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Improving Engineering Awareness of Secondary School Students

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BACKGROUND
In the middle part of the last decade the authors observed a downward trend in the number of students choosing electrical engineering courses in Victoria. This trend was evident across all of the engineering disciplines in Victoria. This trend was exacerbated over the past decade by a reduced number of students studying engineering pre-requisite and enabling subjects at year 12. This result combined with the fact that the national demand for engineers exceeded graduate supply, led to a shortage of engineers. The report by King (2008) into the supply of engineers for the 21st century made a number of recommendations relating to an attempt to increase the supply of engineers. This paper discusses some strategies for improving the awareness of engineering as a career amongst the secondary school student population.

PURPOSE
How can the introduction of engineering experiences through Physics in secondary schools improve the interest in engineering careers? Note the word "Physics" refers to Victorian Certificate of Education (VCE) subject.

DESIGN/METHOD
A group of Swinburne academics engaged with a number of VCE Physics teachers to collaborate and determine a suitable approach to improve the awareness of studying engineering at University. A number of discussions and a consultative debate led to the development of a learning resource kit. The VCE teaching staff using the kits were then surveyed to determine their effectiveness.

RESULTS
The kits are being used in a number of secondary schools. As the study is not finalised, we anticipate that the results will show that this strategy is effective. This is backed up by the positive feedback from the VCE physics teachers as well as the survey results of the teacher's opinions.

CONCLUSIONS
The learning resource kit has contributed to increasing the awareness of the connection between electronics and physics, by providing VCE physics teachers and students with what we consider to be excellent resource to facilitate an exciting and interesting approach to learning Further Electronics. We believe that this activity has encouraged more students to consider studying electronic engineering at University.
We have shown a model which we believe is successful in improving the pathways to engineering from secondary schools using a "hands-on" activity as the motivator. We recommend that Engineering staff in Universities should develop similar partnerships with physics teachers to increase the students' awareness of engineering as a possible career choice and thereby improve the pathway.
On the whole the project has achieved the majority of its aims well or very well and some aims partially.

KEYWORDS
hands-on, physics education, engineering, inclusiveness, equity.

Introduction

In the middle part of the last decade the authors observed a downward trend in the number of students choosing electronic engineering courses in Victoria. This trend was evident across all of the engineering disciplines in Victoria and was exacerbated over the past decade by a reduced number of students studying engineering pre-requisite and enabling subjects at year 12 (Kaspura, 2010). This trend seems to be ongoing as can be seen in (Dunn, 2012).

This result combined with the fact that the national demand for engineers exceeded graduate supply, led to a shortage of approximately 20,000 engineers in early 2008 (King, 2008). The report by King into the supply of engineers for the 21st century made a number of recommendations relating to an attempt to increase the supply of engineers. One of the main findings of this project was:

> ***"Recommendation 1: raise the public perception of engineering***
>
> *Raise the public perception of engineering, including within primary and secondary schools, by increasing the visibility of the innovative and creative nature of engineering and the range of engineering occupations that contribute to Australia's prosperity, security, health and environment."*

In order to ensure that the number of students choosing engineering matches the industry requirements, there is a need to increase the interest and awareness of secondary school students when making career choices. Currently most engineering degrees no longer have Physics as a pre-requisite, from our experience we suggest that this is probably due to falling numbers of students studying VCE Physics see figure 1. We believe that it is important for students to study Physics even though it is no longer a pre-requisite as this is the best avenue for stimulating students' interest in engineering. Figures 1 & 2 show that the number of students studying the physics and advanced mathematics subjects is reducing and this trend must be reversed if we are to ensure sustainable numbers of students choosing engineering. One way of achieving this reversal in trend is to create better collaboration between Universities and Secondary Schools.

