Peer tutoring in the design and build Warman competition

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Abstract: *The design and build Warman competition at the University of Adelaide is run as a compulsory part of level 2 Design Practice. To achieve the best educational outcome, the course has been structured to incorporate project-based learning by providing support in the form of lectures and tutorials to guide and support students through the project. To further increase the effectiveness of this teaching method undergraduate students, who were winners of the past competition, were employed as peer tutors. This particular aspect of the learning process has proven to be immensely successful with these tutors managing to provide support and stimulate peer enthusiasm as was reflected in many high quality designs and unprecedented learning outcomes.*

Introduction

Pear mentoring and tutoring schemes have been recognised as an effective tool to stimulate enthusiasm of engineering students. The schemes are often used in first year support initiatives to address the issues of retention rates as discussed by King (2008), but they have proven to be most effective when applied to project based programs such as in Formula SAE projects (Godfrey 2008).

The Warman design and build competition has been run for twenty two years and involves around 2000 students from up to 20 universities from Australia and overseas (Smith, 2008). It is organised by Engineers Australia for teams of second-year mechanical-engineering students and sponsored by Weir Minerals Australia Ltd. Each university holds their own competition amongst their own students and the winners attend the finals in Sydney. The competition is promoted by the National Committee on Engineering Design to provide a competitive problem-based learning (PBL) environment. The objective is to design, build and prove prototype autonomous devices to perform a number of tasks on a competition track. The scoring system is generally quite complex with points awarded for the speed and accuracy of the tasks that are performed.

Warman competition at the University of Adelaide

The School of Mechanical Engineering at the University of Adelaide has participated in the Warman competition from the very beginning, with the competition incorporated into a level 2 design course. Currently it is part of level 2 'Design Practice'. Unlike some of the other participating universities, the competition is compulsory for all mechanical engineering students because it is recognised that the project provides excellent opportunities to address the many practical challenges which relate to engineering design and is therefore seen to be an invaluable educational tool.

The assessment of the project assessment is based on two, preliminary and final, design reports, the quality of the device design and the team's competition score. The project therefore provides learning

experiences in communication skills, problem solving skills and ability to work in a team which is increasingly considered to be an essential part of engineering education programs (Hadgraft, 1998).

For most of the students, this is the first opportunity to apply their theoretical knowledge to a practical engineering problem. This creative process involves many aspects that are important for their future engineering career and include the development of their ability to:

- critically analyse complex competition rules and draw a design specification
- apply theoretical knowledge (including steps in design) to a practical design
- effectively work in a team
- manufacture a device based on their design
- allow for testing and improvements of the device (design iterations) and
- work within a budget.

To address the above design issues, while achieving the best educational outcome, Design Practice has been structured to incorporate project-based learning. One difference between problem and project based learning is the degree of learning support provided by the teaching staff, as discussed by Maier (2008). Project-based learning includes some form of structured support such as lectures or tutorials, with the level of support depending on the adopted strategy of project-based learning (Kolmos 1996; Mills and Treagust, 2003). In Design Practice students are given lectures (synchronised with the competition) which focus on the theoretical steps of design, the aspects of working in teams and organising a project, written communication skills, power transmission devices and basic microprocessor programming. Each 2 hour lecture is followed (later in the week) by a 2 hour workshop in which the students can work on the project with the assistance of tutors.

In recent years Design Practice class sizes has grown to over 200 students resulting in over 50 design teams. With so many teams involved running the competition created a serious challenge for the School organisers. The student numbers combined with increasingly restrictive safety rules resulted in the School being able to offer only very limit workshop support. Instead each team is given a limited budget ($100 in 2009) to cover material and manufacturing expenses.

The compulsory nature of the project has created a challenge with respect to stimulating the students' enthusiasm. For this reason the temptation to allocate students into groups of balanced gender and ethnic backgrounds (thus providing more realistic teamwork experiences) has been resisted with students free to work in teams of their choice.

Historically the tutors in the 2-hour workshops were usually retired engineers who, while possessing vast engineering experience, did not necessarily related to the students and their problems associated with the Warman design (especially the more modern mechatronic aspects). In recent years these experienced engineers were replaced with higher-degree students (from a dwindling pool of postgraduates). While in most cases these postgraduates could relate to the modern technical aspects of the competition and empathise with undergraduate students more effectively, some either lacked the required commitment or did not possess the required communication skills. In many cases they were far from being motivational.

