Completing the learning cycle: The role of formative feedback when using self and peer assessment to improve teamwork and engagement

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Abstract: There is a reported competency gap between the teamwork skills required by employers and those developed by engineering students during their undergraduate courses. It is important for university courses to develop learning-oriented assessments that will encourage development of teamwork skills and a commitment to ongoing development after graduation. While assessable team-based projects increase the opportunities for team interaction, because of problems such as free-riding they do not automatically develop students' teamwork skills. Self and peer assessment has been widely reported as a means of reducing problems with free-riders while motivating students to learn and develop teamwork, critical evaluation and self reflection skills.

However, often the focus is on using summative assessment to punish non contributors. While this use is valuable, less research has been undertaken on using it for formative purposes to improve subsequent contributions and learning. We found that formative learning-oriented feedback to complete the learning cycle played a major role in not only encouraging the ongoing development of teamwork skills, but also promoted academic honesty by discouraging free-riders and saboteurs.

This paper reports how educational technology was used to facilitate formative self and peer assessment allowing, even in large classes, several opportunities to close the learning cycle and develop teamwork skills.

Keywords: Formative feedback, self and peer assessment, teamwork, SPARK.

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Background

There is a reported competency gap between the teamwork skills required by employers and the level of teamwork skills developed by engineering students during their undergraduate courses (Martin 2005; Meier et al 2000; Natishan et al 2000). In addition to being technically competent professional engineers require skills of collaboration, communication and the ability to work in teams (Lang et al 1999; Sageev & Romanowski 2001). Team-based assessment projects are often used to develop these skills.

While such projects increase the opportunities for team interaction they do not necessarily facilitate the development of teamwork skills (Natishan et al, 2000). Students need to understand team dynamics, how to resolve conflict and the importance of doing so. While this can be facilitated by instruction, it is insufficient on its own (Messer, 2001; Stonyer et al 2001).

Since the development of teamwork skills is an ongoing process, it is important for university courses to develop learning-oriented assessments that not only encourage these skills to be developed but promote future development and learning after graduation (Boud & Falchikov, 2006). The first step is to develop a method of assessment that not only tests such outcomes but also promotes their development. Such a method should incorporate feedback since it facilitates and encourages students to self reflect and further improve their interpersonal and teamwork skills.

Self and peer assessment has been championed as a way of promoting the development of teamwork skills. However, often its implementation only focuses on summative assessment. While this has proved effective in discouraging free riders and promoting group collaboration, we found that using it to aid formative feedback significantly improved the learning outcomes. The use of formative feedback allowed students to reflect on their performance and identify their strengths and weaknesses in regard to their teamwork skills. In addition, we found that formative feedback, building on a summative assessment platform, further discouraged free-riders and extended students in their ethical development by focusing on free-riding as an aspect of academic honesty. We also found evidence of students developing the skills required for lifelong learning such as the ability to evaluate and make complex judgments about their own work and that of others. To encourage these positive outcomes, students should be provided with opportunities to play an active role in the assessment process.

The process of applying self and peer assessment in higher education has a well-documented history (Falchikov & Goldfinch, 2000; Goldfinch, 1994; Goldfinch & Raeside, 1990) but is relatively less-used in engineering contexts. This may be due to the fact that engineering classes are often large (> 150 students) and the administrative burden of applying self and peer assessment might outweigh the perceived benefit. Rust et al (2005) reports "that of the whole assessment process, the research literature is clear that feedback is arguably the most important part in its potential to affect future learning and student achievement". However, feedback is often provided long after the assessable work has been completed at which time students may no longer be interested, instead being focused on the next assessment task. Hence for feedback to be productive and used for student reflection, it must be both timely and focused. The burden on academics to achieve this outcome by incorporating more and earlier iterations of self and peer assessment, especially in large classes, would be unbearable without the assistance of educational technology.

In this paper we report the use of an online tool called SPARK or Self and Peer Assessment Resource Kit (Freeman & McKenzie 2002, SPARK 2005), to facilitate confidential self and peer assessment to focus students' efforts to learn and practice the skills required for teamwork. Unlike other self and peer assessment packages, SPARK provides both summative and formative feedback factors. When carefully implemented, the use of self and peer assessment to provide both summative and formative feedback proved effective in encouraging students to provide fair assessment, reflect on their performance and develop their teamwork skills.

