ENGAGEMENT WITH SECOND LEVEL – DOES IT WORK?

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ABSTRACT

Most Western economies are suffering from problems in attracting students to study Science, Engineering and Technology courses at university level. To address this demand shortage, and also with regard to current financial pressures, many higher education institutions are engaging with secondary schools in a wide range of activities, including schools visitation, open days, activity sessions, presentations, internships and work experience placements. While all of these activities are undoubtedly worthy, there is little evidence for the long term effectiveness of such interventions, either relative to each other, or in absolute terms.

The work reported on in this paper seeks to address this knowledge gap by comparing the long and short-term effects on student interest and knowledge level, as assessed through a longitudinal series of questionnaires, of presentations and more extended interactive workshops.

KEYWORDS: Engineering Education, Secondary School, Outreach

INTRODUCTION

National and European debate consistently recognises the need for Europe to produce greater numbers of highly-skilled graduates in engineering and technology fields in order to improve our competitiveness in the global economy. Despite the importance of this being frequently stressed in policy discussions and the media, both applicant and graduate numbers in these fields are not increasing quickly enough to keep up with demand from industry and academia [1].

Targets have been set both by individual countries and on a Europe-wide level, and in many cases these are not being met. A task force established to examine the issue in Ireland reported that a 6-7 per cent annual increase in supply would be required, but noted that this would prove "very difficult in the current climate of falling numbers of entrants to third-level courses in engineering and IT" [2].

Part of the difficulty in recruiting students may be due to the fact that engineering has been said to be "hampered by a reputation that deters many students, especially the ones with a broad range of interests (including women)" [1]. The reality is that an engineering education can be a good basis for a broad range of careers, but is not consistently perceived in this way.

This paper describes a project that was carried out in order to investigate secondary-school students' attitudes to and understanding of engineering as a profession, and to test the effectiveness of a range of interventions designed to promote engineering as a career choice to them.

1 ENROLMENT TRENDS

Enrolment trends in many European countries show static or declining numbers of people entering engineering dropped programmes. In Ireland, the numbers of new entrant students selecting engineering as their first choice fell by 40% between 2000 and 2012 [3].

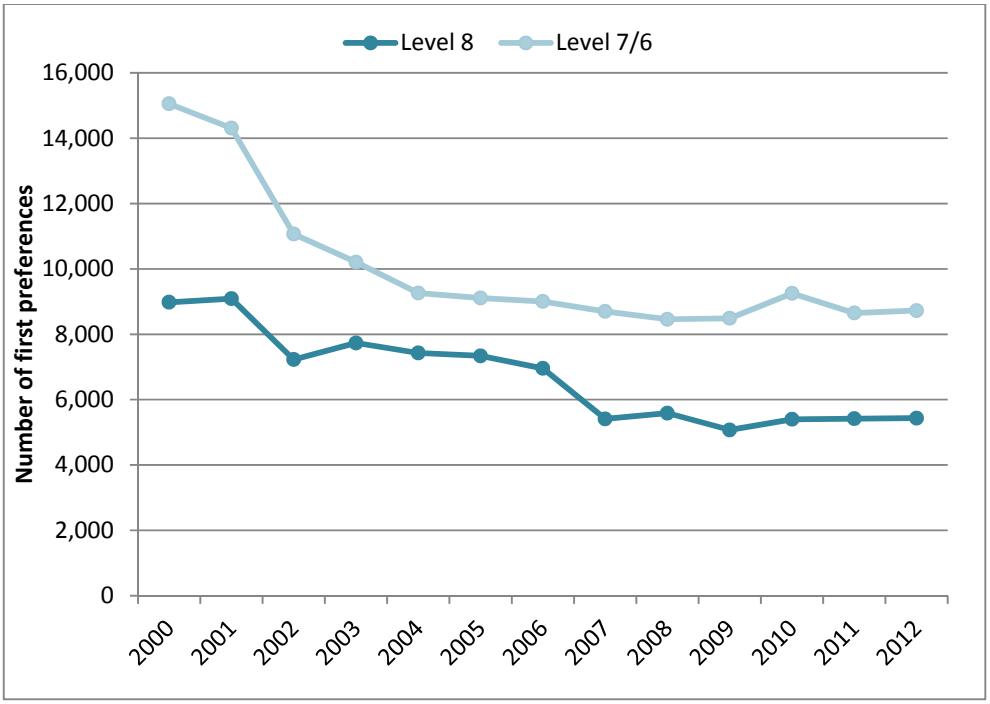

Fig. 1. Trends in number of students selecting engineering programmes as their first choice in Ireland

