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STUDENT DESIGN-AND-BUILD PROJECTS REVISITED

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Abstract

The Weir Warman Student Design-and-Build Project and Competition has been run in universities in Australia and New Zealand for eighteen years, with up to 1000 second-year students from up to 18 campuses taking part annually. A completely new project is set each year. Students work in groups of 3-4 to define the problem, create a concept, design, build, test, modify, then demonstrate their device in a public campus heat. The emphasis at campus level is on helping rank-and-file students to achieve "good" design. The student group designing the most successful device on each campus competes in a National Final, where the emphasis turns to competition and a quest for design excellence.

Student surveys show a high proportion of students agreeing that they gained up to 14 separate learning benefits resulting from the project (range 52-92%). Amongst the most highly valued benefits over the years have been: the importance of simple design (up to 93% support); and practical experience of design (up to 92%). Learning how to work in a group has been consistently highly valued (80-90%). An important finding is that approximately 50% of students claim that they have changed their concept of good design as a result of the project.

Keywords: Student design-and-build project, student surveys, design experience, learning benefits

1. Introduction

Design-and-build projects as part of an undergraduate engineering course have, to our knowledge, been in use in Australian universities for more than forty years, and a number of investigations into their learning benefits have been reported [1-4]. The Weir Warman Student Design Project and Competition falls squarely into the design-and-build category, with a number of innovations distinguishing it from earlier forms of design-and-build projects. One significant feature is its two-tier organisation, with all students at participating campuses taking part in the design-and-build project and campus winners proceeding to the National Final competition. A second feature is the creation of a completely new project each year, avoiding "recycled" designs. Now in its eighteenth year, the Weir Warman Project and Competition is open to second-year students in mechanical-engineering courses (broadly defined) in universities in Australia and New Zealand. Up to 20 campuses have competed annually, but the number has dropped to 16-18 in recent years.

In the early years of the project, we reported the learning benefits gained by students taking part in the Warman projects [3, 4, 6, 8]. In closed-end questionnaires (yes/no/unable to say), we demonstrated at least 14 identifiable aspects of the design process which students believed they had gained, or improved, or had become aware of, by taking part in the project. There were also a significant number of perceptive responses to open-ended questions which indicated the depth of learning associated with the experience.

The past decade has seen significant changes in the ethnic and gender mix of Australia's undergraduate student population. Students are also under greater pressure in their courses and financial pressures force many to undertake regular paid outside work each week. The widespread adoption of computer modelling as the medium of engineering design and communication brings potential benefits but probably occupies more course time than the courses it replaced, and has certainly not increased students' exposure to hands-on activities. It is also possible that students' attitude has become more focused on passing their course rather than gaining a broad education – the so-called "meal-ticket" approach. The nett result of these factors may well be a significant decrease in the time students have available for, or are willing to devote to, university activities. Consequently, there may also be a significant change in students' overall attitude to a time-consuming subject such as engineering design, including their acceptance of the Weir Warman Project and Competition. It was for these reasons that we conducted a survey of the students who took part in the 1997 Weir Warman project [6], using the same mix of closed-end questions and open-ended comments. However, we increased the scope of the survey by considering two different groups of students: the rank-and-file who participated in the project at campus level; and the campus winners who had the additional experience of competing at the National Final. The 1997 survey demonstrated that significant additional learning, particularly increased depth of understanding of the underlying concepts of the design process, resulted from that experience [6].