SPARK

SPARK is an 'open source ' software package that solves most of the administrative issues associated with paper-based self and peer assessment approaches such as data collection and analysis. SPARK enables students to confidentially rate their own and their peers' contributions to a team project by allowing data entry of self and peer assessment ratings online at any time during a rating period. Students are assisted in making their self and peer assessments by a requirement to rate each other over multiple criteria which can include

specific project tasks as well as good team practices. Students rate each other relative to their perception of the average contribution for their team on each criterion. They do not rate each other against an objective standard of performance on the team task or team process.

SPARK automatically produces two factors from the aggregation of all the selected ratings. Some criteria can be excluded from the calculation if they are used merely to prompt more accurate reflections. The first factor known as the SPA or Self and Peer Assessment factor is a weighting factor that can be used to change a team mark for a project (stage) into an individual mark.

Individual mark = team mark * Individual's SPA

The second factor calculated is the SAPA or Self Assessment to Peer Assessment factor. It is the ratio of a student's own rating of themselves compared to the average rating of their contribution by their peers. The use of the SAPA factor has strong feedback value for development of both self-critical reflection and peer evaluation skills.

The SAPA factor provides students with feedback about how the rest of the team perceived their contribution. For example, a SAPA factor greater than 1 means that a student has rated their own team performance higher than they were rated by their team peers. Conversely, a SAPA factor less than 1 means that a student has rated their own performance lower than they were rated by their peers. While the SPA factor is typically used only for summative purposes, both factors can and we believe should be used for formative purposes as reported in this study.

Method

The multiple use of SPARK for self and peer assessment was first applied to a third year Electrical Engineering Design subject at the University of New South Wales (UNSW). In this instance, formative feedback in the form of the SPARK generated SAPA factor was issued personally for student self reflection. It was also used to detect potential manipulation or sabotage of the summative adjustment process since very high SAPA factors could indicate intentional bias in self ratings. Its formative assessment use was extended (as discussed below) when used in a multi-discipline Engineering Design subject at the University of Technology, Sydney (UTS). Compared to previous semesters, both subjects were modified to address the teamwork competency gap (Martin 2005, Meier et al 2000, Natishan et al 2000) as well as dealing with the problems introduced by free-riders (Mills & Treagust 2003).

Each subject involved completing a team-based design project. The projects were high stakes, valued at 40% of the grade at UNSW and 50% at UTS. The team-based project involved developing a unique product from initial concept to the production of a prototype.

Several changes aimed at developing teamwork were made to the subject design:

- The need for good teamwork was continuously promoted and reinforced throughout the life of the project during lectures, laboratories / tutorials and in the online environment
- Students were given instruction on teamwork skills and how to both give and receive feedback during lectures. Students were encouraged to practice these skills during their team project at every opportunity.
- Teams consisted of four students. This allowed students to experience team dynamics and develop the appropriate teamwork and communication skills while reducing the logistical burdens often present with larger teams, for example arranging meeting times.

- The projects had three stages. Two of the assessment tasks were written team reports. To reflect a typical industry experience the first report included a requirements analysis while the second report contained the detailed design, production and manufacturing documentation, including a costing and marketing analysis. The third assessment task was a team oral presentation made to a fictitious group of managers, comprising students and staff, demonstrating a functioning prototype and making a business case for funding.
- Each stage had some individualisation for assessment. For example, the oral team presentations were followed by individual questioning. This allowed students to be marked individually on both their presentation skills and technical knowledge. For the two written reports individualisation of the group mark was achieved by applying self and peer assessment.
- Self and peer assessment using SPARK was implemented to provide an effective way to capture the ratings from students and an efficient method for the academic to implement self and peer assessment.
- Assessment criteria related both to specific engineering project tasks and importantly to team maintenance and team building. The latter criteria were used not only to assess a student's teamwork skills but also to encourage students to develop these skills.
- Students were provided with formative feedback that compared their self-assessment of their team contribution with the assessment of their team peers. Both the SPA and SAPA factors were fed back to each team member. In the UNSW trial students were not forced to share their SPARK feedback (SAPA factor) with their team peers, however many chose to do so.

