Ensuring the Continued Quality of Vertically Integrated Student Engineering Projects

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Abstract: Student based learning projects that necessitate vertically integrated organisation (across all year levels) have a positive effect on pedagogy and more particularly, a positive effect on students' attitudes towards learning (Snyder 2002). Such projects help to create a thriving culture and a team identity in which students can develop a sense of belonging and of team pride. Because of these obvious benefits, in 2000 the School of Mechanical Engineering at the University of Adelaide introduced an annual student engineering challenge in which student teams develop their best engineering solution in a highly competitive environment. The school continues to run these challenges and now also implements other measures with the explicit aim of developing organisational culture amongst the student cohort. However, the students' perceived value of the annual competition is apparently on the decline and warrants investigation. If participating students are, as Snyder suggests, our customers and our customers' satisfaction is paramount, then we must endeavour to ensure that the outcome quality is maintained, or even improved, in the face of more demanding academic timetables and increasing student numbers from a far more diverse demographic. While acknowledging the value and importance of vertically integrated student engineering projects in conjunction with other means of developing organisational culture, this paper demonstrates that the success of such plans can easily be impeded by the limitations imposed by real world constraints. The influencing factors are each identified and recommendations are proposed to ensure that, despite the increasing professional demands upon those that administer them, the value of such projects does not diminish.

Keywords: Organisational Culture, Student Projects, Cognitive Skills
Introduction

In 1999 the School of Mechanical Engineering at the University of Adelaide considered the implementation of three plans of action with the explicit aim of improving the organisational culture within the school’s student body (Snyder 2002). These included recommendations to establish: horizontal focus groups for all students; a mechanical engineering only subject for level-1 mechanical engineering students, and a vertically integrated design and build project.

Student focus groups have since been established in a variety of forms that now include: discipline specific focus groups for mechanical, mechatronic, aerospace and automotive students; a staff mentor assigned to a group of students for the entire duration of their program; and staff year level coordinators for each particular level cohort of students. Students are also represented in staff meetings by their own nominated year level representative.

First year students within the School of Mechanical Engineering are traditionally placed into large classes that are common either to several disciplines of engineering or even to several other faculties. Restructuring (for a variety of reasons beyond the scope of this paper) has since resulted in a level-1 subject (Design Graphics) for mechanical engineering students only, providing an opportunity for mechanical engineers to share in an exclusive mechanical engineering team environment and thus foster an early cultural identity.

In accordance with the 1999 recommendations, an annual inter-year level School ‘Design and Build Competition’ was introduced in 2000 to help strengthen cultural identity and to develop a sense of mechanical engineering team pride. Student teams, with representation from each year level in mechanical engineering, are given a task and develop their best engineering solution in a highly competitive environment.

The scope of this paper is to analyse the continuing effectiveness of the Design and Build Competition in an environment that is becoming more and more demanding for both staff and students alike.

Student based learning within an organisational culture

A sense of organisational culture amongst the student body is an important aspect of the overall quality of higher education learning. Snyder (2002) stated that vertically integrated (all year levels) student based learning projects have a positive effect on students' attitudes towards learning and help to develop an organisational sub-culture within a university. The benefits of such projects and organisational cultures in a student cohort are well documented. Well designed challenges also encourage students to be more independent (Jumaily and Kuo 2005) and develop their level of innovation and their ability to adapt to novel situations (Brophy 2005). Active peer support amongst students and their involvement in problem based activities helps to develop a healthy dynamic learning environment in which students improve their cognitive skills and their sense of community (Smith et al. 2005). In addition to students' peer interaction, interaction with faculty significantly affects students’ academic and personal development, as well as their overall level of satisfaction (Astin 1993). The more a student becomes actively involved in his or her undergraduate experience, the more likely it is that their educational development will improve (Light's 1992, 2001). Croswaite et al. (2003) state that such activities assist with new student orientation and help them to rise above the
“confusing experience of their education”. Their single day intensive exercise at the University of Queensland focused on team building and problem solving with extremely positive results; 93% of their students gained a better understanding of what engineers do and 92% formed clearer ideas of what was expected of them as a result of participating. Randwana and Pope (2004) stated that incorporating heterogeneous team projects to encourage cooperative peer learning reduced the student attrition rate at Flinders University.