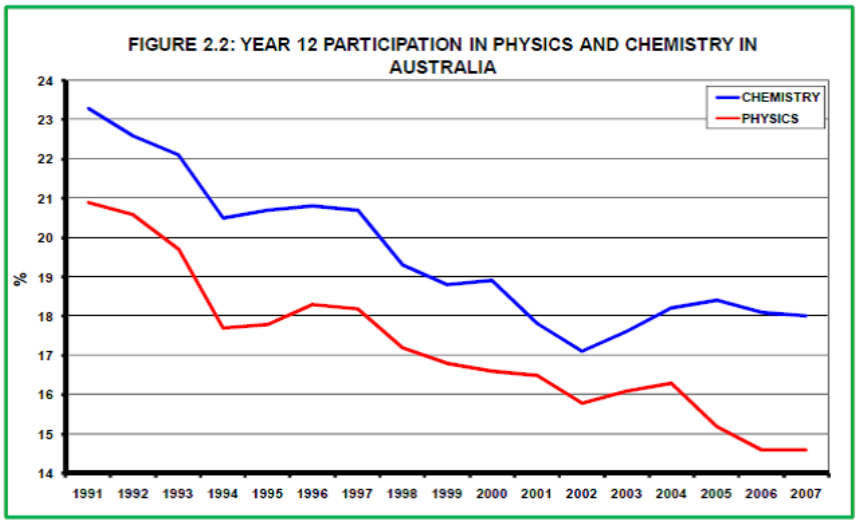


Figure 1 Year 12 Participation in Physics, Chemistry (Kaspura, 2010)

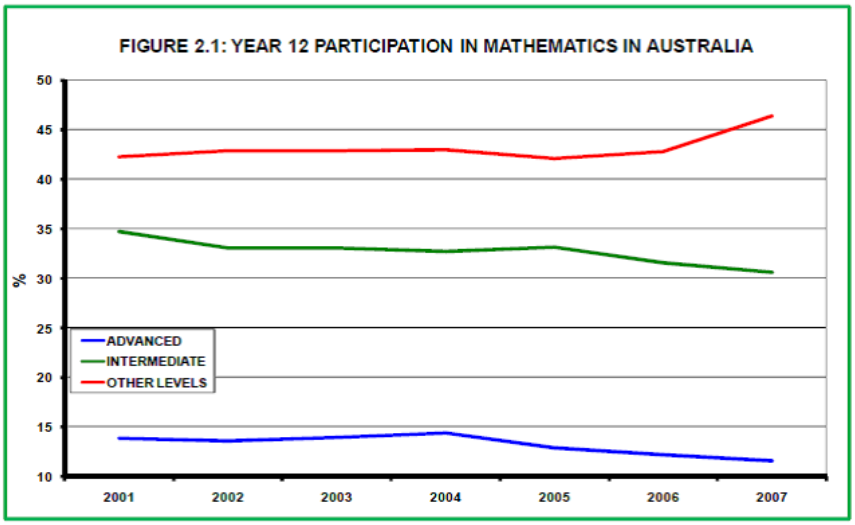


Figure 2 Year 12 Participation in Mathematics (Kaspura, 2010)

At Swinburne University of Technology a group of academics from the electrical engineering discipline identified this trend in the early 2000s from the reduced number of students choosing electronic engineering over a period of time. As such this group decided to implement their own version of recommendation 1 above through an outreach activity with secondary schools. Similar programs have been implemented by others (Little & Leon de la Barra, 2009), (Sahllcross, 2002) and (Alford, Calati, Clarke, & Binks, 2009). The group's chosen strategy to improve the pathway into electronic engineering for VCE Physics students was to provide an interesting "hands-on" learning task supplemented by additional support learning material for the VCE Physics Unit 3 Detailed Study: Further Electronics module. This support learning material is provided to allow the physics teacher to spend more time on the preparation of supplementary learning activities instead of dedicating time to designing the primary activity and sourcing the relevant equipment/components.

In this paper we describe the process and rationale for developing the VCE Physics learning resource. We outline the background and motivation of the VCE Physics learning resource followed by its description. We also outline the benefits and feedback from the teachers of using such a resource. Lastly we present our conclusions and recommendations.