In the second trial conducted at UTS we decided to increase the value and amount of the formative feedback component. First, students in their initial tutorial had to work in their teams to design a small project, for example a structure made from drinking straws that is 30 centimetres high and capable of supporting two cans of soft drink. These exercises are effective in breaking down barriers and encouraging communication between team members, while facilitating practice and critical evaluation of the engineering design process. After the exercise students are required to reflect on their group process, provide feedback and decide on ways to improve their team performance.

The second improvement was that class time was set aside in a tutorial session for the individual formative feedback produced by SPARK to be openly shared between group members. Students were guided on how to reflect on their own performance and give positive and negative feedback as required to other team members. Students were reminded that the tutorials were not about pointing the finger or attributing blame but rather about improving their own performance and developing their teamwork skills, including giving and receiving feedback. The format of the tutorial was as follows. Students were given both the SPA and SAPA factors for each of their group members. After allowing a short time for students to personally reflect on the assessments, each group was guided through a feedback process. Students were initially asked to provide positive feedback facilitated by expressing to other team members what they had done well and how they had contributed positively to the project. Students were next asked to share their own self-evaluation, explaining how they thought they could improve their own performance or would do something different to improve their own contribution to the team in future tasks. Students were then asked to conclude by providing honest but initially gentle negative feedback. Students were

encouraged to be specific and discuss how the behavior or contribution of individual team members had affected their group work experience. The in-class discussion concluded by teams agreeing how to improve their overall team and individual performance for the remaining parts of the project and or in future group work opportunities.

Thirdly, tutors provided feedback to groups and individuals after the team oral presentation. This feedback followed the model described above including asking students to verbally reflect on their own performance, after which the tutors provided feedback on what the team did well and how future presentation could be improved.

Results and Discussion

To research the impact of the revised learning and assessment strategy, students provided data via an online feedback survey while the coordinating academic kept a reflective journal. The student surveys used at UNSW were extensive as this was the first implementation of this subject design model. The UTS experience focused more on encouraging the same skill development amongst teams containing students from different engineering disciplines and the use of formative feedback to complete the learning cycle. Of the 180 students at UNSW an average of 140 students participated in the pre and post SPARK surveys. At UTS 141 out of 240 students completed the post subject survey.

Results from UNSW

Students responded positively to the incorporated changes with 80% of respondents indicating that the project had enabled them to develop teamwork skills. Overall 49% of responding students indicated that their teamwork experience had been improved by using SPARK. 51% agreed that SPARK helped make teamwork fairer and 56% agreed that it encouraged otherwise non-performing team members to put more effort into their assigned project work. Students agreed that relevant criteria and the ability to make assessments confidentially were important (75% and 65% respectively)

Results from UTS

70% of the respondents agreed that the group assignment had improved their ability to work as part of team. While 58% (28% neutral) of responding students agreed that the emphasis on self-evaluation has helped them develop their reflective skills.

Discussion

Team skills are important for engineering professionals. Although most engineering degrees include assessable team-based projects, we found that in general students possessed little if any knowledge about the key skills required to successfully work in teams. We combined instruction (lectures), practice (team project, tutorials, feedback sessions) and assessment (rewarding individual contributions) to encourage the development of team work skills.

While each of these approaches contributed to achieving the learning outcomes, this paper focuses specifically on using formative feedback to complete the learning cycle.

Students reported that the use of self and peer assessment improved their group work experience, reduced the instances of free-riders and encouraged them to improve their teamwork skills. Most students reported that the use of self and peer assessment (facilitated by SPARK), together with criteria that particularly assessed teamwork processes, had encouraged team cooperation and commitment.

