needs more specific preparation and consideration as evidenced by the experience of this follower:

> *Our group leader was an easy going person, soft, saying things nicely, and doesn't push anyone. I expect this type of manager is a meal for lazy people because they don't have to listen to all the complaints from anyone.*
> *It's fine. If that's his personality I know it cannot be changed.*
> *He designed our plan as everyone can pull equal weight, so I've learnt a lot because of him. I really thank him and he did great job until the end.*
> *However, that kind of behavior killed my motivation several times. I'm not sure whether other members felt the same thing.*
> *I know how hard it is to be a leader or manager. They have to listen to all the complaints from staffs, and have to satisfy his/her boss at same time. And I know I'm not a manager-to-be type person either.*
> *Just something I've learned about leadership is being nice to everyone and saying nicely are not always good choices all the time.*
> *And I think if leaders have lil more extra mark (like 2∼4%) they will be more motivated to make team members work and further, they will make team more bonded. [female, internal group, S2 2008]*

While some industry sponsors prefer the internship model involving a dedicated individual rather than a team for a fixed period which the company can manage within one of their own teams, our model suits some companies better. Each year since 2001, we have had companies wanting to take on one or more of our student self-managed teams. Our model for group- and industry-based projects won runner-up (highly commended) in 2004 in the Australian National Business Higher Education Round Table (BHERT) "Outstanding achievement in collaboration in teaching and industry."

Ensuring that project teams stay on track requires project management and use of options such as assessable recording of progress, completion of checklists, and meeting with the lecturer [Grundy 1997]. A survey of academics by Nicolay [2002] emphasizes the importance of communicating effectively, encouraging regular interaction, and monitoring student collaborations.

Assessment usually falls within the role of the lecturer. The use of strategies to ensure consistent marking is important and evaluating "the many as one," assessing the whole group rather than individuals, has been found to be preferred by students [Nicolay 2002]. For increased quality control of our internal projects we provide the project problem description, deliverable definitions document with fixed milestones, standards specifications, the use of TRAC[2] project management software with version control, and mandatory blogging and discussion board participation. In support, a survey of 22 educators revealed that thoroughly structured projects (task description, milestone dates, writing expectations) were preferable to vaguely defined projects [Nicolay 2002].

Mindful that all our students must achieve the graduate capabilities required of an IT professional (see the list provided by Von Konsky [2008] and Von Konsky et al. [2008]), the learning outcomes (LO) given in Section 9 are identical for our capstone units regardless of whether the student participates in an internal or industry projects. It is important that we do not provide scaffolding which prevents internal project students from achieving the learning outcomes, particularly LO1 (involving critical analysis). Bidois et al. [2004] found that in their efforts to provide a compact one-semester version of the traditional computer science capstone unit for their Diploma of IT students, that the project "was effectively too small to encompass all the necessary capability development, as well as provide enough time for students to perform and complete all practical projects" [2004, p. 260]. The structure we provide to internal groups corresponds to what might be provided by the industry sponsor. In some cases what we provide is less structured as some of our sponsor organizations have strict documentation standards and processes to which our students must adhere. The problem statement we provide is half a page. Students must still do background research to understand the problem and produce a complete software requirements specification conforming to the IEEE standard. The deliverables definition provides a list of what must be handed in and when, but success requires the students to read through sets of guidelines and standards and independent investigation. Groups are free to make any design choice (e.g., architecture, programming language, etc.) within the design constraint "you must be able to demonstrate it from within the third year laboratory." All choices must be justified. For both the industry and internal projects students are expected to learn whatever technology is needed to solve the problem or required by the sponsor. This is similar to the philosophy used in the ETH program at the University of Colorado [Fincher et al. 2004]. So while structure exists, we are still seeking to provide an open ended group project (OEGP) [Hauer and Daniels 2008] that allows alternative interpretations as evidenced in this year's 11 unique implementations and set of project documents. To provide more of an OEGP in 2009, following the suggestions of a couple of students, we will vary the deliverables required in each semester.

In sum, project management requires the combined effort of both students and lecturers. Where students are capable, primarily evidenced by their

[2]http://trac.edgewall.org/

academic success in previous units, the greater portion of management is given to them. However, as a learning outcome of the project units is experience and ability to manage a project, by definition the students must learn (via themselves, peers, sponsors, and other aspects of the situation [Lave and Wenger 1991]) how to manage effectively while the lecturer provides a source of knowledge, guidance, and support acting as a sounding board, safety net or reality check.

8. FORMAL CLASSES AND CONTENT?

In this section we consider Grundy's two questions: 1) Should such courses have lectures and tutorials, and if so what material should these cover? and 2) Do students need preceding or subsequent "theory" courses to prepare them for or build upon their project course experiences?

Roy and Veraart [1996] identified the essence of the dilemma: should we teach top-down or bottom-up? As they point out, education requires a balance of theory and practice. If we take a top-down approach we would first impart the theory and give the students problems requiring the theory to be put into practice. This has been the traditional approach. Taking a top-down view then our project units are the ultimate demonstration of putting the theory one has learned into practice. However,

> *"to reach an understanding of complex, and sometimes abstract concepts, the student must have, or develop, the necessary [communication] skills," gained primarily through practice and experience. Taking a bottom-up view we "presume that all (most) of the underlying theories can be taught (learnt) in an application framework, ie in the context of the software development problem and project work. While this approach is not without merit, there is some danger that the "theory" components are too easily lost, or brushed aside, under the pressure of 'getting to the solution.' " [Roy and Veraart, 2006, p. 260*].

