How do university engineering graduates influence high school students through mentoring programs

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Structured Abstract

CONTEXT
The participation rate of female students in the fields of engineering is disappointingly low. Mentoring is suggested as an effective mechanism in improving female participation in engineering through changing attitudes towards engineering. The work of Woelfel and Haller (1971) outlined by Sjaastad (2012) defines attitude as the relationship between the individuals concept of self and that of the object. This paper explores how mentors influence the concept of self and the concept of the object.

PURPOSE OR GOAL
The aim of this particular intervention is to improve female participation using mentoring to change the negative attitudes held about engineering and to understand how this is attitudinal change is achieved. Given the gender differences between the attitudes of boys to girls to engineering, a further question arises: are there differences as to how mentors influence each group?

APPROACH
Female university engineering undergraduates were recruited to become mentors and received a short course in mentoring. Mentors were placed in both co-educational and single sex schools working with Physics and Science teachers. On completion of the mentoring the mentees filled out a survey instrument developed by Jorgen Sjaastad. This instrument defines four modes of influence. Upon analysing the responses it is possible to determine which mode of influence has the greatest positive response and whether there are any gender differences between the responses.

ACTUAL OR ANTICIPATED OUTCOMES
Mentors will be able to focus on the mode of influence which will achieve the greatest positive response for girls and boys. This could be incorporated into the mentor training with strategies of how to achieve this during mentoring in the classroom.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
All of the mentees principally found the mentoring useful in Modelling the self (mentors showing how it is possible to engage with engineering). The girls also found that the mentors were useful in helping them Define the object, while the boys found this to be the lowest contribution of the mentors. These results can be used to train future mentors to maximise their impact on the high school students in the classroom.

KEYWORDS
Mentoring, attitudinal change, STEM

Introduction

Even though the participation rates of women at universities are increasing the enrolments in engineering are slowly decreasing as women choose other career paths (Barnard, Hassan, Bagilhole, & Dainty, 2012). Australia is no different and the participation rate of female students in the fields of engineering remains disappointingly low. (Prieto et al., 2009). This is despite the fact that there good career prospects for engineers in Australia brought about by brought about by the resources boom and resurgence in infrastructure activity (Kaspura, 2013). The low participation rate of women in engineering is problematic as skilled female engineers are lost to the industry and there are growing concerns of the general shortages of engineers worldwide. It appears that the perception remains that engineering is a male dominated field which can be hostile work environment for women. One of the challenges perhaps for the engineering profession is to find ways to change this perception in order to increase female participation rates. The image of engineering is profoundly affected by the way students acquire information and how they receive this information, with parents and family members playing a significant role in career decisions (Prieto et al., 2009). A study at UTS indicated that female students chose engineering as consequence of counselling with career advisors, parents and teachers. It made mention of the fact that many talented female students may be lost as a result of a lack of positive role models and supportive counselling (Tully & Jacobs, 2010). Typically those female students who have chosen to participate in engineering have had direct contact with engineering, either through parents being engineers or being exposed to engineering in the workplace. A recent Spanish study highlighted that of those students interested in engineering 64% of females had men in their family who were engineers and 58% of boys had men who were engineers (Molina-Gaudo, Baldassarri, Villarroya-Gaudo, & Cerezo, 2010). Other strategies have to be devised for those girls who do not have an engineer in their immediate family or whose parents have no interest in engineering as for these girls there is a possibility that the negative perceptions surrounding engineering will persuade them to choose other careers. For these girls, targeted school programs along with mentoring are seen as valid strategies to increase the participation of women in engineering (Chanderbhan-Forde, Heppner, & Borman, 2012). Mentoring is a really important opportunity in the field of Engineering where the profession is not well represented within schools or the general community.

Mentoring as described in the Aspire Mentoring Program is about developing a relationship which gives those involved the opportunity to share their professional as well as personal experiences, where both the mentor and mentee grow and develop in the process. It is based upon open and constructive dialogue, often with set pre-determined goals of the mentoring process. This definition of mentoring; that of a more experienced person helping the development of a less experienced person appears as a recurring theme in mentoring (Harris, 2002). Mentoring focuses on explicit action by mentors to assist the young person reach their goal (Koerner, 2007). Importantly mentoring is also recognised as a strategy to develop community partnerships (Australia, 2000). As it stands there are many types of mentoring programs: face to face, on line, structured approaches and informal to name a few.