At first glance it may appear that the results from UNSW were disappointing in that only 49% of responding students felt their teamwork experience had been improved by using SPARK and only 51% agreed that SPARK helped make teamwork fairer. However, many students can be committed to working as a team because they implicitly want to pull their weight or

because they become motivated to do so by the urgings of the lecturer's. For such students neither self and peer assessment nor SPARK is required to motivate engagement and discussions with a number of high performing students confirmed this. This may account for the high neutral responses of 35% and 34% respectively to these questions. Interestingly, the formative value of using self and peer assessment facilitated by SPARK was not stressed in this first trial. Whether high performing teams will still feel the same with the added focus on formative feedback is the focus of ongoing research.

While the summative component of the self and peer assessment rewarded students for their efforts, it was the formative assessment that played a major role in improving academic honesty, providing feedback and challenging students to reflect on their strengths and weaknesses to facilitate changing their behavior.

In both implementations we found that one benefit from providing students with the SPARK generated SAPA (formative feedback) factor in the early stages of the team project, was that students reported it encouraged them to be more realistic and honest in their own self assessments. The potential embarrassment of receiving a SAPA factor much higher than 1.0 appeared to be a significant motivator in promoting honest assessment.

In the second trial at UTS we significantly increased both the attention given to, and the amount of formative feedback provided. In a compulsory tutorial session students were given both the SPARK generated SPA and SAPA factors for themselves and each of their group members. After allowing sufficient time for students to personally reflect on the assessments, each group was guided through the previously described feedback process. This entire process was facilitated by the tutor who encouraged students to stay on task and indicating when it is appropriate to move onto the next part of the exercise. During the exercise the tutors moved between groups using well targeted questions to encourage groups to have fruitful open and honest discussions. Hence the success of these feedback sessions was in part due to the enthusiasm and ability of the tutor to encourage and motivate students to participate. One strategy used successfully to promote student engagement was for the tutor to relate from their professional experience a situation when they had to effectively manage working in a dysfunctional team to complete a project. Another strategy was to show examples of well-paid job advertisements that required teamwork and other generic skills. These examples reinforced the importance of these skills to a successful industry career. Once students recognised the value of developing teamwork skills their motivation and engagement appeared to increase. During these tutorial sessions the tutor also provided each group with feedback on the first stage of their project. This included an explanation of what was done well and what needed improvement. By providing feedback early in the semester, and at the same time as the feedback on their own contribution to the team project, students had an opportunity to reflect and learn to modify their group behavior or approach to the second half of the project. Hence they had an opportunity to practice and test what they had learnt. Many groups who performed poorly in the first part of their project responded to this feedback positively, significantly improving their performance in the remaining stages of the project.

An additional positive outcome of using the pedagogical model described in this paper was that the responsible academic had to spend relatively little time acting as an arbiter in disputes between team members. This can probably be attributed to the holistic approach to closing the learning cycle as well as the inclusion of instruction on the different aspects of teamwork, the use of explicit criteria in SPARK to assess these skills and the desire by students to receive positive feedback. These combined to provide incentives for teams to apply their skills to resolve teamwork issues independently.

Many students commented that the formative feedback would be more valuable if SPARK provided more detailed analysis than just the current limitation of the two aggregate (SPA and SAPA) factors. For example a student may wish to know how their peers perceived they performed in a particular aspect of teamwork. While this was assessed in the criteria, the SPA and SAPA factors provided are generated using all the criteria and represent an aggregate response. We agree that more detailed feedback would be highly desirable. A new version of SPARK is currently being developed that will facilitate the provision of such extended feedback.

A small number of students reported that they thought that the inclusion of self and peer assessment was stressful and that it had the potential to generate conflict between team members. Pope (2005) finds that 'students undergoing self and peer assessment report higher levels of perceived stress than students undergoing faculty marking only' and this is consistent with Biggs' ((2003) p.142-143) more general observation that assessment arouses 'passion, resistance and subterfuge'. Students should be forewarned that they may experience increased stress and perhaps even conflict during the self and peer assessment process. We maintain that to encourage development of the full range of teamwork skills, students should be prepared prior to undertaking self and peer assessment for the first time with instruction and practice in teamwork, conflict resolution and giving and receiving feedback. Additional opportunities to complete self and peer assessment and continuous reinforcement and support in lectures and tutorials will promote positive outcomes and reduce student's stress.