Background

In 2004 a group of academics from the electrical engineering discipline from Swinburne University of Technology and VCE physics teachers collaborated to determine a suitable approach to improve the awareness of studying engineering at University, whilst delivering relevant learning outcomes for the VCE students. A number of discussions and consultative debates led to the development of a learning resource kit for the VCE Physics module on Further Electronics.

In the quest of furthering the VCE Physics students' knowledge in electronics the group decided to set the following aims.

- Improve the motivation for learning for each student - through a hands-on activity (where the students build something which they will use in the future)
- Increase the VCE Physics students' knowledge of electronics
- Provide supplementary material to allow the more motivated students to extend their own learning of advanced topics
- Make the learning resource available to any secondary college in Victoria
- Assist teachers in remote areas, with limited technical resources or expertise

- Promote and support equity and inclusiveness by improving access, participation and outcomes for students from low SES and remote locations
- Raise the awareness and importance of engineering to both secondary teachers and students

Description of the Learning Resource

The first part of this project was the development of curriculum material for VCE Physics Unit 3 Detailed Study: Further Electronics module. The curriculum material consisted of a theoretical component and a practical component.

The theoretical component comprises of a set of Web resources, which contain:

- a student manual outlining important electronic concepts
- a teacher's manual with further in-depth notes and explanations
- links to various aspects of the Electronic Engineering courses at Swinburne University of Technology (http://www.swinburne.edu.au/engineering/study-areas/engineering/electronics/vcematerial/)

The practical component comprises of:

- A power supply kit which contains the necessary electronic components and a printed circuit board (PCB)
- An instructional booklet with experiments and relevant questions to challenge the understanding of each student

Since the middle of 2004 approximately 1100 learning resource kits have been used in a number of secondary schools. Figure 3 shows what a fully populated PCB looks like. The students take the time to build the power supply and then use it to carry out experiments. A fair degree of learning takes place during the building of the power supply as the students are required to identify, correctly place and solder the components onto the PCB. The PCB is clearly labelled and laid out to make it easy for students to identify functional sections of the power supply.