In response to this dilemma, Roy and Veraart [2006] propose a software engineering curriculum based on a combination of bottom-up and top-down. First and second year primarily provide top-down courses. In the third year project work in teams is introduced to allow the theory to be applied. A fourth year reinforces in greater depth the theory and includes a "complete, and larger scale, design under real-life conditions, and hopefully industry" [p. 261].

We think ideally that a project/capstone unit should be the place in which knowledge acquired formally in previous units is put into practice. While some additional theory or technology will need to be acquired (or relearned in many cases where students have forgotten or picked up erroneous or flawed concepts) we see that the onus should be on the student to fill in the gaps. This is an important life skill required in moving from a real problem to a real solution. Knowing what one does not know is a starting point for gaining that knowledge. Particularly in the case of the industry projects, we expect students to realize that design is all about choices and choices can only be made when you

know the alternatives. Often students have learned one technique or theory. The project should at least make them aware that alternatives exist and that if they decide to use a certain system development life cycle, database, programming language, software architecture, etc., because that is all they know that is a choice they have made and must justify. From an experience-based learning perspective, the project provides an opportunity to question and challenge the theory students may have memorized. Thus we see the project as providing reinforcement to understanding the theory already learned and motivation for discovering new concepts, technologies, and ways of doing things.

However, we also see that this ideal world requires a four-year study program which is not an option for our degrees. As a result we have run a lecture stream within our project units in the first semester to provide key material which students may not have acquired such as project and team management skills. Over the years we have had to restructure the lecture content, the practicals/laboratory sessions and tutorials according to the changing pathways that students may have taken to reach this unit. The benefit of including some course content and concurrently being enrolled in other units of study, rather than doing the project between the semesters or being dedicated full-time to only the project unit, is the potential interplay of theory with practice and the increased motivation to discover the theory when driven by a real problem.

9. FAIRLY ASSESSING GROUP WORK?

Assessment possibilities for project-based courses include [Grundy 1997, p. 174]:

—The work of the group as a whole: the same grade for whole group versus items of individual assessment versus project management notes.

—Individual assessment: tests, examinations, essays, individual reports.

—Product (quality of deliverables) versus process (quality of how it is done).

Roberts [2001] describes both a “capitalist model” of assessment where the final grade is based on the student’s own work, and a “socialist model” where achieving the best outcome for a particular individual or small group is considered secondary to achieving the best outcome for the class as a whole. Roberts [2001] proposes that the socialist model tends to support less able students as there is incentive to share skills and knowledge, and thus increase the overall number of pass grades. On the other hand the capitalist model is proposed to result in more individual effort and high achievement by more able and motivated students. We recommend mixing the two approaches.

For instance, a project unit at Central Michigan University [Sigwart and Van Meer 1985] differentiated between assessment items for the groupwork project that would be “Based on Group Work” (G) and “Individual Work” (I), resulting in the following assessment schedule (which represented 50% of their total assessment):

—Specification and implementation plan (G)—15%.

—Test plan and test data (G)—10%.

—Debug and test results (I)—5%.
—Final code documentation [10G and 30I)—40%.
—Project demonstration [15G and 10I)—25%.
—Editing (I)—5%.

Sigwart and Van Meer [1985] deconstruct each of these items into various outcomes, providing a grading rubric they used for determination of individual student grades.

The extent to which students should be rewarded for the process of the project versus the outcome of the project is a contentious issue [Johnston and Miles 2004]. While traditionally the emphasis has been on acquiring domain-specific content knowledge, some academics focus on generic learning objectives. For instance, in their discussion on student evaluation in WBL contexts, Brodie and Irving [2007] propose an assessment model based on the interrelationship and interdependency between understanding learning, critical reflection, and the identification and development of capability. The elements are defined as follows:

—Understanding Learning: students learn how they learn (approaches, theories, validity, applicability) to make the most of learning opportunities.
—Critical Reflection: Students reflect critically on their learning: applying models, establishing validity, applicability, and appropriateness.
—Capabilities: Self-audit, target setting, interpersonal and transferable capability, and subject-specific technical work skills.

Brodie and Irving [2007] argue that if the three components are inherent to their WBL outcomes model, then to achieve cognitive alignment all three need to be assessed. Feichtner and Davis [1985] cited in McConnell [2006] report that students were most satisfied when their group experience included group exams. McConnell [2006] points out this promotes the characteristic of positive interdependence between group members.

Biggs and Tang [2007] emphasize the use of holistic rather than merely analytic evaluation. This involves applying a hermeneutic judgment (understanding the whole in light of the parts) rather than entirely reductionistic approaches that judge the merit of the work based on evaluation of the deconstructed components.

The task break-up for the internal project units in 2008 showing (I) for individual and (G) for Group is given in Table III together with the Learning Outcomes (LO) listed below.

LO1. Critically analyze, describe, and apply principles and models of software development.
LO2. Perform the stages of the software engineering life-cycle (requirements analysis, design, construction, testing) in an authentic context.
LO3. Demonstrate an understanding of the influences of group effectiveness and strategies for supporting effective interoperation.