University students as mentors provide a personalised link between school and University and hence are a useful resource to schools, teachers, the school students and the university (Koerner, 2007). University undergraduates as mentors are seen as knowledgeable and experienced guides where they pass on their knowledge and skills onto school students helping them with academic and social adjustment to university and or school life (Kavanagh 2012). University students are able to provide firsthand experience of Engineering and female mentors in particular are able to help dispel some of the myths about women in engineering. Their credibility is high, as they are proof that there are females in engineering and it is likely that the mentors themselves have overcome some of the barriers which restrict female participation in engineering. It was found that when questioned as part of an Outreach program in Spain that 52% of girls thought that engineering is difficult, whereas this was only the case for 37% of the boys (Molina-Gaudo et al., 2010). Female mentors could challenge the perception of girls that engineering is difficult. Over the past few years The University of Southern Queensland has been running a mentoring program BEAMS- Building engagement and aspirations through mentoring in schools program using university students as mentors. The Girls in Engineering Mentoring (GEMs) scheme was introduced at the University of Southern Queensland in 2013 as a project of BEAMs. The aim of GEMs was to place female engineering graduates in school classrooms as mentors. Their role was to raise the profile of engineering when relevant and help change the negative perceptions about engineering and help change students' attitudes towards engineering and science.

There are plenty of instruments designed to measure students attitudes towards science, technology, engineering and mathematics (STEM), however very few evaluate in what way a mentor or significant person influences the attitude towards STEM (Sjaastad, 2013). If it is understood how mentors change attitudes then this approach could be incorporated in mentoring training, resulting in positive attitudinal change towards engineering. Attitude as defined by the work of Woelfel and Haller (1972) and outlined by Sjaastad (2013) is as consequence of the relationship between the individual's concept of self and to the object. One's attitude may change by changing one's definition of self or the object or both. So a mentor or significant other is able to influence the mentee's attitude through either altering the mentee's concept of his or her self or that of the object or both (Haller & Woelfel, 1972). There are two major modes of influence: influence which is defined through direct interaction and communication, referred to as definers, and those who exercise influence by providing examples, referred to as models (Haller & Woelfel, 1972). Sjaastad (2013) developed this model further expanding it into four modes of influence: defining the self, defining the object, modelling the self and modelling the object as spheres of influence.

1. Defining the self: Providing attitude-relevant information about the mentees' perception of self through direct interaction (Offering encouragement to study engineering)
2. Defining the object: Providing information about the object through direct interaction (Describing career opportunities within engineering)
3. Modelling a self: Providing an example of a self in relation to the attitude object (Mentees get to know and understand their engineering mentors where the mentors themselves are examples engineers, or mentors discuss other engineers and what they do)
4. Modelling object: Providing an example of the attitude object (Mentors provide examples of engineering in action)

Furthermore, Sjaastad developed a the Significant Persons Influence Attitude towards STEM (SPIAS) survey instrument with which to measure the ways a significant other influences attitudes towards STEM. This survey instrument has seventeen questions which measure the four different ways a significant other influences attitudes towards STEM.

The aim of this particular GEMs intervention is to change the negative attitudes held about engineering using mentoring. With all interventions it is important to establish the impact of the intervention and identify opportunities for improvement. Using the framework suggested by Sjaastad (2013) this paper explores how mentors influence the attitudes of mentees with respect to engineering. Which mode of influence has the most impact and how do the modes of influence interact with one another? Given the gender differences between the attitudes of boys to girls to engineering, a further question arises: are there differences as to how mentors influence each group?

Method

Female engineering students were recruited for the GEMs at the University of Southern Queensland and five volunteered to act as mentors. All mentors received a training course in mentoring, had valid blue cards and were achieving a GPA of at least 4 (were passing all their University courses). The mentoring training was presented by BEAMs project officers and covered the following topics: Mentoring roles and responsibilities, mentoring skills, building on core skills, working as part of a team, understanding learning, techniques to facilitate and mentoring strategies (Kavangh 2012). The training was conducted as a daylong interactive workshop. Training manuals were provided to mentors as reference material for the mentors. Science teachers from local high schools were approached in Toowoomba and interested teachers were invited to participate in the GEMs program. Mentors were placed in physics and or general science classes. To avoid disruption to the class the mentors worked alongside the teachers during normal classes and as such did not mentor one-on-one with students but rather worked in small groups with the students. In order to maximise the opportunities for discussions between the mentors and school students, mentors worked in classes when students were conducting their own experiments during practical classes .This arrangement lends itself for discussion with the mentors as the school students work in small groups on the experiments.