We will continue over future semesters to refine and develop the approach outlined in this paper to promote the development of teamwork skills. The uniqueness of SPARK in that it provides both summative and formative feedback made it an excellent tool for facilitating self and peer assessment, particularly in large classes. In addition, the fact that it is an online tool assisted tremendously with student engagement with the approach. However, we would like to stress that using SPARK is not a hands-off process that automatically produces benefits if introduced (Freeman & McKenzie, 2002), thought must be put into the subject design.

Conclusion

The ability to work effectively in a team is a highly desired attribute to succeed as a professional engineer. Undergraduate courses often use team-based assessment projects that students complete out of class to provide opportunities for peer learning and encourage students to develop teamwork skills. However, these outcomes will not automatically happen without careful pedagogical planning, including the appropriate orientation of assessment. In this paper we report on the use of a multi-staged project designed to encourage the development of teamwork skills in engineering students. Students not only needed instruction and opportunities to practice teamwork, but also a tightly designed and motivating assessment regime. Self and peer assessment was facilitated by an online tool called SPARK making it possible to implement multiple iterations of self and peer assessment in a large class without an intolerable administrative burden. While the use of multiple and appropriate assessment criteria facilitated by using SPARK motivated students to develop teamwork skills, our investigations suggests that it was the formative feedback, self reflection and practice component that cemented their learning experience.