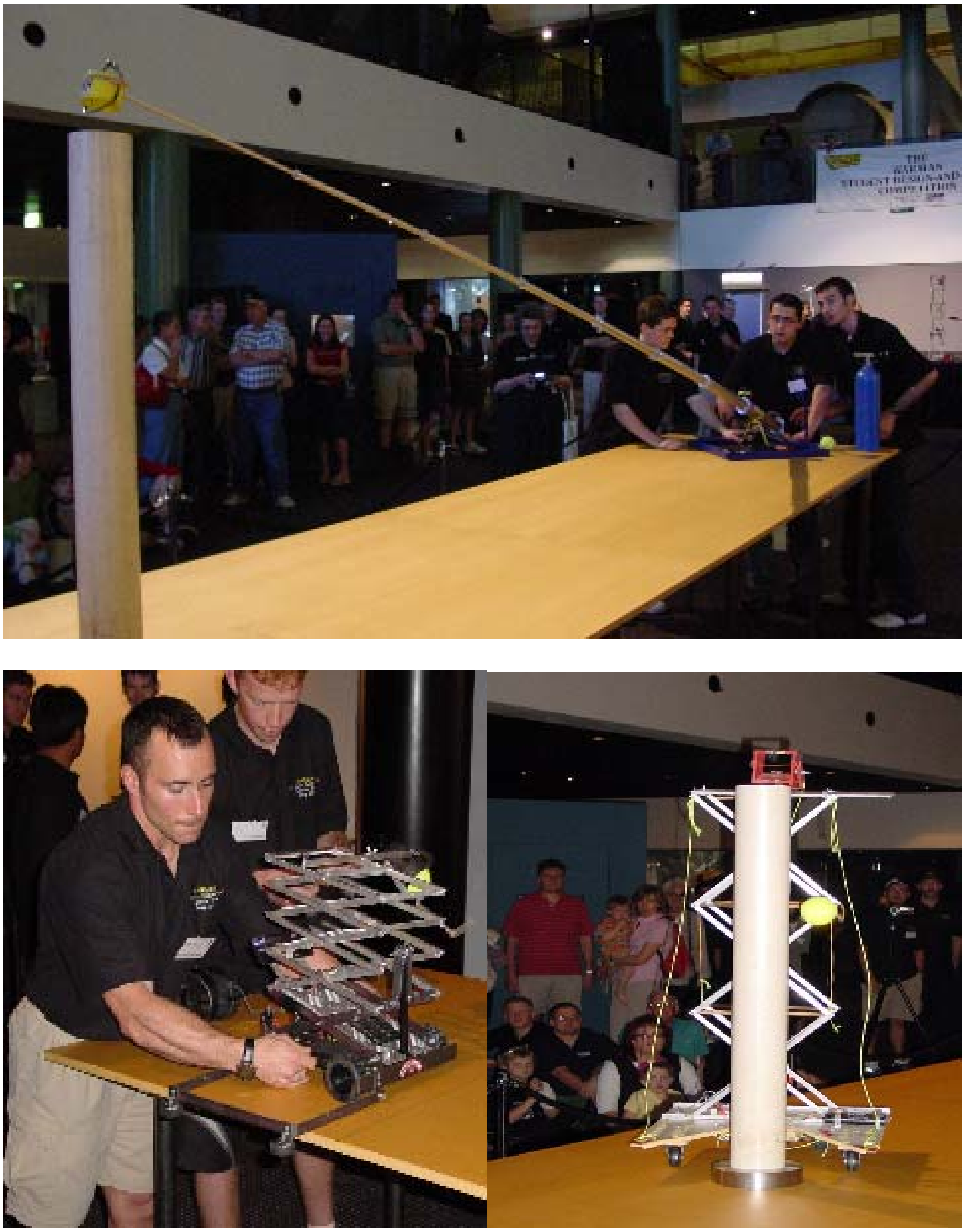
The results of a further survey of 2002 students were published in 2003 [8]. In the same year, in view of the demonstrated learning benefits of the project, an effort was made to determine the rationale for a number of campuses not competing and, if feasible, to make changes to increase the acceptance of the overall project and competition. Our sponsors provided funding to bring a key design teacher from all Australian campuses, irrespective of whether their campus competed, to the 2003 National Final, the aim being to provide a forum to identify difficulties and suggest ways to encourage more campuses to run the project. This revealed widespread support for the design-and-build concept, even on some campuses where the teacher chose not to run the project, and resulted in a number of suggestions for fine-tuning of the project format and specifications.

A possible criticism of the surveys up to 2002 was that the student responses had been voluntary, with response rates being quite low on some campuses. To test for possible bias, surveys were undertaken in 2004 on three campuses, ensuring better than 95% response rate on each campus. Further data were provided by a survey of all students who took part on the 2004 National Final. It is the purpose of this paper to report on the results of the latest survey, to compare them with earlier data and to assess the worth of a design-and-build project as part of an undergraduate engineering curriculum.

2. Project and competition format

An important aspect of the Weir Warman project and competition is the creation of a completely new and different project each year, avoiding "recycling" and a devolution into "second-order" design improvement of last year's models, rather than *ab initio* design. Setting the scene on the mythical Planet Gondwana, where Earth students are imagined to go on work experience, also helps to break "set" thinking.

(a)



(b) (c)

Figure 1. Different concepts at the 2002 National Final in Sydney's Powerhouse Museum in 2002. The task was to traverse 3.0 m, then drop a tennis ball down the 1.0 m high vertical plastic pipe in the minimum possible time. (a) The top photograph shows the winning device, which used pneumatically-powered telescopic tubes and dropped the ball to the bottom of the pipe in 1.0 sec. (b) This device used guide wheels running on the edge of the track to ensure lateral accuracy. It dropped the ball as it ran past the pipe. (c) This design employed a large V 'catcher' to guide it into position on the pipe. Unfortunately it failed to rise to its design height, did not align correctly, and the ball can be seen falling outside the pipe.