2 OVERVIEW OF EXISTING ENGINEERING OUTREACH ACTIVITIES

To respond to the large demand for graduate engineers in a climate where the number of students choosing engineering programmes is declining, it has become common practice in Ireland and elsewhere around the world to institute initiatives to encourage interest in engineering among young people. Several national campaigns operate in Ireland, a number of which are supported by the government while a large proportion were developed in conjunction with private organisations and industry. Some of these are designed to promote engineering specifically, whereas others encourage engagement with the science, engineering and technology (SET) fields more generally. A number of the initiatives and bodies most relevant to this study are discussed briefly below.

2.1 Discover Science and Engineering (DSE)

Discover Science and Engineering (DSE) was set up in October 2003 in response to a key recommendation of the Task Force on Physical Sciences [4]. DSE brings together many science, technology, engineering and mathematics awareness activities that were previously managed by different bodies. Its objectives are to increase the number of students studying in STEM fields, promote a positive attitude to careers in engineering, technology and science, and to foster a greater understanding of the value of these fields to Irish society. Programmes operated by DSE fall into three categories: primary school science & engineering initiatives, second-level science & engineering initiatives, and general awareness activities.

2.2 STEPS to Engineering

STEPS to Engineering is managed by Engineers Ireland, the professional association of engineers in Ireland, and supported by DSE. Founded in 2000, STEPS encourages primary and secondary-level students to explore the world of engineering and science, and to consider engineering as a career choice. Its goals are:

- encouraging a positive attitude towards science, technology, engineering and mathematics
- introducing to students the relevance of science, engineering, technology and mathematics to industry and everyday life
- raising a positive awareness and understanding of engineering as a career choice
- promoting a greater understanding of the role and contribution of engineering in society
- highlighting the advantages, diversity, opportunities and excellent rewards offered by a career in engineering [5].

STEPS runs a range of initiatives aimed at both primary and secondary-level students, which reach an estimated 65,000 – 75,000 children per year, as well as offering support to teachers in order to help them deliver STEPS initiatives in schools.

2.3 Engineers and Science Weeks

Two separate week-long programmes are held in Ireland annually to promote engineering and science. Engineers Week is organised by STEPS to Engineering, while DSE runs Science Week.

During Engineers Week (usually held in February) events are held nationwide to celebrate all aspects of engineering. The aim is to promote the profession and create enthusiasm among people of all ages. Events include careers talks, site tours, and practical hands-on workshops [5].

Science Week takes place in November and is Ireland's biggest annual promotion of science to the general public. It aims to make science more interesting and accessible to children and adults alike. Hundreds of science events are held all over the country and attended by over 100,000 people [4].

3 OVERVIEW OF STUDY CONDUCTED

The primary objectives of this study were as follows:

i. To better understand how to successfully interact with secondary-school students in order to promote the understanding of engineering
ii. To investigate the perception of the engineering profession and the reasons why students choose/do not choose to study engineering at tertiary level
iii. To design and implement an initiative/workshop that could be carried out as a project within the transition year in secondary schools. This initiative/workshop would serve to introduce engineering as an attractive choice for tertiary-level education by introducing basic engineering concepts and reinforcing these concepts through practical application.

3.1 Data Acquisition

To gather the necessary data a three-phase survey process was designed to target secondary-school students, combined with visits to a number of schools. In addition to measuring the perception of engineering among the cohort, this process was structured to facilitate the evaluation of the impact of a specially-designed engineering promotional initiative on this perception.

Data was collected from visits to a total of four schools. A talk from a member of the engineering school at Trinity College Dublin was given in three of the schools. During the talk an interactive presentation was given, explaining different aspects of engineering, and students were encouraged to ask questions and give their opinions throughout. The content and delivery of the presentation emphasises the

creative skills required by engineers and the importance of engineers in solving the challenges faced by 21st century societies.

Phase one of the survey process was completed before the students have any interaction with the study activities, so as to gauge their pre-existing opinions without any external influence. The survey content was design to elicit information about the students' perception of engineering, including topics such as the importance of engineers to society, job and salary prospects for engineers, the effort involved in studying engineering and working as an engineer. Respondents were asked to rate engineering under each of these headings, relative to other careers and tertiary-level courses such as those in the fields of education, nursing, medicine, art and design, law, management and business. The survey also assessed the level of interest the respondents had in pursuing each of these fields.

