Fast-Cars in Schools: a CADET Outreach Initiative

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SESSION Educating the Edisons of the 21st Century

CONTEXT In order to provide for Australia's long-term needs for engineers, it has become apparent that the profession needs to promote itself to school-age children. This is so that the seeds of interest in engineering are planted early enough so that they can grow. Recent research indicates that this can be most effectively done in primary schools. Students tend to decide whether they have an interest in STEM fields before secondary school.

The Centre for Advanced Design and Engineering Training (CADET) was established as a facility for educating engineers, starting in primary school and providing facilities and expertise all the way to doctoral studies. One key component of CADET's mission is to provide outreach programs in engineering to students in both primary and secondary school.

PURPOSE A primary-school outreach program was developed to give students an authentic engineering experience in the context of developing a small racing car and working with an associated cross-disciplinary team. The program was designed to be completely immersed and integrated with the Victorian Curriculum at year six.

APPROACH The program was named "Fast Cars in Schools." Teams of students from a number of primary schools developed a complete racing package of a small car, team jerseys, logos, advertising posters, and even sponsorship. The teams then competed with each other to develop the best car and the best overall presentation. Members of the teams had specific roles on designing and building the car, designing and producing the jerseys, promotion, and reporting. In addition to tasks specific to the cars, participating students attended additional practical sessions on the physics and aerodynamics of racing cars, and how one's reaction times affect the outcome of a race. The program was fully integrated in the school curriculum over two terms. In developing a competitive racing car, the student teams were required to formulate their own questions of inquiry. Under the guidance of their teacher and assigned mentors, the teams also had to solve several basic engineering problems associated with producing a car that performs well in an actual race.

RESULTS The 2015 pilot program ran with a small number of schools in the Geelong region. In 2016, this was extended to 14 schools across Geelong and the Werribee region. In all, around 1000 students participated in the program. The final competition was held at the Deakin Waurn Ponds campus and was attended by 190 students. Feedback from teacher and students was overwhelmingly positive.

CONCLUSIONS The team successfully showed how the CADET centre is helpful to a school's curriculum needs and is not merely a destination for one-day excursions. By applying the educational concept of activity-based learning, the CADET team successfully integrated most aspects of the Victorian year-six curriculum into this program.

KEYWORDS Outreach; F1 in schools; primary school; Victorian curriculum.

Introduction

The shortage of engineers in Australia is well known, and does not appear to be going away anytime soon (Hoffman, 2017; Topsfield, 2006; Walton, 2012). A broader problem nationally is the inadequate number of school leavers and university graduates with training in the STEM fields, which includes engineering (Tytler, Osbourne *et al.*, 2008). This skills shortage may be traced to the lack of interest, or disengagement, of high-school students with STEM-related subjects. There is evidence that seeds of a high-school student's interest in STEM and the aspiration to pursue a career in STEM are sown in primary school (Archer, Osbourne *et al.*, 2013). Recent strategies for increasing STEM interest in high school include exposing and engaging students in primary schools to activities that promote STEM-related fields as exciting and attractive (Education Council, 2015). These activities include those related to engineering, such as design (Brophy, Klein *et al.*, 2008).

In 2015, Deakin University opened a new education centre called the Centre for Advanced Design and Engineering Training (CADET) (Loussikian, 2015). This centre provides engineering education opportunities from primary school right up to doctorates. The Centre rests on three foundations: university education in engineering, industry engagement, and school outreach. Indeed, one of CADET's main objectives is to "increase the awareness and attractiveness of engineering as an education and career option, particularly for women, in regional schools" (Littlefair & Stojcevski, 2012).

Numerous outreach activities exist with the goal of making STEM fields interesting to school students. Many are related to engineering. Since its opening, CADET has run numerous school outreach programmes aimed at students of all levels. The activities range from simple tours of the facility and labs, to short engineering-design projects, to preparing students for exams in years 11 and 12.

With this national goal in mind, CADET investigated and developed a primary-school outreach initiative that would engage students; and hopefully instil in them not only an interest in engineering, but an excitement for the field. Central to the activity are the practice of engineering design, and the need to engage all students, both those who are comfortable with maths and science and those who are not. Thus the problem considered here is whether an engineering outreach program can be developed that engages students in an immersive method of learning with a comprehensive approach to the process of engineering, and at the same time is fully integrated with the local school's curriculum.

Methodology of Fast Cars in Schools

The outreach programme described here is called "Fast Cars in Schools," a collaborative project between CADET, Catholic Education Melbourne, and a number of local primary schools. Fast Cars in Schools was designed to support year-5/6 teachers and students to engage in science, design and technology through the topic of 'Formula 1 Racing'.

A working party with representation from the schools established the curriculum goals and supported the design of assessment rubrics for the major areas of study, aiming for a deep-learning, inquiry-based experience for the students. Curriculum areas included activities for understanding science, mathematics, design, engineering and art, with options for considering humanities. Additionally the STEM skills and capabilities of ethical thinking, critical & creative thinking, and collaboration for learning, as well as the technologies for learning and literacy, social and emotional learning underpinned the inquiry. The education model behind everything was experienced-based learning (Andersen, Boud, & Cohen, 2000). Students were allowed to formulate their own inquiry questions and work out the answers themselves.