The task of the National Organiser is made more difficult by the need to set a project which will allow a large majority of students to complete the campus project with some degree of success, yet challenge the best student designers at the National Final. To emphasise the diversity of engineering design, it is also intended that the project parameters will be set in such a way that several different design concepts will have similar viability and will be represented at the National Final. For example, Fig 1 (a-c) shows three different concepts competing at the National Final in 2002 (a year for which suitable photographs are available). The set task is described in the descriptive caption for Fig 1.

The project specification is issued to the Campus Organiser at each eligible campus, more than 20 in Australia and 2-3 in New Zealand, in February each year. At participating campuses, all students in second-year design classes take part in the project. Campus Organisers are responsible for the timing and running of the project on their own campus and, for the purpose of campus heats, may relax the specifications or performance criteria, if considered desirable. Students normally work in groups of 3-4, giving weaker students a chance to learn from their colleagues and make a contribution to the design. Each group works through the design process, including creative thinking, construction, testing, and modification, culminating in public testing of their designs in campus heats. Whilst the emphasis at campus level is on at least a partially successful attempt at the set task, there is an undoubted element of competition amongst the better groups, since it is known beforehand that the best-performing group on each campus will be selected to compete against their peers at the National Final.

National Finalists are flown to a central venue which, in recent years, has been in the Turbine Hall of Sydney's Powerhouse Museum or at the University of Technology, Sydney. The students are provided with reasonable accommodation for three nights and generally treated as conference delegates. After briefing and a conducted tour of the Weir Warman plant at Artarmon (a Sydney suburb), groups are allowed a day of practice. The National Finals, comprising two runs for each group, are spread over the morning and afternoon of the third day, so timed that visiting members of the public can watch the event. Our sponsors have been very generous, not only in financial support, but also in ensuring that very senior engineers are present at each National Final, acting as judges, talking to and encouraging the students, and presenting prizes at the Presentation Dinner which is held on the evening of the National Final.

3. The 2004 Warman project

The 2004 project, upon which the latest student survey has been based, was couched in terms of capture and utilisation of scarce energy resources for transport purposes on the mythical Planet Gondwana, where Earth students are imagined to go each year for work experience. The set task was to develop a prototype vehicle which was capable of capturing potential energy from an external source, transforming it into some form of energy stored within the vehicle, then using that energy to drive the vehicle, carrying a payload, as far as possible up a sloping roadway. Full details of the project specifications and rules may be viewed at http://www.unsw.adfa.edu.au/acme/warman/index.html or www.ncedaust.org.

In the more prosaic earth-bound situation (i.e. the actual test conditions under which student designs were required to run) potential energy was provided by a mass, equal to the laden mass of the students' vehicle, dropping a fixed distance of 1.0 m. The roadway comprised 3 pieces of medium density fibreboard, of total length 4.8 m, set at progressively increasing slopes of 5°, 10° and 20°. Students constructed their own device, at their own expense, from commonly available materials. At the start of a run, the complete vehicle had to fit within a 400 mm cube. However, students were allowed to design and use some form of “intermediate device” to allow the transfer of energy from the falling mass into their vehicle and the intermediate device was not regarded as part of the vehicle. Once a vehicle left the starting position, it had to proceed without intervention or external control. The focus at campus level was on the successful design of a vehicle which moved its payload at least some distance along the upwardly sloping track. To this end, Campus Organisers were encouraged, if they considered it desirable, to modify either the task or the performance requirements set for their students. However, the device selected to compete in the National Final had to comply strictly with the project specifications.

Several different design concepts, in several different forms, were present at the 2004 National Final. Most groups elected to transform the potential energy into some form of elastic energy in the vehicle. Helical-coil steel tension springs, rubber bands and spear-gun rubber were commonly used. One concept was to use the stored elastic energy to drive axles and wheels via gears, pulleys and belts, or cords. In this group, there were some reasonable attempts (e.g. cone pulleys) to match overall drive ratios to decreasing spring force and increasing track slope. Other groups used the stored elastic energy in “catapult” mode, depending on kinetic energy (high initial velocity) to propel the vehicle as far as possible up the track. The latter concept proved to be the most effective design on the day, probably by avoiding frictional losses in drive trains. A few groups used the potential energy from the falling mass to lift their device above the roadway, then released it to run down a steeply sloping ramp. No students at National Final level attempted to use a flywheel to store energy in kinetic form.