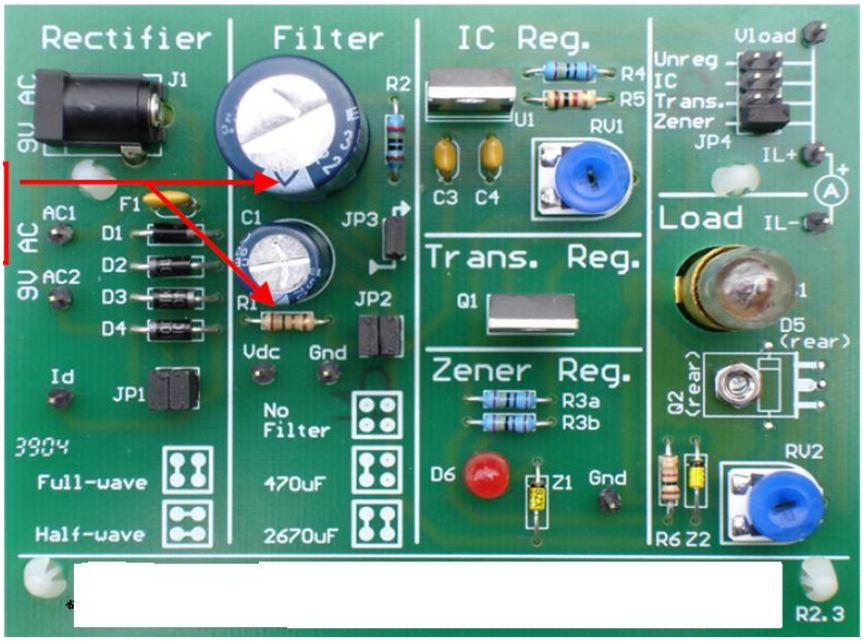


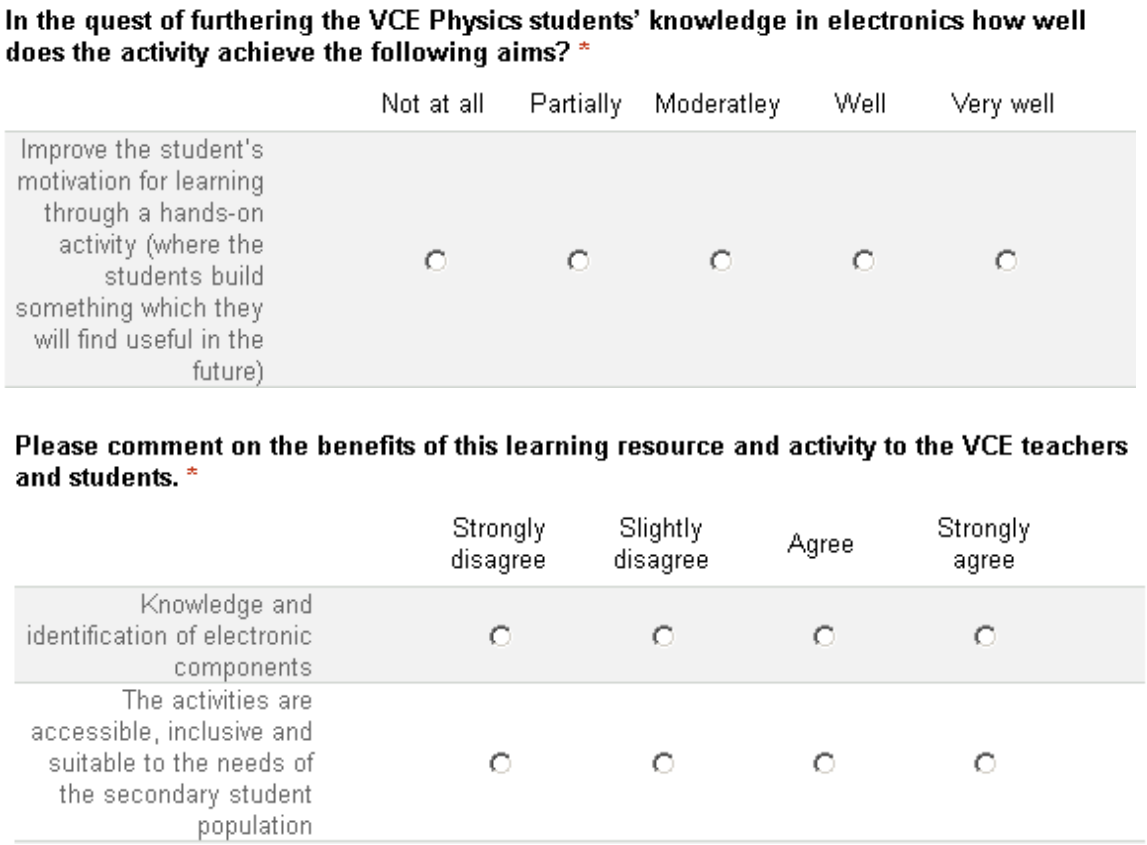
Figure 3 Fully Constructed Power Supply

This modular design gives teachers the opportunity to discuss the theory behind these functional sections via break-out sessions. As can be seen from figure 3 the students are gradually led through the various stages of construction of a power supply. They start off with the alternating voltage input, which then needs to be rectified in the “Rectifier” section. They are led through 2 different types of rectification chosen by the combination of jumper settings. Then the rectified signal is fed to the “Filter” section. Again through the use of jumper settings the students can change the degree of filtering and see the effects this has on the signal and so on through the rest of the powers supply circuit.

The learning resource kit was trialled by the Methodist Ladies’ College (MLC) VCE physics teachers to ensure that they were satisfied with its performance and to suggest any changes after the first student use. The feedback resulted in improvements in the layout of the PCB to make the power supply more robust and student proof. Then the MLC VCE physics teachers were to convey and share this knowledge with other VCE physics teachers through various forums such as the STAV/AIP Physics Teachers’ Conference which is held annually (Anderson, 2011) (Anderson & Crawford, 2010).