Phase two was completed after the previously described talk on engineering was held. This allowed for the immediate impact of the talk to be measured. The questionnaire used was a condensed version of that employed during phase one.

In order to measure the lasting impact of the activity, phase three of the survey was conducted after a given period of time had passed. The length of the interim period varied but was at least one month in the shortest case. In this phase of the study the questionnaires were posted back to the schools for completion by the students without any further interaction.

Reponses from individual students were tracked across all three phases to enable a full statistical analysis of the effects of the talk and workshop

4 DATA

A total of 191 students were surveyed during phase one, 167 during phase two, and 121 in phase three. Of these students, 86 were common across all phases and thus could be measured to assess any changes or lack thereof over the course of the project. 79 per cent of students surveyed were female, while the remaining 21 per cent were male. The majority of students surveyed (86 per cent) were in transition year, or fourth year, with the remainder (14 per cent) coming from fifth and sixth year.

4.1 Phase one: Survey results prior to interactions

At the outset students were asked to rate the subject areas they had an interest in studying at university-level, to allow for a comparison between the interest expressed in engineering and other fields.

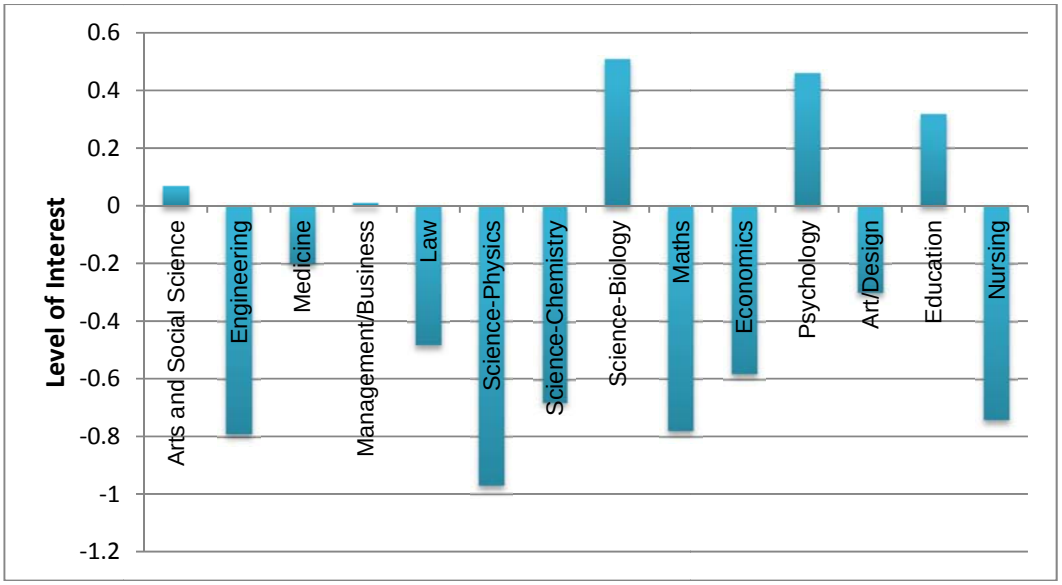

Figure 2: Areas in which students expressed interest in pursuing third-level study

The results of this initial survey show that, prior to any engagement with the project, engineering is the second least-desired area behind only science-physics. Key points from the survey conducted during phase one are as follows:

- A large proportion (49 per cent) of students stated that they made the decision of what career path to pursue during transition year. However this figure is likely to be skewed by the fact that 86 per cent of the respondents were in transition year at the time of answering and thus had not yet experienced fifth or sixth year
- The information sources ranked by students as most useful in helping them make this decision were, in descending order, 'Reputation of higher education establishments', 'Visits to higher education establishments', 'Parents' opinions', 'Other', and 'Information from secondary-school teachers'
- When asked how difficult a range of professions would be to work in, students ranked medicine, law and maths as the most difficult professions, with engineering also above average in terms of difficulty. In terms of salary prospects, respondents felt that medicine and law were the highest paid professions, with engineering perceived as quite well paid.
- Engineering was not felt to be difficult to study at university
- 55 of the 191 students surveyed felt that an engineer has neutral employment prospects, while 97 students felt that employment prospects for engineers ranged from quite good to excellent

4.2 Phase two: Results following interaction the presentation on engineering

Once the phase one questionnaire was completed a talk and presentation on engineering was delivered to the students. Upon completion of the talk, the phase two questionnaire was administered in order to measure the immediate effects of it. 87 per cent of the total student sample received this talk which was carried out by a faculty member of the Department of Mechanical & Manufacturing Engineering at Trinity College. 90 per cent of these students were female.