Table III. Assessable Tasks

Task	Learning Outcome	Weighting
Examination	LO1	(I)25%
Project 1	LO2	(G)17.5%
Project 2	LO2	(G)30%
Quality of contribution to discussion boards	LO1, LO3	(I)5%
Quality of contribution to blog	LO4	(I)5%
First Presentation and Interim Report (5% and 2.5% respectively)	LO5	(G)7.5%
Final Presentation & Final Report (5% each)	LO5	(G&I)10%

LO4. Demonstrate the capacity to work effectively in a software development team.

LO5. Effectively communicate results of the software development process (in both written and oral form).

Our goals overlap with many of the goals of project work specified by Fincher et al. [2001]. Note that LO2 encompasses all system development life cycle models (including waterfall, iterative, incremental, component based software-engineering, and extreme programming [XP]) which use these basic stages even though activities, sequence, and number of repetitions may vary. For each of the 11 project types/composite case studies, Fincher et al. [2001] outlines the following associated pedagogic focus:

1. Final Year Individual Project—Substantial, independent software development.
2. Second Year Group Project—Introduction to group working and a "complete" system.
3. Taught MSc Project—demonstration of subject master, academic skills, and the potential for individual contribution.
4. Project with Handover—learning about working with other people's code.
5. Research-type Project—develop critical thinking and research skills.
6. Design and Build Project—analysis, design, and implementation of a software system.
7. Project with Industrial Involvement—relevant exposure to industry practice and concerns.
8. Project with a Client—developing professional skills to work as a contractor for a real client within realistic constraints.
9. Process-based Project—the process of project work and professional activity.
10. Integrative or "Capstone" Project—to integrate and demonstrate the skills and knowledge acquired previously.
11. The Professional Bodies View—the demonstration of sufficient professional technical skill.

Our industry project encompasses all of these pedagogic foci to varying extents depending on the particular project.

Feichtner and Davis [1985] cited in McConnell [2006] report that students were most satisfied when group activities accounted for a significant portion of the grade. Feichtner and Davis indicated that two-thirds of the students reported a "best group experience" when the group evaluation accounted for between 41 and 80 percent of the final grade, with only around 15 percent of students reporting a "best group experience" when the group evaluation accounted for less than 20 percent of the final grade.

9.1 Approaches to Distributing Marks Within Groups

Johnston and Miles [2004] point out the importance of assuring students that they will be rewarded for their efforts and that any free-riders will not unduly benefit from the work of others, otherwise students may become unmotivated or disgruntled with the groupwork process.

Based on a survey of the literature, Lejk and Wyvill [1996] identify no less than six approaches to distributing marks between groups:

1. Multiplication of Group Mark by Individual Weighting Factor using the calculation: Individual student's mark = Peer assessment factor x Group mark, with the peer assessment factor based on student Likert scale ratings or the like.
2. Distribution of a Pool of Marks (as students see fit).
3. Group mark plus or minus an individual contribution mark.
4. Separation of process and product (for instance, an allocation of high, medium, and low peer grade) to task functions (Information and Opinion Giver, Information and Opinion Seeker, Starter, Direction Giver, Coordinator, Diagnoser, Feasibility Tester, Evaluator) and group maintenance functions (Encourager of Participation, Harmoniser and Compromiser, Tension Reliever, Communication Helper, Process Observer, Standard Setter, Active Listener, Trust Builder) otherwise each student grade is independent of the mark awarded for the product.
5. Equally shared mark with tutor intervention in exceptional circumstances.
6. Splitting of group tasks and individual tasks (i.e., some components assessed as group, other deliverables assessed individually).

Joyce [2002] provides students with a choice for distributing group project marks between individual members of postgraduate computing studies groups:

—Agreeing that all deserve the same mark.

—Agreeing on mark variations for the group members.

—Completing self and peer evaluations.

If all students in a group choose the first option then the teacher awards the same mark to all unless the instructor has evidence that their contributions were significantly unequal. If all students in a group choose the second option they nominate variations that sum to zero which are used to determine the mark adjustment (for example, if an assignment completed by three students is worth 64% and the variations are +10, 0, and –10, the students will score 74%,

64%, and 54% respectively). If all students in a group choose the third option, or if they cannot agree on any option, the instructor awards grades based on the students' self and peer evaluations and any other available evidence [Joyce 2002].

Research by Barfield [2003] indicated that a particular strata of students are less likely to be satisfied with group grading. Their study of 230 students in a U.S. university found students who work full time or are older are more likely to be dissatisfied with group grading. This has also been our experience. As well, Barfield's study found people who have more experience with group grading are less likely to agree that everyone in the group deserves the same grade.

Care is required when allocating marks to individuals based on peer evaluation, and researchers have developed approaches to ensure fairness of grade allocation. Li [2001] notes how individual students can bias the assessment process, and proposes an approach to normalization that accounts for this. Bushell [2006] points out how the exclusion of self-assessment scores in cases where the best performer in a group ranks the second best performer much higher than other students can lead to a distorted ranking of results. Bushell [2006] suggests an alternative approach to moderation which preserves the rank order of the students when distributing marks.