Results

The evaluation of the project was undertaken through the use of both written feedback and an anonymous survey of the physics teachers asking questions about how well the project met its aims and what benefits the learning resource provided to the teachers and students. The survey was created on “google docs” and the link to the survey was sent to a large number of the physics teachers who had used the learning resource. Examples of the questions posed and the style of possible responses are shown below in figure 4.



In the quest of furthering the VCE Physics students' knowledge in electronics how well does the activity achieve the following aims? *

	Not at all	Partially	Moderatley	Well	Very well
Improve the student's motivation for learning through a hands-on activity (where the students build something which they will find useful in the future)	○	○	○	○	○

Please comment on the benefits of this learning resource and activity to the VCE teachers and students. *

	Strongly disagree	Slightly disagree	Agree	Strongly agree
Knowledge and identification of electronic components	○	○	○	○
The activities are accessible, inclusive and suitable to the needs of the secondary student population	○	○	○	○

Figure 4 Samples of the survey questions

Feedback

All of the teachers we have communicated with, either by email or phone conversation have found the learning resource kit very useful and helpful to their teaching. They found it to be a very valuable tool in their teaching of relevant electronics concepts. All of the comments were positive and there were no negative comments. A sample of comments made by some of the teachers is presented below.

- “It’s a breath of fresh air in the physics realm of learning. The students love the fact that they can actually do something rather than just read. They also love the fact that they actually build the experimental equipment and find that it gives them a better understanding”
- "Fantastic kits. The students have been working on them all week and are teating [sic] them today[Friday]"
- “It’s a great package. It’s got it all, the components, the board and the notes….. I would have loved some questions with answers”
- “It is a worthwhile and enjoyable activity. It is a good and legitimate extension of the fundamental physics material”
- “great to have a ‘hands-on’ activity that keeps the students interested week-in week-out”
- “one of our students is hell-bent on coming to Swinburne as a result of using the kits” This teacher has become a strong supporter of Swinburne and promotes the University actively amongst his students.

Benefits

The benefits of this learning resource to the VCE teachers and students are outlined below:

1. The activities are accessible, inclusive and suitable to the needs of the secondary student population
2. Exposure to electronics in both theory and practice
3. A better understanding of electronic design and implementation
4. Improvement in the ability to use a Cathode Ray Oscilloscope for measuring electrical quantities
5. Improved soldering and construction skills
6. Knowledge and identification of electronic components
7. These programs can cater for different learning styles i.e. visual/participative, directed or independent
8. Better access for low SES students and students located in schools in remote areas

The survey results show that 100% of the responding teachers agree that the learning resource has benefits 1, 4, 5, 6 & 8 listed above. 67% of the respondents agree that the kit has benefits 3 & 7, whilst 83% agree with benefit 2.

To date a large number of schools have used the learning resource kit. Table 1 (ABS, 2008) shows that 24.2% of the schools who have used the learning resource kit are in the bottom 3 deciles of the socio-economic index measure. This indicates a significant number of low SES schools are using the learning resource kit, thereby meeting one the project’s aims in improving access for students in those areas.

Table 1 School SES distribution

SES range	Bottom 3 Deciles	Middle 4 Deciles	Top 3 Deciles
Number of Schools	16	13	37

Another project aim was to assist teachers in remote areas; Table 2 below shows that 27.3% of the schools who have used the learning resource kit are located at a distance of more than 50 kilometres from the Melbourne central business district. This indicates that the resource is providing a service to the students who are in remote schools in Victoria. This learning resource kit enables both the students and teachers in these remote schools to have access to pre-prepared curriculum and the "hands-on" electronic kit.