Key points arising out of the data gathered during phase two are as follows:

- Most students found the presentation to be valuable, and very few considered it not to be useful
- During all phases students were asked to rate their understanding of engineering as a profession compared to their understanding of several other professions. Following the talk, understanding of engineering was significantly improved, but this effect was not long-lasting.
- A significant increase in students' rating of the importance of engineers to society was demonstrated immediately following the talk, with the average rating reaching almost the top of the scale. However results from phase three demonstrate that this effect is largely lost in the long term.
- Concerning students' interest in studying engineering at university, again the immediate result is of a significant increase in interest. However, as with the previous result, this increase is not sustained long-term, as the results from phase three will show.

4.3 Phase two: Results following the engineering workshop

A smaller number of the student cohort also participated in a specifically-designed workshop which aimed to introduce basic engineering concepts and reinforce these concepts through practical application. Two separate workshops were carried out, both in single-sex schools. 21 girls participated in the first workshop, and 26 boys in the second. The girls had received the talk on engineering as well, but the boys had not.

The main findings from this interaction are as follows:

- At the outset the boys involved had a much greater understanding of, and more positive views towards, engineering than the girls.

- Despite having a better understanding of engineering, the interest of the male students in studying engineering was reduced due to a perception that it is too hard, boring or because they felt they lacked the requisite level of mathematic ability.
- As with the results following the talk, an increase in understanding of engineering was demonstrated following participation in the workshop. Again, this increase is reduced during the follow-up survey in phase three, but to a somewhat lesser degree than for the students who did not take part in the workshop.
- Similar results are observed with regard to responses relating to the importance of engineers to society, whereby an initial boost gives way in the long term by a return to a lower level of understanding, similar to that held previously or slightly higher.

4.4 Phase three: Lasting impact

The follow-up questionnaires that were sent to each of the schools some time after the interventions took place allow for the lasting impact, if any, of these interactions to be measured. The graphs in this section demonstrate the variations over time that were observed in these results.

4.4.1 Understanding of engineering

Firstly, the variation in the students' understanding of engineering relative to other fields of study is displayed in Figures 3 to 5, below. Students were asked to rate their understanding on a scale of negative to positive three, where negative three indicated they understood the specified profession more than engineering, and positive three indicated they understood engineering more than the specified profession.