The mentors worked in four different high schools in six different classes, four of these co-educational and two were girls-only classes. The level varied from Year 9 to Year 12. The number of visits also varied as they had to fit in with the schools' requirements: in some cases mentors had seven contact sessions with the most being twenty-three contact sessions. Most mentoring sessions lasted a class period which is normally an hour long. During this time the mentors went to the classes and worked with the school students. In some situations teachers asked mentors to talk about University life and their experiences as engineering university students. During practical classes mentors walked around working in small groups helping students with their science experiments offering alternative ideas to problem solving. This gave the mentors the chance to talk to students in small groups.

After the mentoring was complete the school teachers handed out survey forms to all the school students. These forms containing 17 questions and were based on the SPIAS survey instrument designed by Sjaastad (Sjaastad, 2013). For each question, students were asked to rate how applicable the statement was to their experience, using a four-point Likert scale ranging from "Small Extent" to "Large Extent". The survey instrument was slightly altered with the author's consent to make them appropriate to engineering (See Appendix A). Ninety-two survey forms were completed by the school students.

Certain questions in the SPIAS survey related to each of the four modes of influence and responses were grouped accordingly. The respondents were not made aware of the four modes of influence, nor which questions were related (pertained to the same mode); the questions were somewhat randomly ordered to facilitate this. The responses from all the surveys were then combined and categorised based on gender of the respondent. An Analysis of Variance (ANOVA) was conducted to ascertain if there was any significant difference between the responses of the girls and boys for each of the four modes of influence.

Results

The results from the survey are presented in the following figures showing the absolute frequency. Each mode of influence is shown separately, with the responses separated by gender.

Defining the self: Providing attitude relevant information about the mentees perception of self through direct interaction. These questions related to the mentees' enjoyment of science and self-confidence with the subject matter. This mode of influence had the highest combined number of "small extents" within the survey (Figure 1).

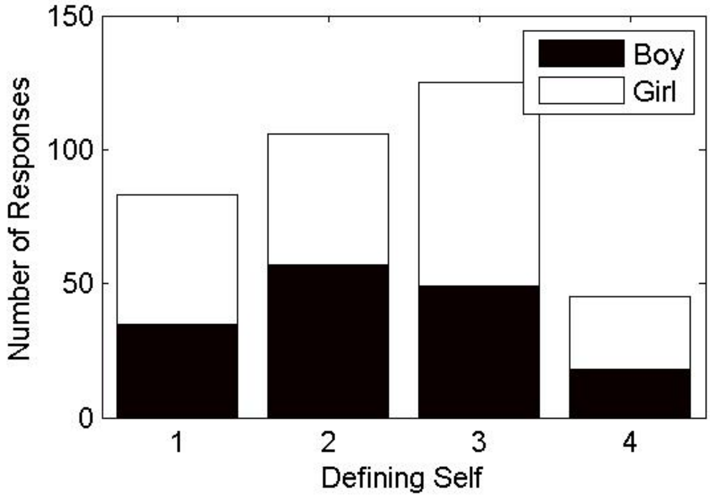

Figure 1: Results from the survey with questions relating to Defining the self: Providing attitude relevant information about the mentees perception of self through direct interaction. Likert scale 1=small extent and 4=large extent

Defining the object: Providing information about the object through direct interaction. This mode of influence relates to how well mentors described what engineers do and what they discussed about engineering (Figure 2).