Fast Cars in Schools explicitly addressed several key learning areas found in the Victorian Curriculum: physical science, arts, media studies, mathematical data analysis, physical education, teamwork, leadership, and public speaking. At the same time, the programme allowed students to apply their learning in a practical, creative and exciting way. The programme was designed to run over two school terms, integrating all curriculum outcomes. It included a visit to CADET, a sports-performance workshop, trial racing days and a final race off day. The programme provided participating students with mentors from local secondary colleges, University students (including engineering students and pre-service teachers) to provide guidance to the teams through their investigations and decision making. It followed a team-based approach, and the tasks required from each team were more than design-and-build. The team was required to design a small racing car, find external sponsorship, design logos and a team T-shirt, produce a poster about their car, and give an oral presentation. This way, the team incorporated a range of skills from the students, not just those associated with designing and building the finished product.

The aims of Fast Cars in Schools were seven-fold:

1. For students to go through the process of designing, creating, testing, analysing, redesigning and retesting a car to race.
2. For students to participate a series of project based tasks linked to Formula 1 racing, the creation of the car and promotion to develop skills and knowledge in diverse areas linked to the curriculum.
3. To provide a platform for promoting group-based learning strategies.
4. To inspire young students to identify the value and application of STEM.
5. To support teachers in developing engaging STEM project based activities for students.
6. To support teachers in developing generic curriculum documents that may be used in any school linking required outcomes to aspects of the activities designed as part of the program.
7. To make connections between primary schools, secondary colleges, universities and industry.

Each team was made up of five students, and there were a number of specific assessed tasks:

- The team needed to design and create a car that would be raced on a 20-m track.
- The team created a poster that included the team's name, a logo, a photograph of the team and their car, a description of their approach to the problem of designing the car, and a description of the science behind their design that discussed technical aspects such as weight, friction, rolling, and aerodynamics.
- Each team was to give a five-minute oral presentation, which was assessed by a panel of judges.
- Each team designed and produced a team T-shirt.

The rules of the competition followed the template used by the international competition "F1 in Schools," junior-cadet class (Re-Engineering Australia Foundation, 2017). The centrepiece of the competition was a regulation cardstock racing car powered by a standard CO_2 soda canister. In Australia, F1 in Schools uses the cardstock racers mostly as a fund-raising tool, whereas the primary-school competition is run mainly in the United Kingdom. The teams raced their cars along a 20-m track, and the times for the trip were measured and recorded.

Originally the programme was aimed at schools within 25 km of CADET, but there were some participating schools up to 200 km away. The schools and their teams visited CADET twice each. In the first visit, the teams attended hour-long workshops on the physics of racing cars, basic aerodynamics, and reaction times, figures 1 and 2. (We note that written parental permission was granted to use and publish photographs of any of the participating children.) The workshops on reaction times were conducted by the Victorian BioScience Education Centre (BioLab, 2017).

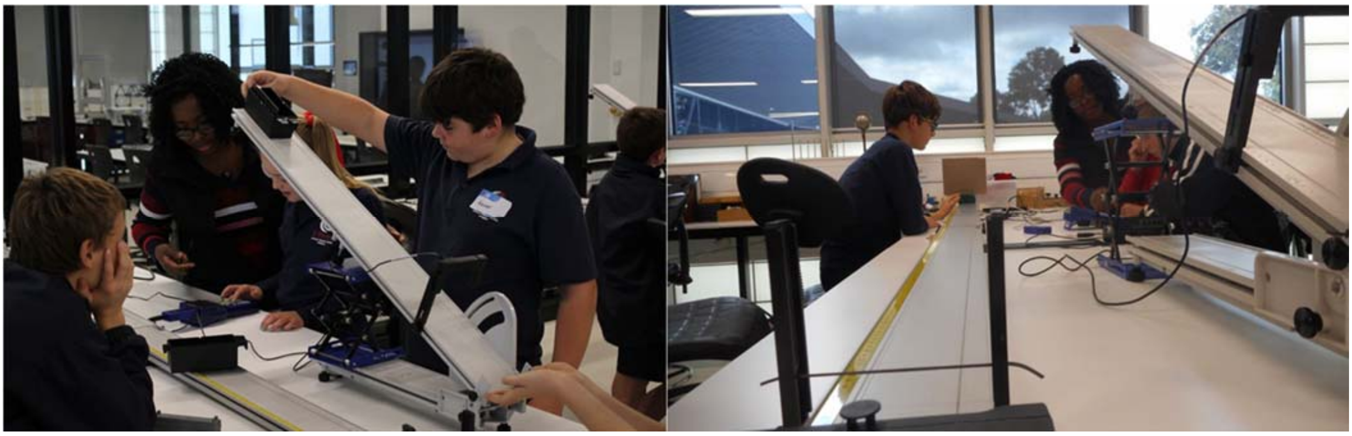

Figure 1: Students performing physics experiments on friction (left) and air resistance (right).