Peer tutoring

The idea of employing undergraduate students, winners of a past Warman competition as tutors was conceived in 2008. Prior to 2008, despite significant effort from the School, only a few of our students' teams were developing solutions that were anywhere near the level of quality of teams that compete in the national finals. Consequently the students that we sent to the competition were having very limited success. In 2008 a team of exceptionally committed and skilled students (Figure 1) invested an unprecedented and extraordinary amount of time effort and resources in the project. As a result the team significantly outclassed all the other teams in our campus finals and went on to convincingly win the Sydney finals.

While everyone in the School was understandably proud of this achievement, it was clear that the success was attributed to the exceptional effort of the outstanding team, rather than due to the

effectiveness of the School's approach to the competition. These winning students were very much a product of their own exceptional motivation. Therefore, to capitalize on this outstanding result and to increase the enthusiasm of students' involvement in the competition in following year, two of these winning students were recruited as tutors and mentors to perpetuate the driving force behind the team's success.

However, while the students' enthusiasm and commitment was unquestionable, concern remained regarding their effectiveness as teachers and their ability to interact with students who were one year their junior. To minimise the risk an additional tutor, a postgraduate student with a significant experience in the competition, was also therefore also employed to work with them.

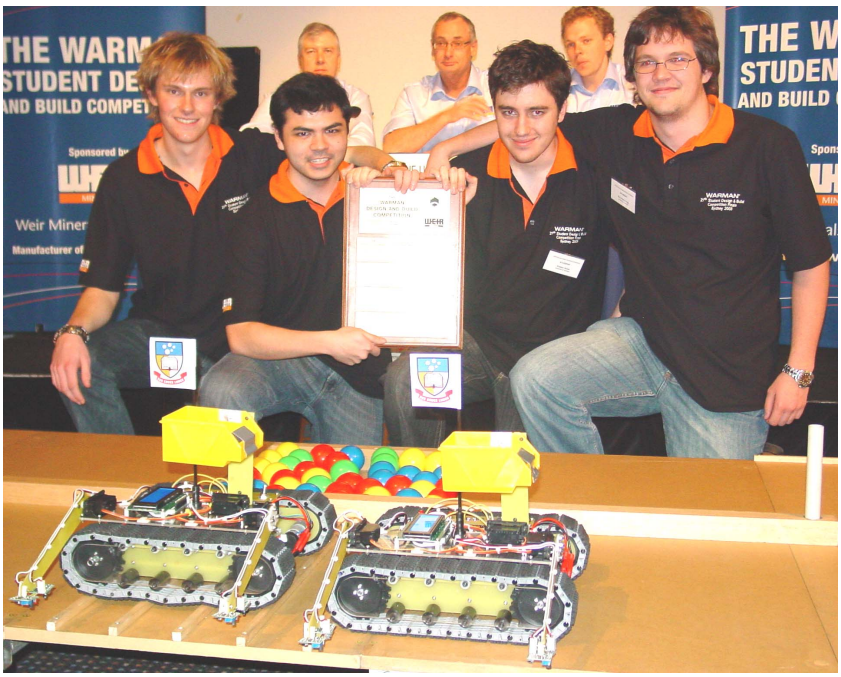

Figure 1. Winners of the 2008 National Final in Sydney, the team of the University of Adelaide: Bryn Crawford, Shane Fitzgerald, Tristan Goss and Eric Parsonage (team captain)

The effectiveness of winning undergraduate student tutors

A coordinator's and students' perspective

From a course coordinator perspective (the first author) the undergraduate tutors demonstrated great enthusiasm and commitment, easily engaged with the majority of their students and were easy to work with. The opportunity to tutor and mentor was also a character building experience for themselves, since they were obviously extremely proud to be given the opportunity to pass on their experiences, with a great deal of enthusiasm. In addition to helping the individual teams with their many design problems, the tutors also introduced their own performance initiative. Early in the course they ran a survey to determine the attributes, skills and experience of every individual student in order to establish who was best at doing what. While this survey did not impose any group allocation decisions, it did help to organise each team in terms of optimising their own internal combined skill sets.

To determine the students' level of satisfaction and their perception of the effectiveness of the undergraduate tutors, a short survey was conducted. The students were asked to agree or disagree with the statements presented in Table 1 and were asked for their additional comments. According to the responses most of the students believed that the tutors were enthusiastic, they had clear understanding of the requirements and they could give a practical advice about the design and manufacture. However the rate of positive responses to questions 1 and 5 (if students liked to work with tutors and if tutors were supportive and easy to work with) while still very high, was slightly lower in some instances. This might indicate, at least to some extent, a lack of teaching experience and maturity of the peer tutors.