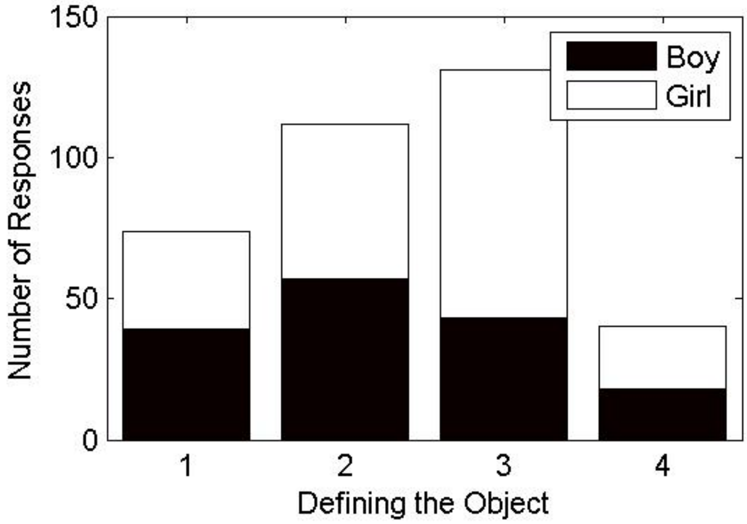

Figure 2: Results from the survey with questions relating to Defining the object: Providing information about the object through direct interaction. Likert scale 1=small extent and 4=large extent

Modelling a self: Providing an example of a self in relation to the attitude object. This mode influence describes how well the mentors were perceived as role models and gave the school students an idea of what engineers might be like. This mode of influence received the highest number of combined "large extent" scores (Figure 3).

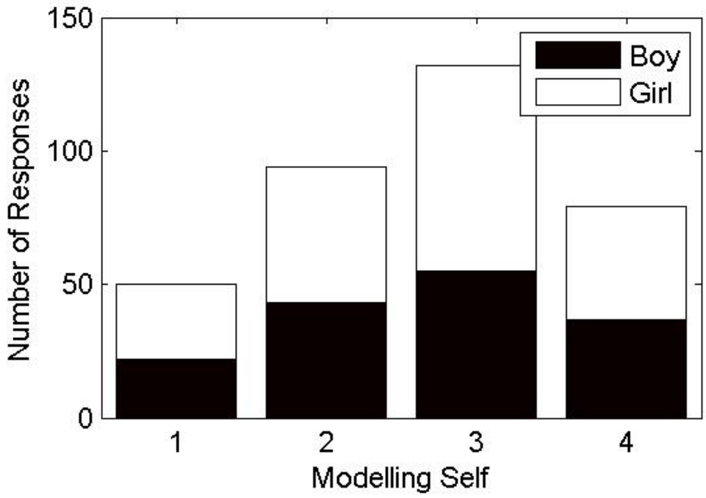

Figure 3: Results from the survey with questions relating to Modelling a self: Providing an example of a self in relation to the attitude object. Likert scale 1=small extent and 4=large extent

Modelling object: Providing an example of the attitude object. This relates to how mentees might experience engineering through the examples provided by mentors (Figure 4). Note that this mode comprised 5 questions, while the others were comprised of 4 questions each, resulting in the higher total number of responses.

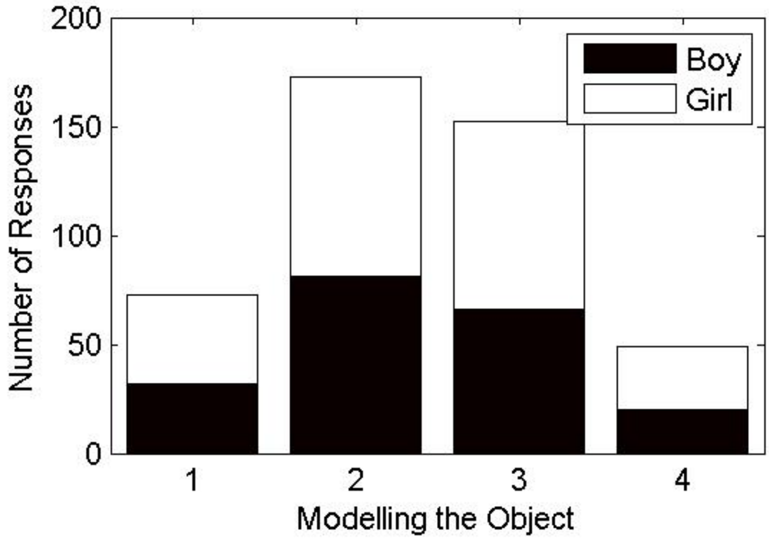

Figure 4: Results from the survey with questions relating to. Modelling object: providing an example of the attitude object Likert scale 1=small extent and 4=large extent

Table 1 contains the statistical analysis of the results from Figures 1–4. For each mode of influence, the mean result for the boys and girls are listed, with the null hypothesis that the results are the same. The *p*-value for the ANOVA test is recorded, with a 5% significance used to indicate whether the null hypothesis can be rejected: *p*-values lower than 5% indicate that it can and the means are significantly different from each other.