For the past decade for internal projects only we have required each individual to complete an online Individual Contribution Form following submission of each deliverable providing a percentage contribution (that is, total of 100) of each member including themselves which is used to scale marks. Other team members do not see the scores provided. Often patterns can be found which identify which person may not be pulling their weight or doing the majority of the work. Underlying our mark distribution scheme is a stress on the sense of team belonging and togetherness. The notions of equity and fairness are framed within the context of diversity. In this spirit, we encourage students prior to allocating tasks and later submitting their individual forms to discuss the distribution in a team meeting to provide an opportunity to resolve any issues and minimize any disputes. However, if disputes arise following the lecturer's allocation of marks, individuals will typically meet with the lecturer first and once an overall picture has been gained of the different sides of the story the group is brought together. We are challenged to consider next year the use of the facilitated group reflection technique [Clear 2002] which invites the group to complete peer and self-evaluation forms at the start of a group meeting with the supervisor. The forms are then reviewed collectively by the group by considering the set of reviews for one individual at a time.

While our online individual contribution forms have been in use since 1999, this semester there has been a trend for students to suggest that individual contribution forms are not appropriate even for the internal projects, as expressed:

> *I don't understand the point of doing a project as a group where marks are going to be individual. In the real world when you work in a team and a project goes successful, the whole team gets praised*

even if one member didn't have as a great input in the project. [male, internal project, S2 2008]

The debate has been entered into by many on the discussion board with most saying that in principle they would rather not have individual contribution forms, but with some saying that it provides a safety net for situations where people are not delivering what they have promised. Here is one sensible suggested alternative.

The peer rating system is a good tool but the problem is that, it isn't a clear indication as to whether groups have decided to spread tasks between members for the whole project or per deliverable.

In my case that is what we did, we spread tasks for the whole project, not just per deliverable. This in turn affected the marks per deliverable.

I guess what to do would be to advise the lecturer at the beginning of the semester that this is how the project is going to be approached across the whole semester. This will save the confusion brought across when determining marks.

Students are always welcome to e-mail/contact the lecturer throughout the course of the semester raising any issue they may be having with particular members, which in turn allows the lecturer to adjust marks accordingly when awarding them.

For example in a group where one member is slacking off. All other members can discuss this with the member (I know this may be hard to do sometimes), but in doing so at the same time advise the lecturer. This will allow the lecturer to put some input into the situation and once again award marks accordingly. [male, internal project]

Another suggestion was:

The peer system could work if

a) Only the Team Leader assesses the individual members of the group (kind of like performance appraisal in real life)

b) At the end of each deliverable, the Individual members give one assessment of the Team Leader to make sure the Team Leader does their job

Encouraging students to strive to manage their teams so that individuals are making roughly equal contributions is fundamentally opposite to the approach employed by Herbert [2007]. Herbert strongly encourages individuals not to give equal marks and believes that equal marks are signs of a pact having been made which is carried out regardless of whether the individual has made their equal contribution. I posted Herbert's abstract and a link to the article on the unit discussion board to elicit students' comments. I received this response, which sums up many of the other responses.

I don't see why "pacts" to avoid conflict should be a problem - isn't it just one of many strategies that teams can use to all work happily together?

My personal opinion is that there shouldn't be any self- or peer-assessment at all. The results ARE what scores the team gets from deliverables. If someone is not pulling their weight then teams should get over it. Incompetent or disinterested team members are just one of many issues that a team has to face.

There's nothing "unfair" about it. One team might have a sponsor that constantly changes requirements, another might have an unforeseen disaster slow them down (i.e., car accident), and yet another might have a dud team member. Either way, teams can find a way to deliver regardless, without having to 'fire' anybody. [male, industry project, 2008]

9.2 Assessment Process: Teacher (sponsor) Versus Student, Criterion Versus Normative

Based on a review of peer assessment in higher education, Topping [1998] identifies peer assessment as holding great promise, especially in the cognitive, social, affective, transferable skill and systemic domains. Orsmond et al. [2000, p. 24] identify benefits of peer- and self-assessment processes:

The introduction of peer and self-assessment methods into a teaching programme has the potential to strengthen the link between tutor feedback and student learning. This is because peer and self-assessment provide tutors and students with the opportunity (1) to clearly define the student learning outcomes of an assessed assignment; (2) to have meaningful dialogue with the student; and (3) to think about the process of carrying out the assignment rather than just the product.

Kwan and Leung [1996] cite literature providing an extensive rationale for self and peer assessment:

Brown and Dove [1991] suggested that self and peer assessment, if handled successfully, can: (1) foster students' feelings of ownership for their own learning; (2) motivate them and encourage their active involvement in learning; (3) make assessment a shared activity rather than a lone one; (4) promote a genuine interchange of ideas; (5) lead to more directed and effective learning; (6) encourage students to become more autonomous in learning; (7) signal to students that their experiences are valued and their judgement is respected; (8) develop transferable personal skills; and (9) produce a community of learning in which students feel they have influence and involvement. Students reported that self and peer assessments made them think more, learn more, become more critical and structured, and found the schemes challenging, helpful and beneficial [Falchikov 1986; Stefani 1992]. Burnett and Cavaye [1980] also found that peer assessment

resulted in increased attitudes of responsibility towards other group members.