Figure 2: Students measuring reaction time.

After the first visit, the schools set time aside in their term schedules for the students to work on their designs, perform further physical experiments associated with the performance of their cars, and obtain lessons on the science and maths that lie behind the competition. For instance, one school had each team attend a double period (1.5 hours) once a fortnight to work on the project as part of its specialist curriculum. Class time was also spent reinforcing the lessons learned on physics and biomechanics that occurred during the earlier visit to CADET. Parental involvement was strongly encouraged and often obtained.

On the second visit, the teams competed with each other in the race, poster, and oral presentation. Each school ran qualifying heats and finals in school, then and sent their team with the fastest car for the finals, along with an additional wild card entry from each school. Additional curriculum-based projects were also assessed on the day and prizes and medals awarded in the major categories of team Logo/T-shirt design and A1 poster of the team's learning journey. Optional minor categories included visual design of the car and an oral presentation of the learning journey. These categories were judged according to scaled sets of judging criteria by an independent panel that included representatives of the University's School of Engineering.

For this study, we determined the success of the programme through anecdotal observations of the students competing in their races and making their presentations, and conversations with the teachers and school administrators.

Results and Discussion

After a small pilot in 2015, a larger programme was run in 2016. Most schools ran the programme in term 3. A few schools ran it in terms 2 and 3. All in all, 12 primary schools, 38 classes, and about 950 year 5 and 6 students completed the programme. Half of the students were boys and half were girls. The majority of participating teachers were women, the gender mix typically found in primary schools. Figure 3 shows some sample cars built by the students, and figure 4 shows one of the races.

Figure 3: Sample racing cars.

Figure 4: Students prepare to race their teams' cars.

From our observations, the response from both the students and their teachers was overwhelmingly positive. Students were clearly engaged throughout the activities. One teacher was impressed by the way his students were able to stay focussed on their tasks during the classroom sessions, even in a double period, and their ability to work out scientific processes that in a primary-school context are quite complicated. He also noted that in this programme, teachers learned new things as much as the students did. Some participating students, parents, and teachers were interviewed by one of the funding bodies and their thoughts published in two *YouTube* videos (Catholic Education Melbourne, 2016a, 2016b). The excitement of the students is clearly visible in these videos, as well as the satisfaction of the parents. The interviewed teachers stressed how the program successfully integrated many aspects of the state curriculum into the students' activities, while working in their teams towards an exciting goal. Table 1 shows some of the comments made by teachers on the day of the final race.

Table 1: Teacher comments at the conclusion of the final race.

Thanks again for such a fantastic day. The kids had the most wonderful time and learning experience.
A huge thank you for the F1 unit, the most successful unit I have had the opportunity to teach and hopefully it will be an option in the years to come!
Thanks for a wonderful day. The students were very happy to be a part of the experience.
Thanks for coordinating a fantastic opportunity for our students on Friday. They really enjoyed the friendly and approachable manner of the judges throughout the day.
Ashby kids learnt a lot and have had a fantastic journey.

The programme was vastly different from what a school usually does. Traditionally, educators tend to put learning into separate boxes (such as reading, maths, physics, design, technology, art). On the other hand, especially at the primary level, students take a cross-disciplinary approach to learning, which is clearly employed here. Thus this programme is well suited to how primary students actually think. It was quite a challenge designing this to fit the state curriculum.

Fast Cars in Schools integrated as much of the year-six Victorian curriculum as possible, and was assessed continuously as the students went through the programme. Each member of a team had a role, whether it be technical, artistic, or social. We must stress that this was neither a series of school excursions designed to market engineering courses, nor an extra-curricular activity, like the official F1-in-Schools. The students who participated were not taking an elective subject as there are no electives in primary school. It was not a pass-fail programme. It was a fully-integrated, whole-class learning endeavour, a far deeper learning experience than what one would obtain from a tour or a series of discrete learning activities.

We certainly intend to run this again in future years, subject of course to funding being available. We also intend to complete the education research by conducting interviews with the participating teachers (or better yet, the students) to see if there were any changes in their students' attitudes towards STEM in general and engineering in particular. It would also be interesting to track the students' selections of elective subjects as they progress through years 7-10.

Summary and Conclusions

An engineering-oriented educational outreach program for primary-school students was designed and trialled. The programme was designed to support the educational needs of the participating schools. The team engaged primary schools into understanding how the CADET facility might be useful for their curriculum delivery. We successfully integrated the Victorian year-six curriculum into the programme through the practice of experiential-based learning. The feedback that was received by participating students, parents, and teachers was exceedingly positive. To finish this research, we intend to interview the teachers involved to see whether they notice any longer-term interest in science and engineering in their students as a result of this experience.

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Acknowledgements

The authors thank all the hard work brought to this project by S. Waldon, N. Sadler, G. McCarthy, L. Oddo, M. Leith, and C. Vine. We also are grateful to J. Micalleuf from the Re-Engineering Australia Foundation for his significant assistance. Finally we gratefully acknowledge significant financial support from Catholic Education Melbourne and Deakin University.