Table 1: Analysis of survey results for each mode of influence. The p-value is the result from an ANOVA with the null hypothesis that the mean responses from the boys and girls are the same; a value less than 0.05 is considered evidence that this is false (they are significantly different).

Mode of Influence	**Average**		**p-value**	**Significantly different?**
	Boys	**Girls**		
Defining Self	2.31	2.41	0.36	No
Defining Object	2.25	2.49	0.021	Yes
Modelling Self	2.68	2.67	0.93	No
Modelling Object	2.37	2.42	0.61	No

Two additional questions were asked in the current survey. The first was “How has your relationship to science changed because of GEMs?” The vast majority of students felt it was unchanged, however a small number did indicate that they like science more (Figure 5). In the second question, asking whether the probability of choosing a university education within engineering had changed, the results were similar, with most not thinking there was a change, but some did think it was more likely (Figure 6).

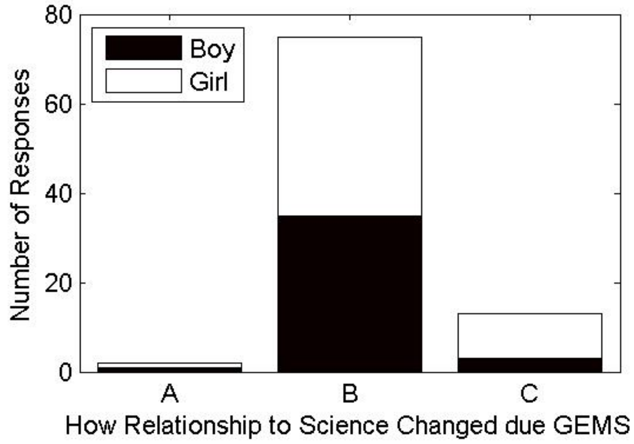

Figure 5: Student responses to question “How has your relationship to science changed because of GEMS?” with scale A-like it less; B-unchanged and C-like it more

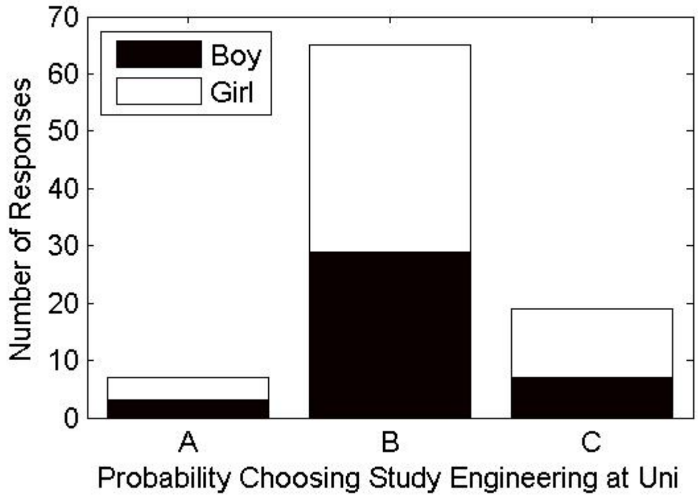

Figure 6: Student responses to question “The probability of you choosing a university education within engineering; is it smaller, unchanged or greater because of GEMS?” with scale A-smaller, B-unchanged, C-greater

Discussion

Sjaastad (2013) concluded that it appears that there is a relationship between the four modes of influence. Modes can be considered to be dealing with an internal view of the object or an external view of the object. Defining the object and Modelling the self provided an external view while Defining the self and Modelling the self were more an internal or introverted view of the object (Sjaastad, 2013). He went onto suggest that this might also be another framework to analyse how a significant person may influence attitude. This relationship between the modes of influence is reflected amongst the girls' responses as the two modes Defining the object and Modelling the self scored higher in the ANOVA tests than the other two modes (Table 1). In Defining the object the mentors have discussed what engineers do by giving examples. In Modelling the self the mentors have themselves been the role models of what engineers are and what they are like as people. The girls responded to this external view of engineering delivered by female engineers, they enjoyed hearing about what the female mentors had to say as well as meeting them and seeing them as role models.

