

Exploring the Reasons South African Students Give for Studying Engineering*

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This paper reports on an investigation into the reasons students give for studying engineering. The data was obtained from free-form responses of a sample of first year engineering students at three tertiary institutions in the Western Cape. It was found that male and female, black and white South African students enter the engineering profession for different sets of reasons. The choice of engineering discipline also appears to be substantially different for black and white students. One category of reasons, Social Identity, not previously reflected in studies of this kind, clearly indicates that career choice is influenced by the socio-political environment. These results have implications for initiatives designed to attract previously underrepresented groups into engineering careers.

INTRODUCTION

CURRENT initiatives to attract more women students to engineering in South Africa lack information derived from the local context on what attracts South African students, in particular female students, to engineering. This project was designed to provide findings that may be used to inform such initiatives.

Although this research was originally conceptualised as a study into women in engineering, previous studies had indicated the importance of both race and gender in student choice of and performance in engineering at a South African university [1, 2]. It was therefore assumed that student background and experience in South Africa is still influenced by racial divisions despite the lifting of restrictions on admission to schools several years ago.

Related studies

A conceptual framework for this project was developed from a model of career choice proposed by Dick and Rallis [3], in which the major reasons for career choice were identified as:

- students' beliefs about themselves (self-concept);
- perceived relative values of different careers (career values), determined by intrinsic (e.g. interest) as well as extrinsic factors (e.g. salary);
- interpretation of past experiences;
- perception of attitudes and expectations of socializers (e.g. parents, teachers).

Based on an earlier free-form survey of teachers on the reasons students choose science and engineering careers, Woolnough [4] developed a questionnaire which was administered to a large sample of

students. Factor analysis of this data yielded six categories of reasons, viz.

- extracurricular activities;
- the way science is taught in class;
- career aspirations (includes salary and status);
- external factors of family background, hobbies, exposure to sophisticated technology;
- difficulty of the subject;
- ease of entry to course and possibility of sponsorship.

Johnson and Stewart [5] point out that this list excludes reasons such as the influence of parents, the usefulness of the work or the uniqueness of the students' particular study, factors which they found to be significant in research using an adaptation of Woolnough's questionnaire.

Shell *et al.* [6], as part of the National Engineering Career Development Survey in the USA, grouped their list of factors into the following categories:

- work characteristics (including salary, status, interest and contribution to society);
- (prior) educational experiences;
- people;
- technical experiences (e.g. hobbies).

These categories cover the same area as the major elements of career choice identified by Dick and Rallis [3], with the exception of self-concept.

In a number of studies it is reported that women and men have similar profiles of reasons for choosing engineering [3, 4, 7]. Areas where differences have been reported include the following.

- Pay was a more important factor in career choice for men than women [3].
- Women were more influenced by involvement with human issues [4, 6].
- Men were more influenced by their experience of engineering-related activities, while women

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Table 1. Sample by race, gender and institution

Institution	Female		Male		TOTAL
	black	white	black	white	
University of Cape Town	42	15	121	60	238
University of Stellenbosch	2	42	19	93	156
Peninsula Technikon	49	0	87	2	138
TOTAL	93	57	227	155	532

seemed more attracted by the characteristics associated with the career itself [6].

- Men cited scientific hobbies and fiddling with gadgets more often than did women [4].
- Men were not influenced by as wide a variety of factors as were women [6].
- Men were encouraged more by their fathers than were women [8].
- More women than men cited 'wanting to be different' [7].
- Ability in mathematics and science cited more by women than by men [7].

METHOD

Research instrument

While the studies reviewed all used a closed-format questionnaire, we were interested in the reasons students would choose to describe, unprompted by items in a list. We therefore decided to collect data from free form written responses to the question 'Why did you decide to study engineering?' While not providing an exhaustive list of all the influences on a particular student, it was assumed that students would write the most important reasons from their perspective. Furthermore, it was felt that this approach would enable reasons related to the South African context to emerge.

A potential disadvantage of this method relates to the influence of writing ability on the data obtained. To minimise the possible influence of English writing skills, where possible students were given the choice of answering in Afrikaans, English or Xhosa. To ensure similar conditions at each institution surveyed the authors personally supervised the administration of the data sheets as soon as possible after students had registered.

Students were asked to indicate their racial category. For analytical purposes these categories were grouped into black (including coloured, Indian and African) and white.

Sample

All first-year engineering students at the historically white universities of Cape Town (UCT) and Stellenbosch, and half of those at the historically black Peninsula Technikon (offering diplomas in engineering), participated in the study. Foreign students, mature students, and those who gave incomplete biographical data were excluded from the sample.

A sampling technique was developed to ensure the comparability of the data across the variables gender, race and discipline. All female responses were retained, and large groups of males in certain departments were cut down by a factor of 1/2 or 2/3 using a randomized selection method. This process was however unable to yield a comparable sample across institutions given the racial profiles of the current enrolment at the different institutions (Table 1). At the beginning of 1998, 95% of engineering students at the University of Stellenbosch were white, while the Peninsula Technikon had an almost exclusively black enrolment. At UCT black students accounted for approximately 60% of the first year engineering intake.