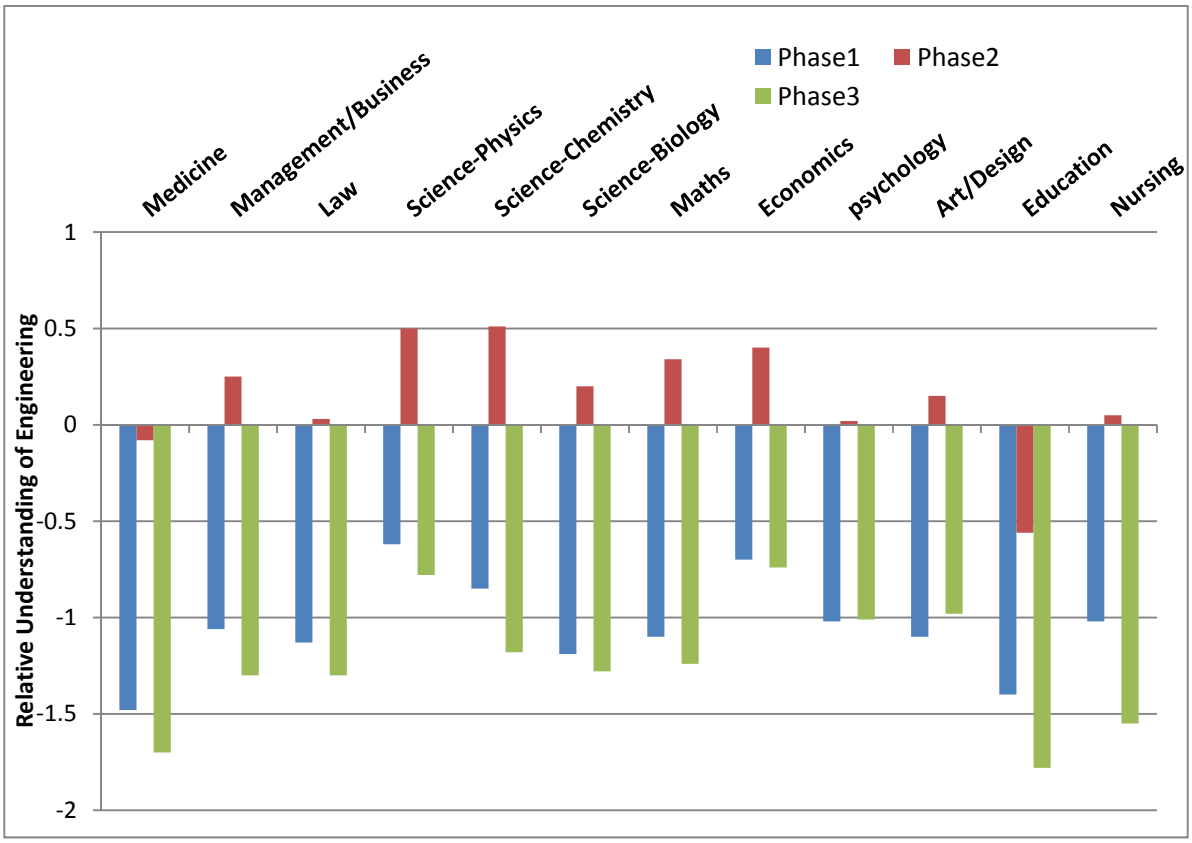

Figure 3: Understanding of engineering with respect to other professions – Results from talk only

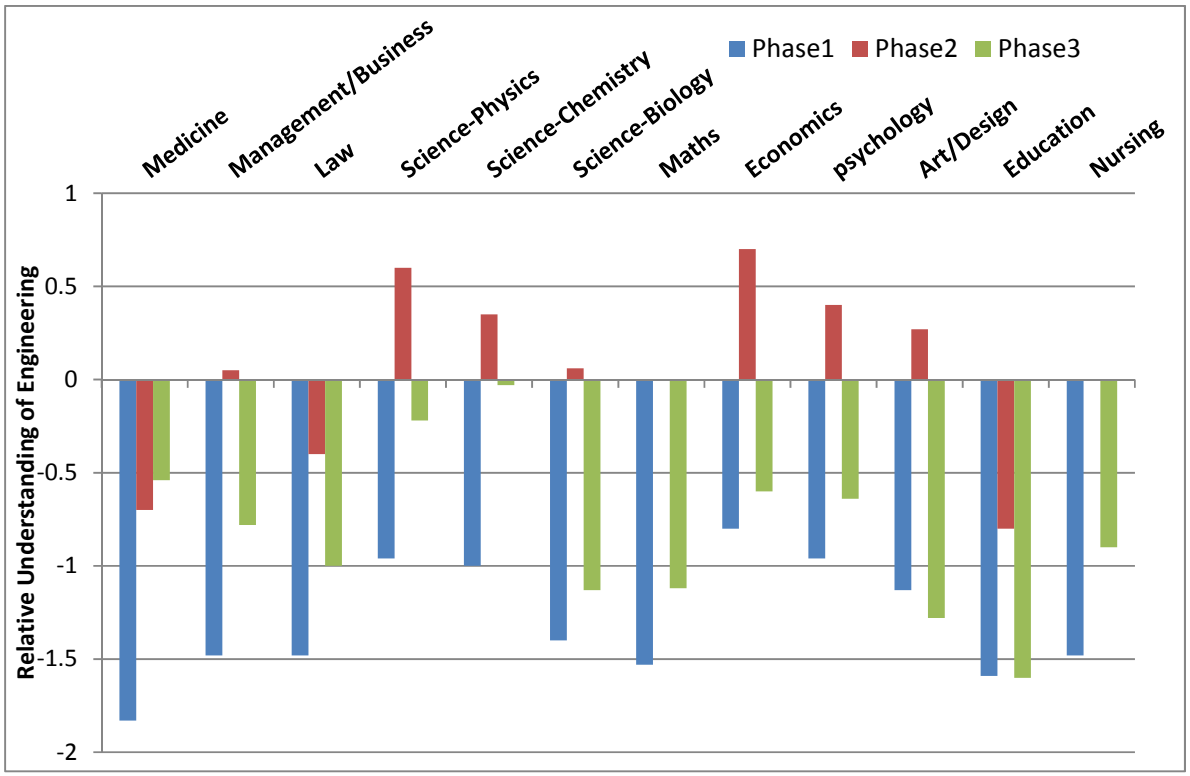

Figure 4: Understanding of engineering with respect to other professions – Results from workshop and talk