4. Student surveys

The student survey form used for the 1997, 2002 and 2004 surveys was identical to that given to our students at UNSW in 1991 and (except for one question) 1993. It comprised mainly closed-response questions which were derived from an earlier open-response survey at UNSW [3]. In all surveys, students were given the opportunity to make written responses to a number of key questions as well as general comments at the end.

Responses to the 2002 survey were received from 8 of the 16 participating campuses. Of the 756 students from these campuses who took part in the 2002 Competition, 357 responded to the survey representing a 45% response rate. At UNSW, 96 responses were received from 151 competing students (64%). The low overall response rate was partly due to the survey being conducted several months after the 2002 competition had been completed.

The 2004 survey was undertaken to assess possible bias due to the incomplete response in the 2002 and earlier surveys. Only three campuses (two large campuses, including UNSW, and one small) complied with our request for “100% response rate”, giving replies from a total of 281 students with better than 95% response.

5. Results

5.1 Learning benefits

Table 1 presents the results of the fourteen closed-end survey questions asked in all five surveys. Students were asked "Did your experience of participating in the design-and-build project result in significant learning in each of the aspects listed?". The percentages shown in

Table 1 refer to the proportion of 'yes' responses to each item. Alternative responses were 'no' and 'unable to say'.

In our earlier publications [3, 6-8], the student responses were split into "UNSW campus", "Other campuses" and "All responses" to allow direct comparison with the 1991 and 1993 UNSW surveys. Any campus-to-campus differences were found to be small and did not change our overall conclusions in any way, hence Table 1 provides a convenient summary of the available data.

Table 1. UNSW Surveys 1991 and 1993, National Surveys 1997, 2002, 3-campus Survey 2004, and Survey of National Finalists 2004: Proportion of students claiming significant learning attained in the 14 aspects listed.

	National Finalists 2004	3-Campus Survey 2004	National Survey 2002	National Survey 1997	UNSW 1993	UNSW 1991
Item	% Yes	% Yes	% Yes	% Yes	% Yes	% Yes
1. Importance of simple design	79	93	75	86	81	89
2. Importance of organisation	87	90	61	74	80	88
3. How to work in a group	83	80	85	84	87	90
4. How to carry out a project	92	86	75	77	83	88
5. Practical experience of design	98	92	61	74	77	85
6. How to translate design into product	85	80	84	86	78	79
7. Importance of initial concepts & calculations	70	76	79	70	64	81
8. Need for a prototype	79	59	79	83	50	76
9. Skills in problem solving	92	89	50	57	71	76
10. How to recognise design deficiencies	89	82	55	65	77	85
11. How to put theory into practice	81	65	55	58	69	68
12. Skills in organisation	77	76	67	63	66	75
13. Estimating time required for completing project	75	65	67	52	64	56
14. Importance of cost considerations	66	66	72	76	55	74
Number of respondents, N	47	281	337	318	87	72
Average "Yes" response %	82	79	69	72	72	79

Higher support (green) Lower support (orange)

As may be seen from Table 1, the results of all surveys show high proportions of students claiming significant learning in all of the 14 listed aspects of engineering design. As shown by the coloured boxes, the four items which drew highest levels of endorsement in the 2004 survey were:

- Question 1: 'The importance of simple design' (93% 'yes' responses);
- Question 5: 'Practical experience of design' (92%).
- Question 2: 'The importance of organisation' (90%); and

- Question 9: ‘Skills in problem solving’ (89%).

These may be directly compared with the responses to the same questions in 1991, 1993, 1997 and 2002, as shown in Table 1.

Although the results of the 2002 survey were generally lower than in 2004, they were nonetheless endorsed by the majority of all respondents as resulting in significant learning, the lowest ‘yes’ response being 55% for Questions 10 and 11.

Partial explanation for the lower values in the 2002 survey can be found from comments made by students at one campus who, in that year, were not provided with the opportunity to build their designs. The project coordinator from that campus (from which the highest number of questionnaire returns outside UNSW was received) wrote that ‘ ...of the 35 syndicate groups (at that campus) only 9 designed and built’. Many respondents from that campus expressed disappointment that they did not have the opportunity to proceed with their design through to the built product:

- Would like to see all students given the opportunity to build... as this is where your design is really tested and most practical experience is gained.
- It re-emphasised the importance of simple solutions. However, we never got to make ours, so it was harder to assess.

Table 1 also shows the extremely high responses of the 47 national finalists, although with different rankings. Their highest level of endorsement was: Question 5: ‘Practical experience of design’ (98% ‘yes’).