However students can have different understandings of criteria used for peer assessment compared to both the teacher and other students, which can potentially compromise the reliability of such approaches [Orsmond et al. 2000]. Furthermore, peer assessment rubrics are very dependent upon the content of the course. Orsmond et al. [2000] point out that while this may mean that self- and peer-assessment is more appropriate as a formative assessment approach, the success of such approaches should not be judged solely on the ability of students to mark to criteria or match the tutor's marks — the success of self and peer assessment as an approach should take into account how much students learn while carrying out the assessment.

In their study, Orsmond et al. [2000] found that students were less able to discriminate between marking criteria that they construct themselves as opposed to those that were supplied by the instructor. This may be because students form predispositions about the interrelatedness of the criteria at the time of creation and/or do not fully appreciate their distinction. As well, student constructed marking criteria did not enhance student/tutor or student/student marking agreement. Orsmond et al. [2000] suggest that student-set marking criteria may also lead to different learning outcomes that are less aligned with course goals than when they are provided with marking criteria. The authors note that student response to the self- and peer-assessment approach was positive, which should be a strong influence in determining its utility.

In another study of peer assessment reliability, Kwan and Leung [1996] found that while there was some degree of alignment between 96 pairs of hotel and tourism students and teacher marks (though less than in previous studies), student-allocated grades exhibited less variability (which supported findings in previous research). This supports the notion that student discriminant ability when assessing performance in courses may be less than the teachers'.

On the other hand Hafner and Hafner [2003] used 1,577 peer-group ratings using a rubric for an oral presentation over three years involving 107 college biology students. Quantitative analysis of data collected showed that the rubric was used consistently by both students and the instructor across study years, with the students' academic strength having no significant bearing on the way that the rubric was employed. A significant, one-to-one relationship (slope = 1.0) between the instructor's assessment and the students' rating across all years was observed. These data indicate that well constructed and implemented rubric based assessment can be a reliable tool for peer-group (and self-) assessment by students.

McConnell [2006] believes peer evaluation supports the personal responsibility of students within the group setting, citing a report by Feichtner and Davis [1985] that students were most satisfied when their group experience included peer evaluation. McConnell [2006] frequently uses two forms of peer evaluation in each course. The first is an anonymized (and teacher filtered) feedback from each student to other members of their group, conducted mid-semester. The second is worth five percent of the groupwork mark, and

requires students to rank themselves and their peers on a six-point scale (never, rarely, occasionally, periodically, frequently, always) for the following items:

—Is prepared for class.
—Listens to everyone's ideas.
—Shares workload.
—Values all member's contributions.
—Helps us progress to a solution.
—Has good ideas.
—Keeps everyone on task.
—Helps the group find mistakes.
—Makes a positive contribution.
—Attends class.

It would be interesting to test whether the cumulative effect of these components may have value in generating a common mark (e.g., a B) which reflects the likelihood that most students by this stage should pass with a reasonable grade, as suggested by one of the reviewers of this article.

There is evidence that peer assessment is taken seriously but that students show a self-bias, rating their own contribution to the group project higher than that of other group members [Johnston and Miles 2004]. Our students revealed similar self biases in their responses to Questions 11 and 12 in Table II. Internal project students rated their own ability to work with others significantly higher than others ability to work with them (paired t-test, $t = 5.567, df = 49, p < 0.0001$) similar to the results of a survey with these two questions with a different cohort in 2004 (paired t-test, $t = 4.83, df = 102$, $p < 0.001$).

Lejk and Wyvill [2001] compare holistic and category based approaches to peer assessment of a business systems analysis project. Holistic assessment of peer contribution (using one mark) yielded a much greater proportion of groups awarding each member equal marks than the category based approach (assessing contribution on several criteria). The holistic approach also produced a greater proportion of students with large deviations from the group mark. The authors argue that holistic assessment seems to be more effective at dealing with outstandingly good and outstandingly weak contributors whereas the category based assessment leads to a more gradual distribution of marks. Category based approaches assess students' contribution to all possible areas of the project even if they only provided a (substantial) contribution to parts, thus resulting in potential distortions. On this basis the authors argue that holistic assessment is more suitable for summative assessment as it better represents an individual's contribution to the project, whereas the category based approach provides useful formative feedback.

Biggs and Tang [2007] recommend the use of criterion-referenced assessment (CRA) over norm-referenced assessment (NRA). NRA is based upon the assumptions that knowledge can be quantified, that percentages are a

Table IV. 2008 Semester 1 Results for Peer Assessment Based on 55 Students for the Presentation Part of LO5

Group	My score	Averaged peer score	Standard Deviation	Diff. Mine-Peer
1	4.5	4.2096	0.8933	0.2904
2	2.5	2.8483	0.8395	−0.3483
3	4.25	4.1614	0.9404	0.0886
4	4.5	4.2965	0.9010	0.2035
5	4.75	4.5254	0.9292	0.2246
6	4	3.7096	0.8543	0.2904
7	3.5	3.2956	0.8334	0.2044
8	4.5	4.5088	0.9359	−0.0088
9	4	3.5535	0.8396	0.4465
10	4.75	4.4254	0.8979	0.3246
11	3	3.3172	0.8230	−0.3172

universal currency, that assessment should be designed to clearly separate the high and low scorers, and that quantitative approaches to assessment are more precise and objective. This can lead to assessors grading on the curve, allowing numbers to determine adequacy of learning, assessment as somewhat separated from teaching, and a student emphasis on achieving marks rather than learning.