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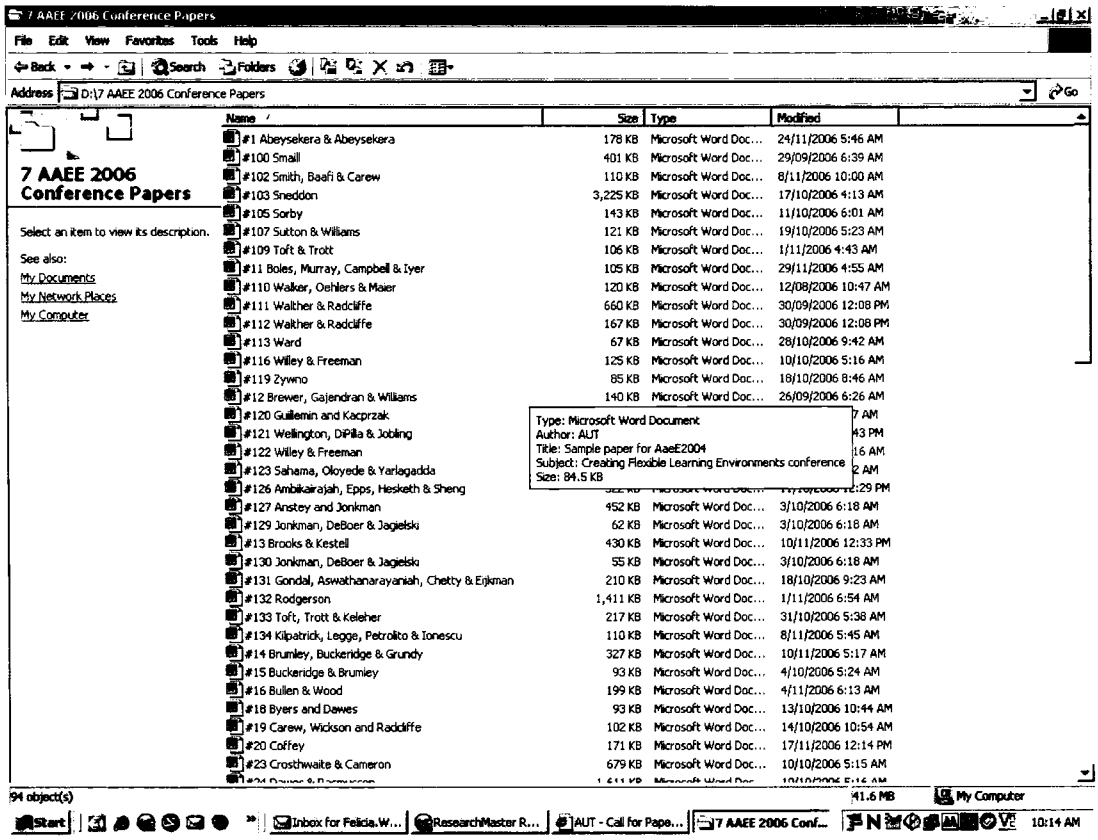
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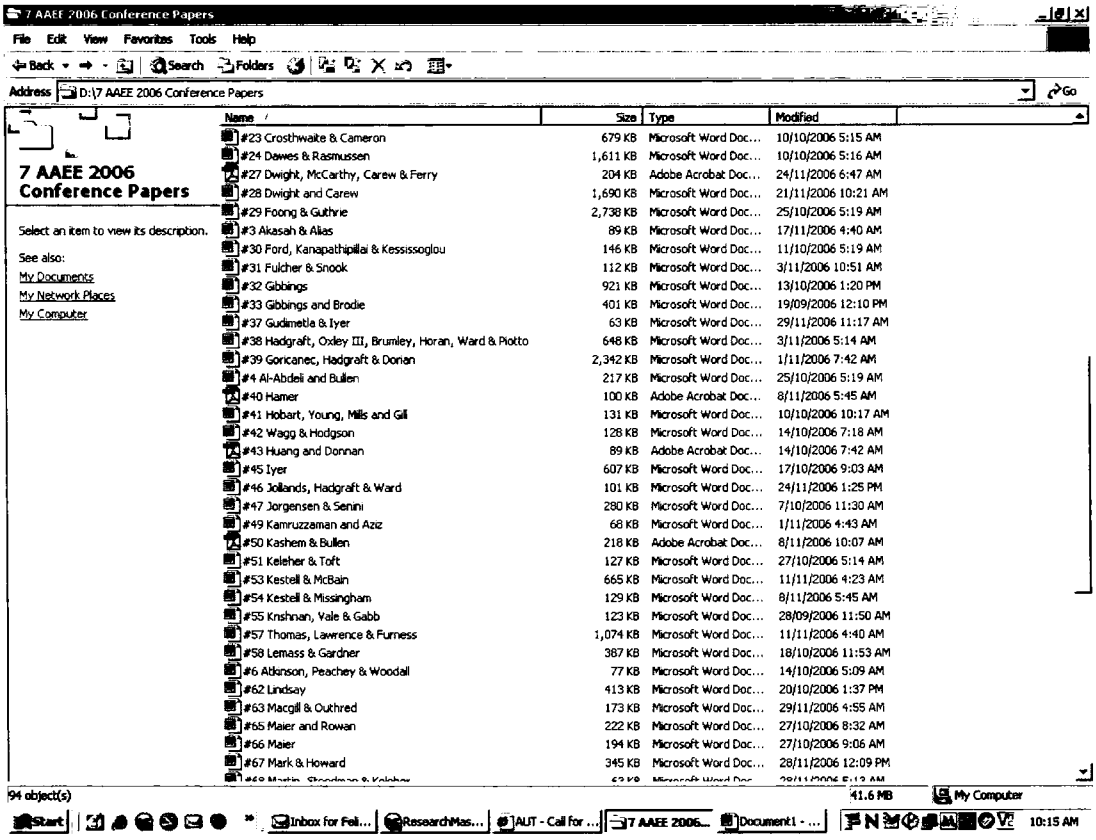
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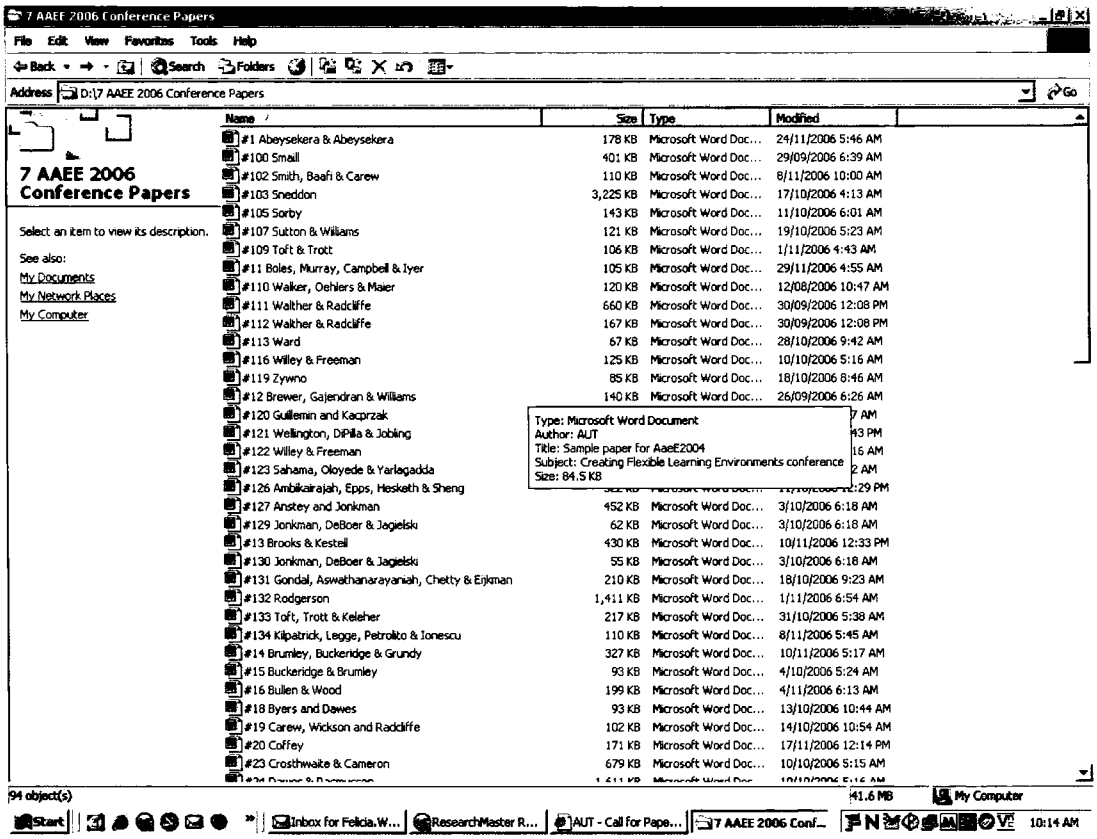
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Proceedings of the 17th Annual Conference of the Australasian Association for Engineering Education