Some representative comments from recent surveys are:

- It’s one thing to design something on paper, but until you try and build it yourself you don’t learn anything about designing for the project to be built (2002).
- We learnt to learn from our mistakes (2004 National Finalist).
- Importance of initial calculations and concepts. Our concept had a deficiency in this area. We did not calculate our energy loss with inertia in the falling mass (2004 National Finalist).
- Was fun and taught valuable lessons in group working, time management and organisation which will be used in jobs in the engineering area (2004).
- Something viable in theory is not viable in practice (2004).
- Confirmed the idea that simple design is best (2004).
- Always simple! If you can’t build it, it won’t work (2004).
- This project helps students to work as a group and improves their communication and organising skills with other people (2004).
- Warman project helped my understanding of good design and how to work in a group tremendously. I have learnt so much from this project, more than any other I have done. (2004).
- Excellent challenge for us to apply practical engineering and will be a basis for further problem solving tasks (2004).
- Once you see everyone else’s finished design you realise there was perhaps a better way than the way you spent so much time constructing (2004).

Figure 2: Student Survey - 3 Campuses 2004 (N=281)
Student responses to the 16 questions listed below

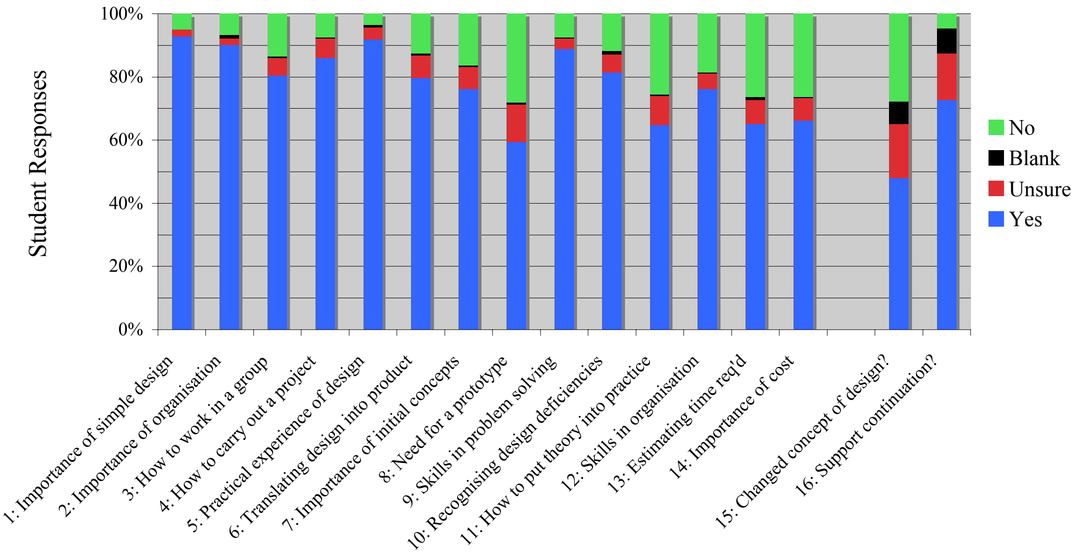


Figure 3: Student survey - National finalists, 2004 (N=47)
Responses to the 16 questions listed below