We have been using peer assessment in our capstone industry and internal project units. For the industry project, the presentations of course content by students were assessed by peers. Using an automated response system [Richards et al. 2006] the scores were electronically and anonymously collected. Initially, students were asked to provide a score out of 10 for presentation, content, material, and level of interaction/ participation weighted 3, 2, 1, and 2 and combined to produce a final mark worth 10%. After the first session, students asked if they could just provide one score out of 10 as they had trouble differentiating the different components of the presentation. This supports the findings (e.g., Hafner and Hafner 2003) that students are less discriminating and struggle with providing category or criterion based peer assessments but my change to a single mark fitted with the goal of summative assessment for this task.

For the internal project groups, peer assessment at the group level is used for assessing the demonstrations of the prototype solution at the end of semester one. In this way peer assessment is formative and summative. For the past two years students were additionally required to write comments for each group. This year, following the recommendation of Lejk and Wyvill [2001], marking criteria were provided to students as the key focus was formative feedback.

Consistent with Hafner and Hafner [2003], in all uses of peer assessment we have found student scores to be consistent with lecturer allocated scores. With the exception of one student last year (almost one mark different), since 2003 in all cases the average score from the students was within half a mark of the lecturer's weighted and averaged score. Table IV shows the results for the most recent use of peer assessment.

Despite this, students sometimes have reservations with peer assessment:

> *I am unsure of how effective marking other teams systems are. Obviously there is a bias to ones own system but I find that I am unable to look at other teams systems without comparing them to our own and I am finding that they do not compare at all. [blog entry, male student, S1 2008]*

At the end of the year, the prototypes were demonstrated and assessed by two academics using a marking sheet with set criteria. As a number of individuals expressed disappointment that they couldn't demonstrate to the group, we invited students to comment on their preferences via the discussion board. Eighteen responses were received, including:

> *Demonstrating in front of the whole class can be a little confronting, especially in the case of last semester where it was peer assessed. I believe this raised a conflict of interest in that systems may not have been fairly marked due to possible tensions between groups or people. If a demonstration is to take place in front of the class, it should be assessed by academics only. [male, internal group, S2 2008]*
>
> *I am torn between whether it is better to present to peers or two academics; I think both have merits, and if I was forced to pick one I'd say . . . public presentation. It's just going to be such an integral part of "what we do" when we're in the workforce. [male, internal group, S2 2008]*
>
> *If you want to assess the project for what it is then I think two lecturers is much better . . . the lecturers can probe the system to see what's working, can ask questions direct one on one. If you want to assess how well a system can be "dressed up" or how good a person is at public speaking then go for the presentations . . . my problem with the presentations was that a team who put more effort into their system throughout the semester can get less marks than a team who put less effort in, solely because they have a good presenter/presentation. I agree that it is good practice to be presenting the system in public . . . but I don't think it is a good means of assessing the work that has been done . . . especially on the part of the poor programmers who put a massive amount of time into the system, if its not 'dressed up' in the end they suffer.*
>
> *On the plus side it was good to see everyone solutions in the presentation and how different ideas and solutions have come about from the different teams. [male, internal group, S2 2008]*

The prevailing view is expressed here:

> *I think it may be better to demo in front of the whole class, but it is not a good idea to be peer-assessed because I think it is unfair for us to judge other group as we all study at the same time. I think it*

> *can demo in front of the whole class and make by the two academics. [female, internal group, S2 2008]*
>
> *Demo in front of the 2 academics is good since they can asked questions that are more specific unlike the silly questions we got asked during the whole class presentation last term!*
>
> *However the fact that other students could see how every team went with their tasks is also nice. Therefore a combination of the two I think is better.*
>
> *I propose a presentation in front of the class and academics asking questions. Students can ask questions if they want but with the academics approval. (or not at all!!). [male, internal group, S2 2008]*

Non-assessable peer review is used within the project units in a number of ways. Review of past solutions (to different problems) is made available to students. Also, good group solutions and/or documents relating to the current problem are posted on the Web site. Also, following return of a deliverable, good and bad examples are discussed in class. While this is mostly lecturer-led, there is still an element of peer review involved.

The use of discussion boards also offers an opportunity for peers to answer or comment on problems or solutions posed by students. These discussion boards cover team issues as well as technical concerns and while contributions are primarily peer reviewed they are lecturer assessed. Blogs, when used as private journals, on the other hand, exclude peers but allow the instructor to monitor and encourage individual reflection and growth. Blogs are not always used in the way intended or welcomed by students as reflected in these comments:

> *Personally I find the use of graded blogs irritating at best. That in mind I have ignored it most of the semester in favor of trying to do real work on the project. Although the blog does provide some useful options. It allows me to make private suggestions about the course and provides a space where I or others may complain about team mates without fear of discovery. [male student, S1 2008]*
>
> *Reflective BLOG: . . . is this a diary? I've never written one in my life so I tend to forgot about putting anything in there. I see it as mainly for girls who have too much time in their hands and like to talk about everything they've done on their days and blah blah. AND/OR it's really for students who have the ability to bs about anything (not that I'm not one of them) but I really don't see any use of it. (as I'm writing this up people in the labs are complaining about the reflect blog and its uselessness!) [male student, S2 2008]*

These comments, however, are not indicative of the attitude of the majority of the class. There were a total of 382 personal reflections, an average of seven per person, 132 teamwork discussion board posts, and 18 posts related to technical issues. When a poll was taken on whether we should scrap use of

the discussion board/and or private blog for assessment, 71% wanted to keep both, .07% wanted to just have the blog, and 21% wanted to scrap them both.