All papers accepted for publication in the Proceedings of the 17th Annual Conference of the Australasian Association for Engineering Education were submitted as full papers and peer reviewed by at least two members of an expert editorial panel. Based on these reviews, authors were asked to revise their papers before a final decision to accept and publish the paper was made. This process of reviewing is in accord with the criteria set by the Department of Education, Science and Training (DEST) of the Australian Government for published papers.

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Introduction and Welcome:

On behalf of AUT University, welcome to the 17th Annual Conference of the Australasian Association for Engineering Education (AAEE) and the 11th Women in Engineering Forum.

The central theme for this year's AAEE conference is:

Creativity, Challenge, Change: Partnerships in Engineering Education.

Creativity, challenge and change create the context in which contemporary engineering exists. This dynamic environment is evident in our partnerships with students, teachers, researchers, industry, government and society. At this international forum we explore the ways these partnerships are responding and working towards successful outcomes for all stakeholders in this context. The conference aims to identify and promote best practice in engineering education partnerships within this creative, challenging and changing environment.

The conference program focuses on partnerships between:

- Learning and teaching
- Teaching – research nexus
- Sustainability and interdisciplinary partnerships
- e-learning and engineering education
- Engineering and society
- Maori and engineering
- Professional bodies and education
- Government funding and institutions
- Local and international engineering education providers
- Industry and education.

An additional focus in the event this year is the special focus on industry/stakeholder needs through a full panel session with industry leaders.

The quality of papers this year has been very high and well aligned to the core themes and I would like to thank the paper sub-committee headed by Dr. Gerard Rowe and all national / international referees for their valuable contributions.