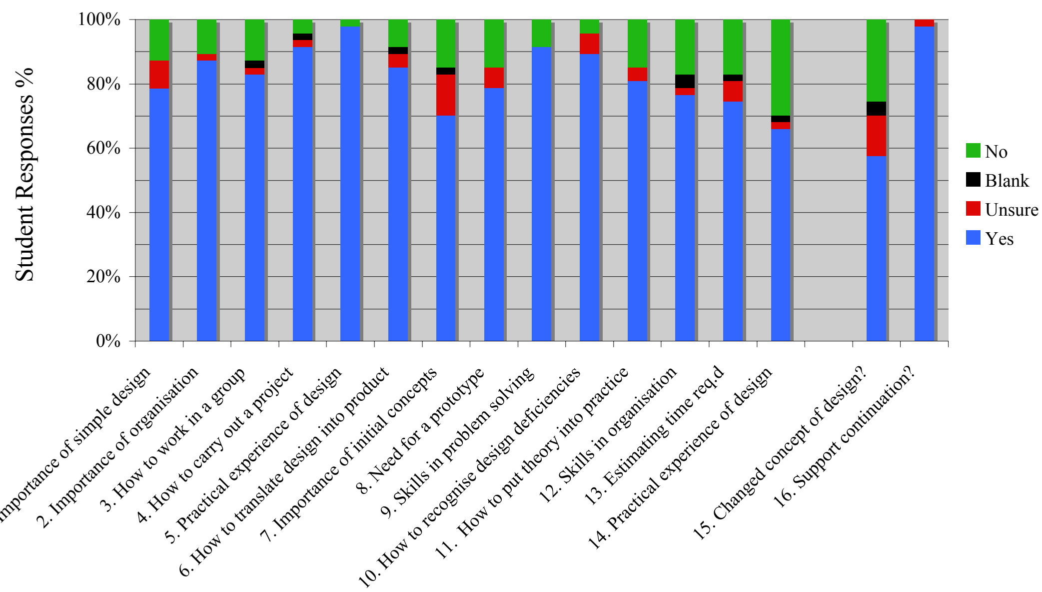


Figure 2 presents graphically the data from the 2004 survey of three campuses with 281 students (better than 95% response rate) completing the survey form. In addition to the 'yes' responses in Table 1, the chart shows the relative proportions of 'unsure', 'blank' and 'no' responses. Figure 3 shows similar data from the 47 National Finalists (100% response rate) in 2004.

Table 2 National Surveys, 1997, 2002 and 2004: Responses to questions on 'fundamental change in conception of good design' and 'support for continuation of the Weir Warman design-and-build project'.

	Nat Final 2004	3 Campus Survey 2004	National Survey 2002	National Survey 1997
Q15. Fundamental change?				
Yes	57%	48%	56%	52%
Unsure/Blank	17%	24%	18%	23%
No	26%	28%	26%	25%
Q16. Support continuation?				
Support	98%	73%	85%	78%
Unsure/Blank	2%	23%	8%	18%
Do not support	0%	4%	7%	4%
Number of respondents, N	*47*	*281*	*337*	*318*

5.2 Fundamental change in conceptions

Table 2 shows student responses to two additional questions (Q15 and Q16) from all national surveys. Fig 2 shows the responses of students in the 3-campus survey in 2004 to the same questions while data from the 2004 national finalists appears in Fig 3.

Question 15 asked students whether the Warman Design and Build Project and Competition had resulted in any fundamental change in their conception of 'good design'. As may be seen from Table 2, 56% of the 2002 respondents answered 'yes' to this question, with 18% 'unsure', and 26% answering 'no'. Many of those answering 'no' came from the previously mentioned campus where the large majority of students did not get to build their design. However, in the 2004 results (Table 2 and Fig 2), which did not include that campus, the 'yes' response had dropped to 48%, with 24% 'unsure' and 28% answering 'no'. Not surprisingly, a greater proportion of the students who participated in the survey at 2004 National Final level (Table 2 and Fig 3) responded more favourably to this question, 57% compared with 48% for the 3-campus survey.

In all surveys, there were numerous written comments attached to students' response to Question 15. The two most frequently mentioned aspects were changes in their conception of the 'need for simplicity', and on the 'process of translating design to product':

- Simple, yet practical design. Complexity is not necessary for simple tasks. I guess the learning that takes place depends on how you approach things, and what ideas you learn when you work on such projects (2002).
- Our design (we thought) was a good design but we lacked the ability to build it. From that perspective, it was a bad design to try and make (2002).

5.3 Continuation of the Weir Warman project

The final question (Question 16) asked students if the Warman project should continue as part of their course, bearing in mind its benefits as against the time invested and the financial cost. As shown in Table 2, 78% of the 1997 students supported its inclusion. In 2002, the 'yes' response had increased to 85% but dropped to 73% in 2004, which may be at least partly due to the 95% or better completion of the survey form. Support from the 2004 National Finalists was almost unanimous (98%). Comments appended by respondents in all surveys who supported continuation made reference to valuing the learning benefits of the design and build experience, or its effect on motivation and interest, or to the benefits of participating in the project:

- Other courses do so much in a theoretical manner that we don't get a sense of reality until we apply in this way. Also gives confidence in that we realise we can design something from scratch, even if it is not perfect...(2002)
- The Warman is a great project. It was part of why I did mechanical engineering (2002).
- It's a fun project, and the only time we get to construct a device in year 2. It produces motivation that the other projects do not (2002).

In 2002, one campus coordinator wrote to us as follows:

- I had a separate questionnaire about my design subject, and asked for three good things. Most common reply (24 out of 96 replies) was 'Warman competition'!