Table 2 School distance from the CBD

Radial Distance (D) from Melbourne CBD	D < 50km	50km< D <100km	D >100km
Number of Schools	48	5	13

The survey results summarising the teachers' evaluation on how well the aims are met by the learning resource kit are summarised below.

100% of the respondents believe that the kits highly improve the learning motivation of each student.

100% of the respondents believe that the kits "Increases the VCE physics students' knowledge of electronics" either well or very well.

67% of the respondents believe that the kits "Assist teachers in remote areas, with limited technical resources or expertise" both well or very well and 33% believe this aim is achieved moderately.

67% of the respondents believe that the kits "Promote and support equity and inclusiveness by improving access, participation and outcomes for students from low SES and remote locations" very well whilst 33% believe it achieves this aim only moderately.

On the question of whether the learning resource succeeds to "Raise the awareness and importance of engineering to both secondary teachers and students", 83% of the respondents believe this aim is being met moderately or well whilst the remaining 17% believe this aim is only partially achieved.

On the important question of whether the learning resource succeeds to "increase the awareness of electronic engineering as a career path" the results show that 83% believe that the kit achieves this aim. This result combined with the last bullet point of the feedback section above is encouraging and gives us confidence in this project.

Conclusion

A learning resource kit for VCE Physics Unit 3 Further Electronics was developed in partnership with the physics teachers at MLC. The kits have been well received by both VCE teaching staff and students.

In putting together these curriculum materials we have contributed to increasing the awareness of the connection between electronics and physics, by providing VCE physics teachers and students with what we consider an excellent resource to facilitate an exciting and interesting approach to learning Further Electronics. We believe that this activity has encouraged more students to consider studying electronic engineering at University.

We have shown a model which we believe is successful in improving the pathways to engineering from secondary schools using a "hands-on" activity as the motivator. We recommend that Engineering staff in Universities should develop similar partnerships with

physics teachers to increase the students' awareness of engineering as a possible career choice and thereby improve the pathway.

On the whole the project has achieved the majority of its aims well or very well and some aims partially.

The first step in evaluating the success of the project through the physics teachers has been positive. The next step is to get a better understanding of how the learning resource kit affects the students themselves and their interest in future career paths. This can be achieved by running surveys to canvass the opinions of the students. This is a fruitful area for further research.

References

ABS, A. B. (2008, 03 26). *2033.0.55.001 - Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia - Data only, 2006*. Retrieved 10 8, 2012, from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/2033.0.55.001Media%20Release22006?opendocument&tabname=Summary&prodno=2033.0.55.001&issue=2006&num=&view=

Alford, K. J., Calati, F., Clarke, A., & Binks, P. N. (2009). Creating a Spark for Australian Science Through Integrated Nanotechnology Studies at St. Helena Secondary College. *Journal of Nano Education , 1* (1), 68-74.

Anderson, M. (2011). Teaching the detailed study Further Electronics. *STAV/AIP Physics Teachers' Conference.* Melbourne: Australian Institue of Physics (Vic Branch) Education Committee.

Anderson, M., & Crawford, J. (2010). Using the 'Power Supply Design' materials. *STAV/AIP Physics Teachers' Conference.* Melbourne.

Dunn, A. (2012, January 22). *Maths, physics fail to get the numbers at school*. Retrieved October 8, 2012, from theage.com.au: http://www.theage.com.au/national/education/maths-physics-fail-to-get-the-numbers-at-school-20120121-1qbjd.html

Kaspura, A. (2010). *The Engineering Profession, A Statistical Overview, Seventh Edition.* Institution of Engineers Australia.

King, R. (2008). *Engineers for the Future: addressing the supply and quality of Australian engineering graduates for the 21st century.* Australian Council of Engineering Deans.

Little, A. J., & Leon de la Barra, B. A. (2009). Attracting girls to science, engineering and technology: an Australian perspective. *European Journal of Engineering Education , 34* (5), 439-445.

Sahllcross, D. C. (2002). An investigative project in engineering for secondary school students. *International Conference on Engineering Education*, (pp. 147-154). Manchester.

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