10. SIZE OF GROUPS?

Smaller groups necessitate smaller problems and thus more assessment [Grundy 1997]. Larger groups allow more complex assignments involving more deliverables to be allocated, accounting for the labor resources and potentially restricted time frames to complete tasks [Speck 2003]. However, to this extent the "mythical man-month"; [Brooks 1995] needs to be considered; increasing the number of workers does not necessarily increase the rate of productivity due to the number of relationships and disparate tasks that then need to be managed.

Smaller groups make group meetings outside class time easier for students to organize [McConnell 2006]. If groups are to meet in class then larger groups can be used. McConnell [2006] recommends groups of five students if teams are to meet in class. Nicolay [2002] also sees five as a convenient group size, with one member of the group designated as the facilitator. From the experience of Fincher and colleagues [2001], the size of teams can vary according to pedagogic goals, nevertheless three is typically a lower bound and seven is the upper bound, though process-based projects report up to 20 group members.

From our experience, groups of four require that each person do their share. A group of five provides some slack which can be helpful if sickness or other issues arise. We have found that teams of four or five people are equally productive, that is, the team of five does not usually produce any more or any higher quality output than a team of four. For industry-based teams the size of the team will naturally impact on the scope of the project. Internal groups of three (none this year in the capstone units) participate in the same project with the same problem statement and set of deliverables. Each group defines the scope of their project to specify exact functionality and design which allows the size of the group to be taken into account. Given that groups of four and five are seen to be equally productive no scaling of marks is performed. Groups of three are compensated as they are marked on the same set of deliverables. We have observed that the better solutions often come from teams of three and thus with scaling these teams can often end up with full marks. It appears that teams of three learn to work harder and better, perhaps suffering less from the problems associated with communication overhead and dividing up and recombining a task (Brook's [1995] mythical man month mentioned previously). Groups of three are avoided because, particularly with scaling, they can be perceived as advantaged and offering less of a "group" experience.

11. CONCLUSIONS AND FUTURE WORK

This article seeks to combine and discuss the issues and findings from the collective experience and experimental studies of other researchers and the author relating to a number of design choices relevant to project-based courses. The key lesson we have learned, consistent with the 22 academics in Nicolay's [2002] survey, is that it is important to stay in touch with groups and put

strategies in place to ensure that issues are identified and dealt with expediently. These strategies need continual review. Some years the strategies work, some years students have learnt to work around them and you need to put in another strategy to catch that problem.

Some of the lessons learned by our students this year include:

> *– Self awareness. I have become aware of how valuable a team member I am. Also, the quality and amount of work I contributed to the team and the fact that I was able to do what I did surprised me.*
> *– A better understanding of working with others. Working in a team with others has taught me a great deal about how a team dynamic works. There has to be both give and take on behalf of all team members. At times there were tensions within the group and it was the way these situations were handled that provided valuable experience in this area. [male student, 2008]*
>
> *Being a team leader, I learned how to force myself to speak-up and motivate others. It was not an easy job for me, therefore I suggested our team should only consist one team leader throughout the project, because not everyone know how to be an effective leader. [female student, 2008]*
>
> *The first semester has been challenging yet exciting for me, and I have learned a lot. Before studying this unit, I was unaware that there was so much involved with developing a software. Being able to plan, develop and implement the system from scratch was a great experience and made me realize a lot of "behind the scenes" things that happen when software is created. [female student, 2008]*
>
> *The first few deliverables were submitted without consistency in the documentation. This happened because tasks were allocated to individuals and not checked for consistency before submission. This can be a huge difficulty with many group projects. As a group we learned that segregating the job too much can mean that the context of the whole system is lost. [male student, 2008]*
>
> *The most positive experience I drew from the presentation was forcing myself to stand up in front of a class full of (mostly unknown) people and explain to them how our software was intended to function. [male student, 2008]*
>
> *The only downside to this whole team project work is that it sometimes takes longer to work on a solution when you have conflicting ideas and different levels of understanding. Sometimes it appears that males and females approach work in a different way. [female student, 2008]*
>
> *I learned a lot. Specially people skills. -I need to be patient about a person. -To listen to other members. -Not to be quick to judge all the problems caused between people. Need to discuss and share idea. -To find person's strength and something good at, and say thanks*

and admire the person always works and makes work easy than finding person's weaknesses and his/her fault. [female student, 2008]

The literature offers many answers to the questions explored in this article. When I pose these questions to my students they similarly can see alternative viewpoints and frequently begin their reply with "it depends." When it comes to designing project-based courses, the burning question does not concern the type of project, how many hours or semesters, how big is the group, how much theory, how should groups and marks be allocated and managed? Most of these questions can be answered by first asking "why." Along these lines, Clear [2007] suggests capstone units should emphasize "w"—what and why (and who). We believe the main factor which makes or breaks a positive learning experience in project-based units is whether difficulties encountered were able to be overcome and when that involves collaborative learning and group work that primarily means whether group conflict was able to be resolved. This notion is simplistically embodied in this student response.