6. Discussion

6.1 The Weir Warman project as part of the course

The difficulties of teaching engineering design in university courses and the unique role of an activity such as the Warman project in giving students experience in defining the problem, conceptualising a solution, then making the leap from the concept to a practicable configuration, have been outlined in earlier publications [3-6, 8]. Although "capstone" projects with industry (usually run as an elective in the final year of study) provide valuable experience for those students with design aspirations, the Warman project does much to plug the "design experience" gap in the crucial early years of the course. It provides motivation and nurtures a "design ambience", both of which are essential if students are to "catch" design [5]. The concept of "catching design" was brought to UNSW by Prof Gordon Wray, now retired from Loughborough University, who recognised that design learning does not come from a textbook, but flows from practitioner to student. It can flourish only in a supportive "design ambience", of which a normal lecture theatre is a very poor example.

Not all students will become designers but, by participating in the Warman project, all will experience, at least once in their course, the full design process, and that in a "fun" but nevertheless challenging environment. On the basis of our survey results, and from our contact with students and staff from around Australia and New Zealand, the Warman project has been shown to focus student attention on the importance of the factors underpinning creative design and to provide an avenue and the incentive for a creative-design experience in the second year of the course.

6.2 Learning outcomes

The 2004 student surveys, based on the 14 learning outcomes established in previous surveys, confirm that the Weir Warman project and competition continue to enjoy a high level of support. The 2004 results were all the more satisfying when compared with the response rates obtained in previous years since, in the two previous national surveys, voluntary response rates were 45% in 2002 and 32% in 1997. To the extent that those who take the trouble to respond are likely to value the experience more highly than those who do not respond, we recognised that some degree of bias may have occurred. In contrast with these earlier surveys, the 2004 survey, with its 95% or better response rate, achieved, overall, a more favourable outcome than that found in earlier surveys. This point may be appreciated from the overall average of 'yes' responses presented in the bottom row of Table 1, i.e. 79% in 2004, 69% in 2002 and 72% in 1997. It goes without saying that, in student surveys of this type, the positive response rates achieved over the years are exceptionally high.

Responses to the 14 'learning' questions have already been covered under Section 5.1 Learning benefits. It is interesting to note that Question 3 'How to work in a group' has consistently been a highly valued learning experience, with 'yes' responses in the range 80-90%. It may at first sight be somewhat surprising to find this aspect so highly rated. However, individual work is almost universally demanded for theoretical assignments, and it appears that students recognise and appreciate the different skills needed for successful group work.

6.3 Change of concept

For Question 15, the 2004 responses (Table 2 and Fig 2) are very similar to those from the 1997 national survey (Table 2), although slightly less favourable than those achieved in the 2002 national survey (Table 2). We are convinced it is of signal importance, and perhaps the most important learning aspect of the Weir Warman Project and Competition, that a consistent 50% of the respondents report 'fundamental change' in their conceptual understanding of good design/design process. The 3-campus survey in 2004 (Table 2 and Fig 2) supports earlier data by providing clear evidence that the result is not due to 'response rate bias'.

From our analysis of the format of the project and competition, we hold the opinion that conceptual change is likely to occur over a prolonged period during the concept-development and prototype-development phases, when the students' first concept designs are found to be unworkable and must be modified, usually requiring simplification. Nevertheless, the effects of the somewhat confrontational public demonstration of performance and competition — the campus runoff phase — certainly should not be ignored. Although this phase is quite brief compared with the project process, it has a powerful effect in bringing about conceptual change, e.g. a realisation that "other designs were simpler and cheaper than ours yet performed better!". In this regard, it is interesting to note that the most common change, as evidenced by student comments, is an awareness of the importance of simplicity in design.

As pointed out in our most recent publication in this area [9], it has long been recognised by educationalists that the most important, and yet most difficult, instructional goal is that of bringing about conceptual change in students' understanding of the core features of the discipline being studied. Although educational researchers and teachers in various disciplines have attempted to develop teaching strategies to promote conceptual change [10-12], few studies report substantive gains in bringing about change of this kind. West's review of a large number of studies which have attempted to promote conceptual change in different disciplinary contexts found that few were able to overcome student 'resistance to instruction' to bring about change, and none of the successful studies achieved this on a large scale. He concluded that 'one of the lessons from this research is that conceptual change is not as easy as one might expect' ([10], p.160).

From our monitoring of the outcomes of the Weir Warman design-and-build experience, it is quite evident that students, including many who have gone no further in the competitive phase than campus heats, have experienced profound broadening of their conceptual understanding of design (Table 2 and Fig 2). Whilst the precise role of 'design project' versus 'competition' cannot be determined from our data, the 2004 students who were successful in campus heats and progressed to the National Final (Table 2 and Fig 3) reported a greater proportion of 'yes' responses to this question (57% compared with 48%), and a slightly smaller ‘no’ response (26% compared with 28%) than those whose experience stopped at campus level. These results are generally in keeping with our survey of national finalists in 1993 [4], from which we concluded that there are significant additional learning benefits in competing at the National Final, particularly in improving students’ concept of “good design”.