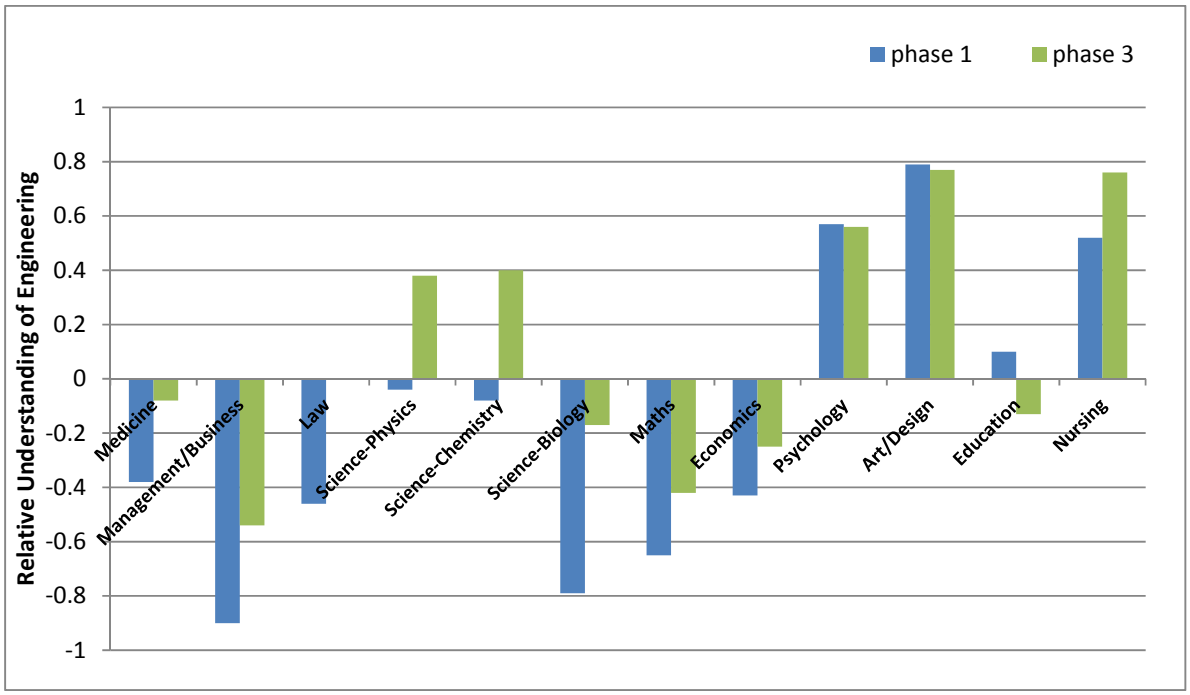

Figure 5: Understanding of engineering with respect to other professions – Results from workshop only

As discussed above, Figures 2 and 3 display a significant increase in the understanding of engineering during phase two, but this increase is largely lost by phase three. The picture in Figure 4 is somewhat different. The results here refer only to the group who participated in the workshop without having received the talk, and the students concerned are all boys. The initial understanding of engineering demonstrated by them is much better than that of the largely female cohort depicted in Figures 2 and 3. The all-male group did not complete a phase two questionnaire, so the phase three survey was conducted one week after the workshop took place.

4.4.2 Importance of engineers to society

Figure 6 demonstrates the change in the opinion held by students regarding the importance of engineers to society. The significant initial increase demonstrated is much the same for the students who received the talk only as for those who received the talk and also participated in the workshop. In both these cases student opinion ultimately returns to the level it was at in phase one. However the importance of engineers to society was rated quite positively by students at the outset, so the dip in rating noted in phase three still reflects a positive opinion. For the male students who participated in the workshop only, there was a small but lasting increase in opinion.