I think it really depends. For example, if I like the group from 1st semester, very likely that I want to keep it for 2nd semester. However, if I hate the group from 1st semester, then I would seek for change [male, internal group, 2008]

Reducing conflict has been the primary goal of the redesign we conducted this year involving careful team allocation based on student survey responses, swapping teams, use of journals and discussion boards, and team skills training. Our experiments this year with group formation seek to test if matching students based on their expectations in terms of effort and grade reduced team conflict. Results after the first semester revealed that 2/6 teams not matched by expectation (control group) had some conflict. Conflict was identified via e-mail and blog entries and unequal distribution of marks across team members. One out of five teams matched by expectation experienced noteworthy conflict, but on review it turns out the conflict was with one individual who swapped in from a control group just after the groups had been announced and before they had met, due to a last minute change in their availability and thus not closely matched by expectation.

In the second semester, we endeavored to match all groups based on the survey criteria, including expectations. A first pass was achieved using an automated group allocation system one student team had designed and developed in the first semester. Some shuffling around was needed to ensure that each person was with all new people. Only one group this semester has shown any signs of conflict which was handled by meeting with the group and regular contact with individuals in the group to monitor personal views. It is interesting to note that in the end all members of this group personally advised me that they wished to distribute the marks equally over all deliverables. Note that some groups did not have equal distributions for all members but this did not lead to conflict.

> *Firstly I feel as though this semester's project was a success. There are many contributing factors.*
>
> *One factor is the group was well allocated (maybe it was the group allocation system that was developed last semester). I feel as though this semester I was allocated in a better group. Although in last semester one of my close friends was in my group, it didn't necessarily mean that we worked well together - there were times where we got annoyed with each other. I now realize how important it is to have to have a mix of skills and knowledge in the group. Also, smaller amounts of people (we had a group of 4 people) would mean lesser conflicting ideas thus the group can attain a uniform vision more easily.*
>
> *The second contributing factor to our success is the fact that we had experience in working in a project before. We easily (with only some complications) went through the SDLC stages although the problem spec was different. It was more enjoyable to do a project the second time round as we were more aware of what to do and how to report.*
>
> *Another helpful factor was to have a team leader with personality and great communication skills who was able to nicely bind the group together. Also fortunately we had a confident/reliable programmer who not only could code but also had understood the requirements as the rest of the group did and had the ability to implement the system.*
>
> *With the factors above consequently all the group members were keen to contribute and do their share of the project. [female, internal project, S2 2008]*

Conflict is not only an issue within teams. Fincher et al. [2004] note the challenges facing students, clients, and academics. Managing competing client, and academic expectations can cause conflict for the students. Authenticity of experience is a guiding principle in reconciling conflicts resulting in the academic supervisor enforcing certain minimum requirements and standards together with flexibility to recognize the uniqueness of each project. This is why we allow industry groups to negotiate their deliverables and their worth with the sponsor and academic. In 2008, two of five industry teams experienced a single critical conflict with their sponsor. In both incidents the unit convenor was required to intervene urgently (via phone), cool both sides down, and propose the way forward. In a few other situations teams were able to handle resolution of issues directly with the sponsor after discussing options with the convenor. Over the years we have found that some sponsors are very difficult to satisfy because they are not able to change their expectations from the internship or work placement model (Fincher et al. [2004] *full cooperative immersive experience*). When sponsors become dissatisfied with what is being achieved the team can become discouraged and often overwhelmed. We also note that with support from the academic, this adversity can weld them into a highly

cohesive team who in the end deliver beyond the client's expectations. Conflict over ownership of intellectual property (IP) is a further potential issue identified by Fincher et al. [2004]. In our industry projects all parties (students, university, and client) sign a three-way agreement at the outset of the project which deals with issues such as ethics, professionalism, commitment, resources, nondisclosure, and IP which always remains the property of the company.

In recognition of the balancing act between team/people and product/technical issues within a project-based course, as future work we are seeking to employ Activity Theory and Engeström's [1987] Activity Theory Framework which brings together tools, rules/customs and division of labor with objects, subjects, and communities. Activity Theory provides "a philosophical framework for studying different forms of human praxis as developmental processes, both individual and social levels interlinked at the same time" [Kuutti 1996, p. 25]. Activity Theory is a clarifying and descriptive tool rather than a strongly predictive theory, whose purpose is to understand the unity of consciousness and activity [Nardi 1996, p. 7]. Within our capstone units we have begun to evaluate the use of technology in general and the role that Web 2.0 technologies and affordances play in supporting cooperative learning within the activity theory framework [Kuswara et al. 2008]. It may turn out that successful groupwork is not a magical or mystic pursuit, but that by identifying and addressing potential and actual pitfalls and providing a framework for the activity-theoretical emphasized "continuity of social practice" [Havnes 2004, p. 171], effective groupwork ensues.

ACKNOWLEDGMENT

A personal thank you to Matt Bower for his research assistant work on the project "Applying New Assessment Methods in Computing Units", LTPF, 2007-2008, and to the Computing Department for making these funds available.

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Received August 2008; revised November 2008; accepted January 2009