The Design and Build Competition

Its history
Since the inaugural Design and Build Competition in 2000 at the School of Engineering at the University of Adelaide it has become an integral part of the annual curriculum. The event is organised by an academic member of staff (a different volunteer each year) who coordinates other technical, administrative and postgraduate volunteers. Approximately 700 first, second, third and fourth year students are carefully organised into teams to ensure that each team has a good mix of students from each year level. At the beginning of the week an engineering challenge, which changes from year to year, is announced. Originally the competition ran in the first week of semester but it now occurs in the student orientation week (O’ week), the week preceding the start of the semester. This is because the growing pressure to include more and more in the engineering curricula has made it extremely difficult to hold the competition at the expense of week-1 lectures. The competition challenges have been deliberately diverse and have included the design and build of: cardboard planes; small vehicles that must either travel the furthest or negotiate a set course; egg catapults, from which an egg must travel the furthest without breaking; mousetrap powered aircraft; battery powered boats and most recently a medieval trebuchet. In each competition students have been constrained by strict rules and have either built their devices from materials that were supplied or have worked within a set budget. Throughout the week the students form and construct a solution, write an engineering report, and are invited to attend lectures aimed at assisting them with design, team work and report writing skills. Throughout all of this each team is also assigned a postgraduate mentor who is expected to assist them by answering any questions that they might have. On the Friday the students congregate in an open area with their devices and compete against one another. Industry sponsors offer reasonable cash prizes for the winning team, the team with the best engineered design, and the one with best report. The School provides a barbecue and soft drinks and the majority of the students enjoy the carnival type atmosphere.

Results from the 2000 student survey
Figure 1 depicts a summary of results from the survey conducted after the inaugural 2000 University of Adelaide Mechanical Engineering competition (Snyder 2002) and it can be seen that the most encouraging aspects were that:
- there was a positive impact on most student’s attitude towards the university,
- it was enjoyed by most students,
- most students interacted well with their group members, and
- most students met new people.
Overall I enjoyed the week 1 activity

I found the interaction with my group members useful

The week 1 activity gave me an opportunity to meet new people

I found the tour with the level 4 student useful (first year students only)

The week 1 activity had a positive impact upon my attitude towards study at the university.

I found the interaction with my postgraduate contact useful

Figure 1: Summary of the results from Snyder’s 2000 survey (Snyder 2002).

There are obvious indications of improving the School’s organisational culture, the student peer interaction and students’ cognitive skills; however, recent student feedback from focus groups has suggested that the effectiveness of the design and build competition has diminished since its introduction. To assess this hypothesis, another survey was conducted at the 2006 Design and Build Competition.

The 2006 Design and Build Competition and survey results

In the 2006 competition, held during the student orientation week, the teams were presented with the task of designing and building a medieval trebuchet (see Figures 2 and 3) and significant cash prizes were offered from industry sponsors. At the end of the competition a survey was conducted with the specific aim of judging the students’ level of satisfaction and comparing it with the survey conducted in 2000 (Snyder 2002). The students were quick to disperse and so the initial number of survey responses was extremely poor. The surveys were then handed out at lectures amongst captive audiences in the following week which resulted in a much higher response rate across all of the year levels (1st through 4th). It is indicated by Figure 4 that the results from the 2006 survey are similar to, though slightly lower than, Snyder’s 2000 results of Figure 1.
Figure 2: Some of the students’ trebuchets.

Figure 3: Students enjoying the competition day.
Participating students had a mostly positive attitude towards the project. Overall they:

- shared a similar level of enjoyment with their 2000 counterparts,
- found the group interaction only slightly less useful, but still useful,
- met a similar amount of new people, and
- agreed that it had a positive impact on their studies, although slightly less so than in the 2000 competition.

While there was a slight reduction in the agreement level for all of these, the overall response was still generally positive. The perceived value of interaction with the student’s postgraduate contact was, however, significantly less. Another extremely negative observation was that the number of participating students had reduced significantly; it was estimated that only just over half of the students actually participated in the activity. An analysis of the response to the survey by year level was undertaken to establish who were the most dissatisfied. The year level subdivisions in Figure 4 clearly show that level 1 (first year) students were in the majority of participants and that level 4 (final year) students were in the minority of participants. Figure 5 also indicates that the level 4 students gave the most negative reactions from all of those surveyed, whilst the level 1 students gave the most favourable responses.
Discussion

The reduction in participating students
The success of any large scale activity can easily be impeded by ‘real world’ constraints and by the limitations that these constraints impose. The Design and Build Competition is no exception. Student participation reduced for a variety of ‘real world’ reasons. While moving the competition from the first week of semester into orientation week (O’ week) ensured that no mainstream lectures were cancelled and that no curricula were compressed, it still created a number of issues for the students. O’ week is important for both new students and returning students alike. The university-wide organised activities are designed to welcome and familiarise students with the facilities and resources of the university in a fun and friendly atmosphere. Therefore, while mechanical engineering students are building an organisational culture within mechanical engineering, their opportunities to develop an equally important organisational culture in the broader university community are compromised. Our new students have fewer opportunities to become familiar with the university and returning students have less opportunity to socialise with their peers. Mechanical engineering students must also complete a twelve week work experience requirement before they graduate and so many senior students, who feel that they have sufficient familiarity with the university, often schedule work experience during O’ week. Senior international students also, understandably, prefer to maximise their stay at home and therefore often stay overseas until the first week of semester. Evidence of students preferring to continue with their work experience or remain overseas was in abundance; many had the good manners to apologise in advance via email for not attending. In short, running the Design and Build competition in O’ week is perceived by many, for a variety of reasons, to be an invasion of a student’s personal time. There is also a growing perception among staff that students only want to do what needs to be done in order to ‘get good grades’ or to improve their employment opportunities. Therefore any extra-
curricula activity organised by the department, regardless of the good intent and outcome, is interpreted by some students to be a fruitless waste of time and an encumbrance. However, the students who do put in the time and effort generally find the experience enjoyable and they benefit as a result.