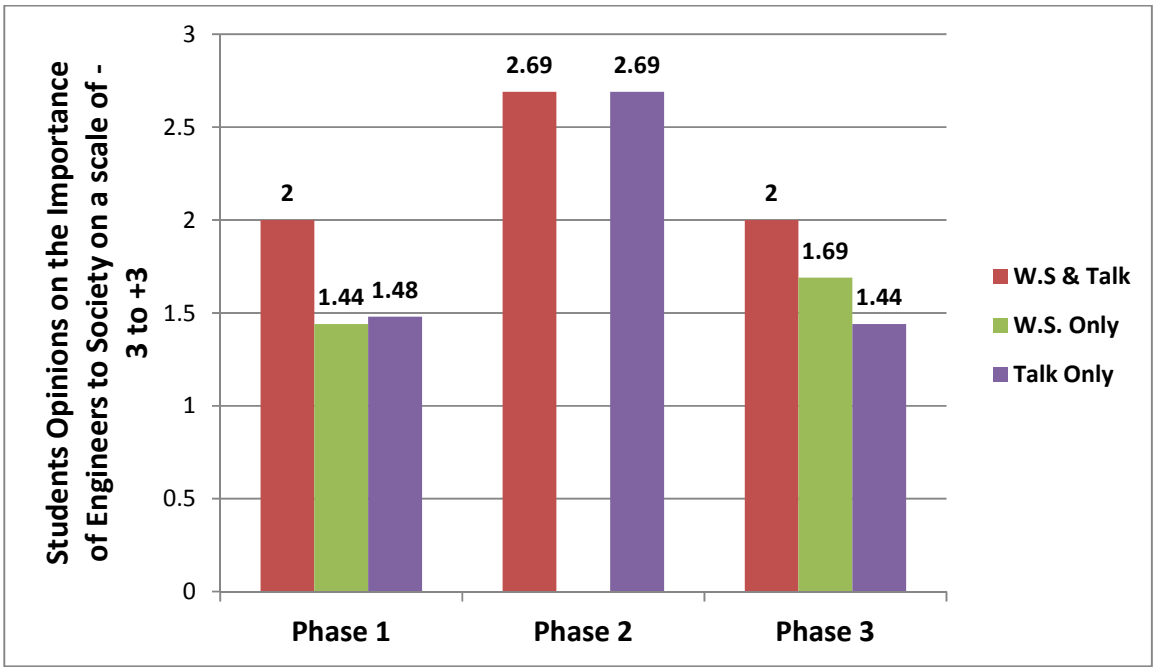

Figure 6: Students' opinion of the importance of engineers to society over Phases 1, 2 and 3

4.4.3 Interest in studying engineering

Since one of the primary concerns motivating this study was the need to increase the numbers of students studying engineering at university-level, it was important to measure the degree of interest held by the students in studying engineering and the extent to which this interest could be altered through interaction with them. Figure 7 depicts the fluctuations in interest reported by the students for all phases of the project.