The boys' response was a little different, where the highest response was for Modelling the self followed by Modelling the Object (Table 1). So this would suggest the boys enjoyed meeting the female mentors and also saw them as role models, however they also had their own experiences of engineering and liked to hear about examples of engineering and how it related to them. This suggests that there may already be gender differences in the classroom. Boys are more likely to have already had some exposure and ideas about engineering and through giving them a more internal view of engineering the boys could relate to it on a personal level. The idea that boys are already attracted to engineering is indicated in a recent survey of over a 1000 science fair projects. Boys tended to present work that related to physics and to aspects of engineering like electricity or paper plane designs whereas girls presented projects about biology and content was often based on household products and plants (Lawton & Bordens, 1995).

The only significant difference between the girls' and boys' responses towards how they are influenced is the mode of influence Defining the object. This is where mentors would describe the kind of work engineers do. Given that most girls, unless they know an engineer, have had little exposure to engineering it would have been very noticeable to them when mentors talked about what it is engineers do. Talking about different engineering careers, and explaining what work engineers do could be an effective avenue of influence for mentors and is one that girls responded well to. As boys tend to already have an idea of what engineering is, perhaps this explains why this response was not as high for the boys.

Whilst overall only a few school students indicated that they would now either consider engineering as a career or now enjoyed science more it must be remembered that this was a mixed cohort of students, some who may not wish to continue with science and others who already have other interests. It does however still indicate a positive role for mentoring in reaching students who may not have otherwise considered engineering as a profession. Some students may also have already made choices to follow career paths in engineering and this would not be reflected in the survey instrument. Some of the limitations of the study, like the relatively short time mentors had in the classroom and how indeed the teachers introduced and involved the mentors may have also influenced the outcome of the mentoring experience for the mentees. Ideally mentoring times should be between six months and two years (Kanaugh 2012). This can easily been improved by negotiating longer periods of mentoring time and discussing with teachers that mentors rather attend practical classes which enhances the participation of mentors and gives them the opportunity to engage with students. Mentoring outcomes may also be improved by including ongoing mentor support throughout the program where mentors have the opportunity to discuss their progress with one another as well as with project officers .Further studies could also include the impact of mentoring on the mentors themselves. Studies have indicated that mentors gain greater self-confidence, improved time skills, negotiation skills through mentoring (Koerner 2007). It is likely to that engineering students may greater confidence about their subject areas in engineering.

Conclusion

The presence of mentors in the classrooms has the potential to help change attitudes towards engineering. For example girls responded well to hearing about the kind of work it is engineers do identifying how mentors may influence mentees through the four modes of influence should also be incorporated into mentor training. This would help give mentors some focus and ideas to work on when mentoring high school students. Using university undergraduate students as mentors provides a helpful link to university and in the case of engineering may help to counter some of the negative perceptions and attitudes towards engineering.

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1 Are you a boy or a girl	Boy	Girl

Appendix A: SPIAS survey instrument

2. To which extent have you experienced that your mentors have done the following	Small extent 1	2	3	Large extent 4
a. Talked about careers you can follow with an education in engineering				
b. Shown new sides of science				
c. Talked about why you should continue choosing science				
d. Talked about different studies you can take with engineering				
3. To what extent do the following statements hold?	Small extent 1	2	3	Large extent 4
a. The mentors have improved my self-confidence in science				
b. The mentors have shown me whether I am suited to be an engineering student				
c. The mentors have been important for how well I understand science				
d. I have an impression of what the mentors are like as people				
e. The mentors have contributed towards my enjoyment of science				
f. The mentors have shown me examples of some of the qualities engineering students can have				
4. To what extent have you experienced that your mentors have done the following?	Small extent 1	2	3	Large extent 4
a. Shown science from a new perspective				
b. Talked about how I can use science				
c. Used interesting science examples				
d. Talked about the role of engineering in society				
e. Shown new ways to solve science problems				
5. To what extent do the following statements hold?	Small extent 1	2	3	Large extent 4
a. I have an impression about how mentors experience their studies				
b. The mentors have helped me discover my abilities in science				
6. Relationship to science and future choice of education				
a. How has your relationship to science changed because of GEMS?	Like it less	Unchanged		Like it more
b. The probability of you choosing a university education within engineering; is it smaller, unchanged or greater because of GEMS	Smalle r	Unchanged		Greater
7. Any other comments				

Appendix A