Table 1. Survey results on the effectiveness of undergraduate tutors in the Warman competition

No.	Question	Agree %
1	I liked undergraduate tutors helping me with my design.	81
2	Being of a similar age and situation they could relate to me.	89
3	They were enthusiastic	93
4	They were very supportive	87
5	They were easy to work with.	85
6	Since they have had already been involved in the competition, they had clear understanding of the requirements.	89
7	They could give a practical advice about the design and where to obtain required components.	88

It was observed that, especially at the early stage of the project, the tutors were mainly focused on helping the most promising students while neglecting the others somewhat. The observation is supported by one of the student's comments:

"The students were enthusiastic and fairly helpful, but only really had advice for those who wanted to spend a large amount of time and money on the project. For us mere mortals, who have a range of priorities, there was much less advice about simpler, cheaper, more reliable methods for designing and building our vehicles."

This comment indicated that the undergraduate tutors were helpful in a somewhat selective way, with their enthusiasm directed towards the most promising teams. It confirmed the need to also include a more mature tutor to be involved with the added responsibility of helping to coordinate the undergraduate tutors so that all students were assisted fairly.

Local competition results

Based on the student performance in the 2009 competition the support from the undergraduate tutors was very effective. The devices that were designed and built by the students were generally of a very high quality and performed exceptionally well and the overall achievements of the students in the course had improved.

A quantitative comparison of the student performance in our local competition over the past few years is presented in Figure 1. Since the competition requirements and scoring systems vary every year a simple comparison was made by looking at the percentage of teams achieving between 50 and 75% of the highest, the percentage of teams achieving at least 75% and percentage of these two put together (percentage of teams over 50%). As it can be seen in Figure 2 there was an unprecedented success rate in the local competition in 2009 with 50% of teams achieving at least 75% of the top score and 70% achieving at least 50%. For the first time in the history of this event in our School there was a dead heat including 5 equal first teams. After an additional run there were still two equal first teams and a final winner had to be decided in a dramatic sudden death run-off. While this exceptionally high success rate can be, at least partially attributed to this year competition rules, it is worth noting that the both top teams were very closely cooperating with the undergraduate tutors. According to one member of the winning team:

"The tutors were extremely helpful. They have told as a lot of things we did not know about including the best type of batteries to use and the cheapest and safest way of purchasing required components."

The effectiveness of the peer-tutoring approach received further boost in the Sydney finals where the Adelaide Uni team performed very well and won the second prize, again in a dramatic sudden death run-off.

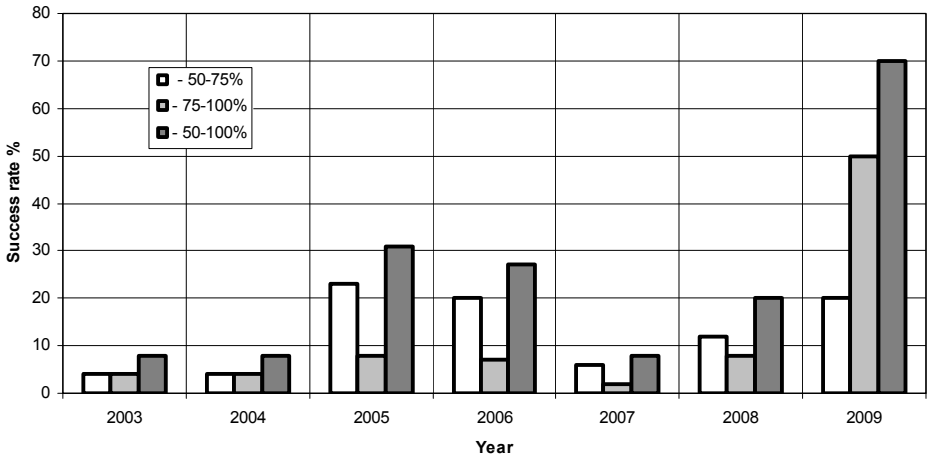

Figure 2. Success rate in the local Warman competition at the University of Adelaide

Conclusions

The idea of employing winning undergraduate students as peer tutors for the Warman design competition has proven to be a very effective teaching tool in many respects. The tutors were generally successful in motivating their peers and while having the experience of the past year competition they were able to help in many practical aspects of the design and manufacture of the devices. This resulted in many high quality devices achieving exceptionally high competition scores. These peer tutors also benefited from the process through what was also a very valuable learning experience in teaching. It should also be noted that while the undergraduate tutors, being generally more enthusiastic and committed to their duties than postgraduate students, were very effective in motivating the majority of the students, they somewhat lucked in teaching experience and maturity. To compensate for these shortcomings the use of a coordinating, more mature and experienced postgraduate student was also put to good effect.

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