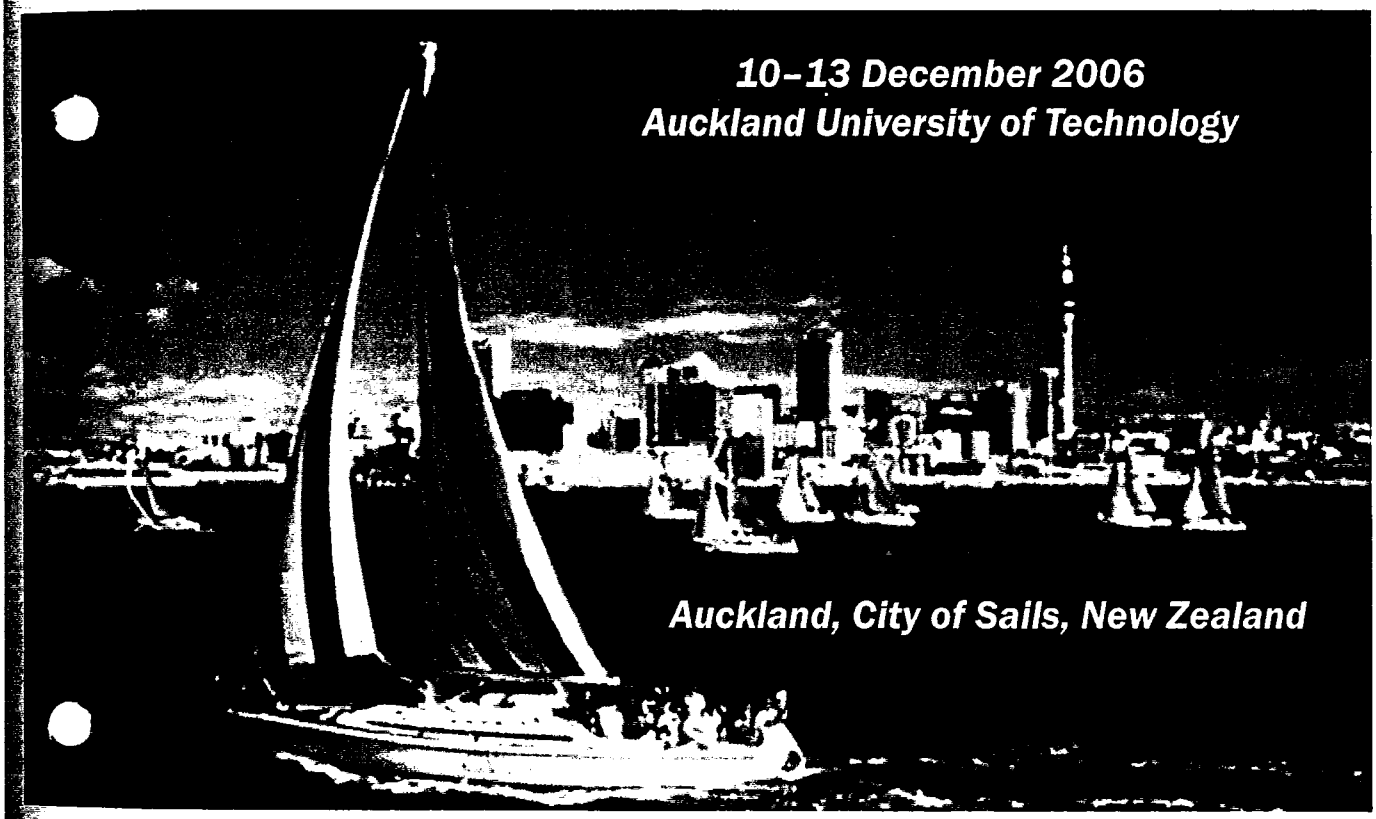
I would also like to thank the Organising Committee and Conference Secretariat for their hard work, excellent advice, and passion in Engineering Education and into making this event a success. It has been a pleasure chairing a team of such creative professionals.

The conference promises memorable events and we hope that you will enjoy them while visiting AUT and New Zealand.

Professor Darius P.K. Singh
Head of Mechanical and Production Engineering
Director of CAMTEC (Centre for Advanced Manufacturing Technology)
School of Engineering
Faculty of Design and Creative Technologies
AUT University

Australasian Association for Engineering Education

17th Annual Conference



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