**Dissatisfaction with postgraduate contact**
As previously mentioned, there is an awareness that students tend to only do what needs to be done to get good grades. This also extends to postgraduates who are increasingly under pressure to complete their studies within reducing timeframes. Consequently, postgraduates would obviously prefer to spend their time researching or earning an income to either improve their standard of living, or to simply survive if their scholarships have run dry. The postgraduate students also realise that many of the undergraduates do not feel that the design and build competition benefits them. Under such circumstances, the expectation for them to volunteer to help with such events is perceived by many to be unfair and many postgraduates either protest loudly or simply minimise their effort in assisting.

**Organisational limitations**
The attitude previously described is, however, not limited to participating students or postgraduate volunteer helpers. Many staff members also resist involvement. This too is understandable when one considers the increasing work demands of academic staff. The magnitude of the project and the time requirements for its proper administration (estimated by the school for work load purposes as 220 hours) are significant and hence, even if the coordinating member of staff is enthusiastic, it can be easy to lose sight of the underlying objectives of the project or to miss out some important considerations. In addition to this, many other academic staff will not take the initiative to proactively assist. While many academic members of staff have expertise in their particular field of research, they are not necessarily experienced in the management or administration of such projects and so don’t know how to help.

**Future recommendations**
It is important that we endeavour to ensure that the outcome quality of the Design and Build Competition is maintained or even improves. Organisers must constantly consider the changing factors in society and the changes in the student cohort in order for effective student outcomes to be achieved (Walkington 2002). While the student outcomes (in terms of developing an organisational culture and peer support) are important, due consideration must also be given to all of those who are involved, so that everybody is satisfied. The magnitude of effective administration must not be underestimated neither should the benefits any of the other activities that students might have to forego, but would otherwise value, by participating. One means of improving the quality of project management and administrative duties undertaken by staff members is that all staff who take on such duties, not just of this project, but of any project within the university, should first have to undertake some management and administrative training which should be provided to them during work hours at the cost of the department. A dedicated team approach to organising the event would also be more effective than a single coordinator trying to powerlessly attract volunteers. However, the team would all need some form of encouragement to participate so that their personal perception of the competition importance is as high as many of their other workload commitments. Postgraduates should be paid for their time and should be made to feel that their assistance adds value to the project. The use of industry mentors for each team would also provide benefits. They may have more project management experience than academic staff and be able to provide assistance in planning. Students would see a connection with industry, equate it with a career opportunity and it would also reduce the work demands upon
staff. The importance of the event should be made clear to all and appreciated by all. As such, it should occupy a timeslot that demonstrates to students that it is a truly important part of the curriculum. If it were to return to the first week of the semester, students would be able to make full use of O’ week and experience and integrate themselves within the broader university culture as well as the more exclusive mechanical engineering culture. This would also permit students to pursue additional work experience opportunities or stay overseas for an additional week if they chose to do so. Lectures in week 1 may be affected, but rather than cancel them, creative lecturers may be able to relate their subject matter to the practical realms of the competition and the two may be used to compliment each other. In short, if students are expected to recognise the value of the competition beforehand so that they enter it with a positive attitude and maximise the outcomes, then the importance to the facilitators must also be visibly apparent.

Conclusions

Vertically integrated large team projects, without doubt, provide substantial benefits in terms of fostering an organisational culture and active peer support. The faculty must be seen to be part of this culture too, rather than just the facilitators. A healthy organisational culture will in turn develop cognitive skills, promote active learning, and improve the students’ overall university experience. However, the scale and cost (in terms of effort) of organising, administering and implementing such projects must never be underestimated, nor should the fact that all of those involved (not just the students) need to experience positive outcomes. While the scheduling of the event must take into account how it affects the semester’s curriculum, it must also take into account how it affects what is considered important to the students from their own perspective. A well designed and integrated competition should, after all, compliment rather than compromise an engineering curriculum. If the competition clashes with something that the student perceives to be of equal or higher personal importance, the student will either not participate, or participate grudgingly and hence not achieve the desired outcomes.

References