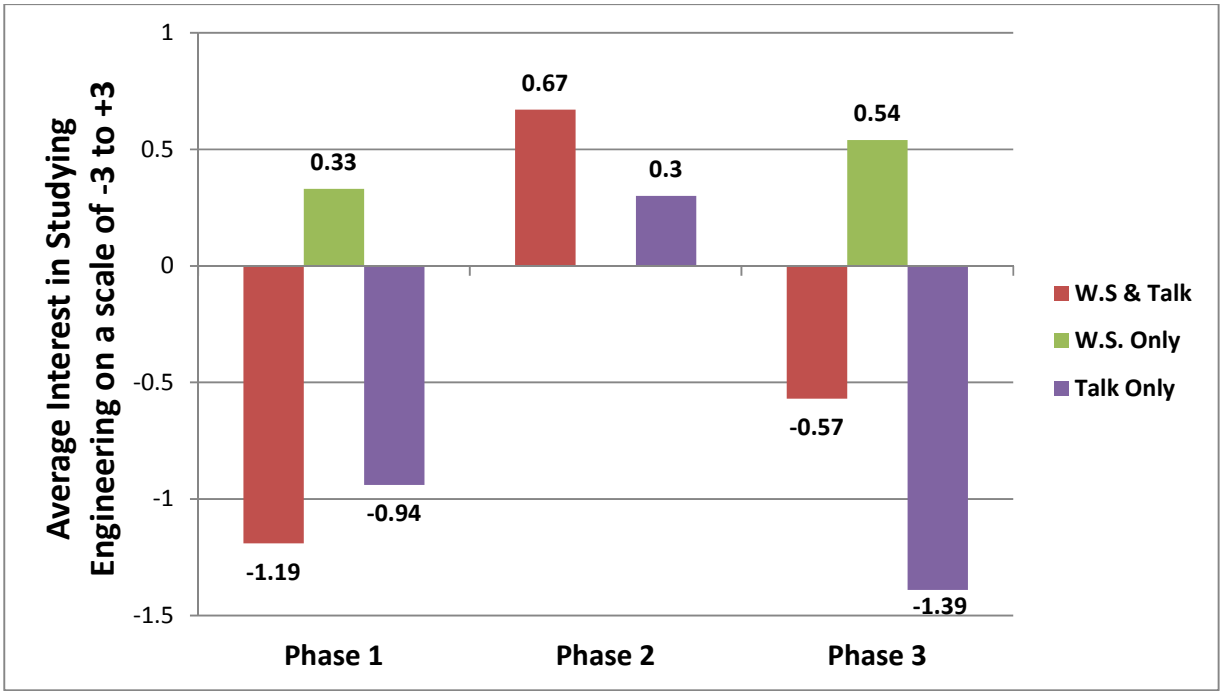

Figure 7: Students' interest in studying engineering over Phases 1, 2 and 3

The most notable point from the above graph is the difference in starting point for the males (W.S Only) and the largely female groups (W.S & Talk/Talk Only). The male students showed a much greater interest in studying engineering than the females. The long-term effects for the female students are shown to be improved by the addition of the workshop, as there is a lasting effect reported for those who experienced both interactions.

5 DATA ANALYSIS

The cohort of 86 students who responded across all three phases, a multivariate regression model was constructed to examine the impact of the interactions on interest in studying engineering. The limited amount of sampling that could be done during the scope of the project meant that there were many confounding influences – notably in the single sex nature of the schools involved. The raw data also suggests significant differences in the average responses under most headings - .e.g. prior interest and understanding, job prospects etc. Whether these have to do with educational, social or gender differences, or other undetermined factors is unclear.

A wide range of input variables were considered with change in interest as the response variable. Those input variables found to be statistically significant are shown in the table below

Variable	Coefficient	p-value	Input range	Notes
Intercept	-1.71	2.2E-7	N/A	Baseline change
Male	1.18	1.2E-3	0 or 1	Gender of respondent (1 for male)
Job Prospects	0.30	6.5E-3	[-3, 3]	-3 being very poor, +3 being very good
Prior Interest Level	-0.98	7.2E-10	[-3, 3]	
Prior Positive Int.	1.19	2.9E-2	0 or 1	

Table 1: Model for Influence of Interventions on Student Interest in Engineering

6 CONCLUSIONS

In terms of measuring the outcomes of the project, it can be said that the results discovered and the implications of these are somewhat mixed. The findings demonstrate that the general awareness and understanding of engineering as a profession is rather low among the cohort, particularly so among the female students surveyed. This poses a significant challenge when it comes to attempting to increase uptake of engineering degree programmes by this group. Awareness-raising actions are clearly required in order to improve this understanding, yet consideration needs to be given to how best these can be conducted. While the engineering presentation given in the course of this study yielded a substantial positive result on the levels of understanding of engineering among the audience, this effect subsided over time. This may suggest that such interactions need to be sustained over a longer time period in order to achieve a lasting impact.

An alternative possibility is that the timing of the interaction may prove to be crucial, and that students who are presently concerned with making decisions about their futures may be more likely to retain this information than those for whom it is not an immediate priority. This theory finds some support when drawing on data gathered within the project from first-year engineering students. A questionnaire similar to that used on the secondary-school students was given to junior freshman (first-year) students at Trinity College on the Engineering, Engineering with Management and Management Science and Information Systems Studies (MSISS) degree programmes. 182 responses were received. According to this data, the vast majority of the respondents stated that they had made the decision regarding what field of study to pursue during the fifth or sixth year of secondary school. Since the majority (86 per cent) of secondary-school students participating in the study were in fourth year this may have had some impact on the results observed.

The responses obtained from secondary-school students who participated in the practical workshop suggest that there is a positive benefit to be gained from this type of interaction. This positive benefit was demonstrated both in relation to the lasting understanding of engineering as a profession, and more substantially in relation to the interest among the cohort in studying engineering at third-level. However, more detailed analysis of the data suggests that the gender and school issue, and prior interest etc may be convolved with the workshop. The multivariate model suggests that interactions in general may have a significant influence – with the effect being largest for students with low prior interest levels but with positive views of the job prospects. In fact, students with high prior interest levels are likely to have this *reversed* by such interventions. This should not necessarily be seen as negative however, as such students may have had unrealistic expectations of what is really involved in engineering. Of more serious concern perhaps is the enduringly low image and understanding of engineering, particularly amongst females.

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