We recognise that, whilst only a relatively small proportion of our students will become career designers, their participation in the Weir Warman project does provide an exposure to the full design process, and promotes the much sought for goal of promoting understanding and conceptual change. Further, and quite apart from the merits of the survey data, we believe it is difficult to overestimate the potential benefits of national finalists meeting with, comparing notes with, and competing against similarly talented peers. This is an important aspect since this group might be considered as amongst Australia's top student creative designers and hence as the future of Australian engineering design.

6.4 Continuation of the project

Student enthusiasm for the Warman project has remained at a high level over its 17-year life, with up to 85% of students (in 2002, Table 2) supporting its continuation. The level of support dropped to 73% in 2004, with 23% ‘unsure’ although the ‘no’ response remained constant at about 4%. Not surprisingly, the 2004 National Finalists very strongly supported both the project and the competition (98%). The decrease in campus-level support in 2004 may be at least partly a result of increasing course pressures, and some fine-tuning may be appropriate, but there may also be variations due to subtle differences in the nature of the project or its organisation, and staffing changes from year to year. Whatever the precise causes of the variations, the level of support more than justifies continuation of the project. As one student commented:

- Brilliant project. Gives experience as to practicality of ideas. Got a sense of perspective as to how accurately you can build something - ie how straight will it go, and how strong you can make a pillar, for example. Useful knowledge gained researching motors etc. (2002).

Those who opposed continuation of the project generally did so on the grounds that it required too much work for too little reward in the form of marks in their design course and/or the time at which it was held conflicted with other work loads. There were similar comments from the 8-23% of students in the various national surveys who were “unsure”, but there was also an occasional response indicating deeper concerns:

- The project was trial and error, and therefore gave little experience in actual converting design to building a model. This project should either be the whole course, or none, since it took up approximately 30 hours each for only 20 marks! We end up weighing up the amount of work we need for other subjects against how many we need to scrape through the course.

- The help given needs to be improved, no real [help] was received. Need better laboratory facilities. All that was provided was a bench, as we cannot use any machinery in the labs- only our own equipment. I live out of town, don't have a drill and set, along with welding equipment.

- Too much other work involved in the [overall design] subject- it [Warman] is big enough to be a subject itself. Access to workshops should be more available, and publicised.

In 2001, we surveyed mechanical-engineering design teaching in Australian universities [7]. We reported a wide variation in several factors which may well be significant in the present context, including the number of lecture/tutorial hours allocated to design, the absence of design-specialist staff and the lack of practical design experience of staff on some campuses, and an increasing tendency to outsource design lecturers and tutors. We also noted the wide variation from campus to campus in the course marks allocated to the Warman project (15-50 %). We feel there is insufficient data to attempt a meaningful correlation between these variations and student support for the project, but recognise that staff enthusiasm and support are critical factors in student attitude to the project. In particular, inexperienced or uncommitted staff, or outsourced staff who are on campus for only a day or two per week, may very significantly affect student acceptance of the project and, consequently, the benefit they derive from it. The following student comment may well have been driven by such concerns:

- More support should be given by the School in form of resources and guidance.

It is commonly accepted that the present organisation of Australian industry tends to force many talented engineers into managerial roles, relatively early in their career, in order to achieve promotion, salary and status. If that is to be the case, we can think of no better background for an engineering manager, and no better criterion for the successful continuation of Australian industry, than for those managers to have a fundamental appreciation of the process and benefits of engineering design in general and creative engineering design in particular.

7. Conclusion

Our overall conclusion is that the Warman Student Design Project and Competition remains, as it has been since its inception 18 years ago, a very popular and a very worthwhile creative-design experience for up to 1,000 second-year students throughout Australia and New Zealand who undertake the project each year. In the interest of fostering an ongoing pool of creative Australian engineering designers, and possibly some enlightened managers, it is our hope that it will continue to run with its present levels of enthusiasm and learning benefits. However, the purpose of this paper is considerably broader than the Australian scene, asking the question “Does the design-and-build concept merit reconsideration as a means of engineering-design education?”. We submit that our experience and our survey results show that serious reconsideration is warranted.

8. Acknowledgments

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The six National Organisers who have served terms of 2-4 years each have done a sterling job in creating, each year, a new and challenging project having a range of viable solution concepts, in ensuring that the project lies within the capability of students, and in carrying out the sheer detailed organisation.

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