Coding

A coding schedule was developed from representative data and used to classify individual responses [9]. Coding was carried out separately by each author, who then met to validate each code entered and to establish consensus on any points of difference. Responses written in Xhosa were translated into English before being coded by the authors.

Initially six categories of reasons were identified and this analysis has been reported elsewhere [10]. In this analysis, one particular category, (Engineering Activities) had a frequency count of 69%, significantly higher than the average of 37% of the remaining categories. Engineering Activity was therefore subdivided into three categories, Manual, and Mental Activities and Challenge & Variety. (see Appendix).

RESEARCH FINDINGS

Multivariate analysis

A multivariate analysis of variance (MANOVA) revealed that the reasons students give for studying engineering are independently and significantly associated with the variables of race, gender and discipline, with significant interaction effects between discipline and race.

Analysis by race and gender

A statistical analysis using frequency counts and chi-square tests was carried out to explore the relationship between race and gender and the categories of reasons identified in our model, with $\sigma < 0.05$ indicating significance (Table 2).

Table 2. Response frequency (%) by category of reason

	SOC socializers	CAR career contact	SCH school subject	MAN manual activities	MEN mental activities	CHA challenge & variety	SID social identity	REW career reward
All	32	36	36	41	30	31	35	45
Female	37	38	40	*(33)	25	#(40)	#(49)	45
Male	30	35	34	(44)	32	(28)	(29)	46
White	#(42)	38	#(46)	#(48)	*(35)	34	#(17)	42
Black	(25)	34	(29)	(36)	(27)	30	(46)	48
White female	*(56)	47	#(65)	39	21	44	#(26)	40
Black female	(25)*	32	(25)*#	30	27	38	(62)*	46
White male	*(36)	35	39	#(51)	#(40)	30	(14)*	42
Black male	(26)	34	30	(39)	(26)	27	(39)	48

Notes: * significant at the level $\sigma < 0.05$; # significant at the level $\sigma < 0.005$.

No significant difference by gender or race was found for the categories Career Rewards (REW), which includes job prospects, salaries and bursaries, and Contact with Engineering Career (CAR), which includes career events and exposure to engineers and the workplace.

The categories Socializers (SOC), which includes the influence of teachers and the presence of an engineer in the family, and School Subjects (SCH), including enjoyment or ability in mathematics, science or technical subjects showed similar differences in response. Both these categories of reasons were mentioned significantly more by white students than by black students, and, amongst white students, by female students than by male students.

The original category of reasons related to the nature of engineering activities revealed no significance by race or gender [10]. However, the three new categories arising from the unbundling of this category revealed significant differences.

- (a) Manual Activities (MAN): reasons in this category include an attraction to practical activities such as designing and building things (including hobbies), and working with real life situations. These reasons were mentioned significantly more by white students than by black students and more by male students than by female students.
- (b) Mental Activities (MEN): enjoyment of problem-solving, research, and a curiosity about how things work, were mentioned significantly more by white students than by black students.
- (c) Challenge (CHA): the desire for variety in one's work and the attraction to challenge were mentioned significantly more by female students than by male students.

The category Social Identity (SID) includes statements about making a contribution to the community or country, working as a team, wanting to be different or to prove oneself. The latter reasons were mentioned particularly in relation to being a member of an underrepresented group in the engineering profession. These reasons were mentioned significantly more by black

students than by white students, and amongst black students, significantly more by African (53%) than by coloured/Indian students (36%). Female students also mentioned this category significantly more than did male students.

Analysis by school

Twenty-five percent of the sample of black students attended historically white schools while no white students in the sample attended historically black schools. For this reason an analysis of school and gender was undertaken with race as a covariate. While the gender effect was found to be highly significant, that of school was not significant at all. Furthermore, comparison of reasons given by black students from historically black schools and those from historically white schools revealed no significant differences between these two groups.

Analysis by discipline

The analysis by discipline was conducted only on the UCT and Stellenbosch sample, as the study at Peninsula Technikon did not include all disciplines. The disciplines of Civil, Electrical, Mechanical and Chemical Engineering were analysed as they had sufficiently large student numbers in the sample.

For those categories of reasons where significant differences by discipline were identified, Table 3 records in which disciplines the highest frequency was found. A significant difference between white and black student responses can be seen. Amongst black students, a significant difference by discipline was found for the categories Challenge and Variety (CHA) and Career Rewards (REW) with Chemical Engineering students mentioning this category significantly more than any other discipline. Amongst white students, a greater number of categories revealed significant differences by discipline. This would appear to indicate that in general white students have specific sets of reasons for choosing particular disciplines. For example, the categories Manual (MAN) and Mental Activities (MEN) were strongly associated with students choosing Mechanical Engineering.

Table 3. Reasons with significantly high frequencies by discipline and race

Discipline	<i>Black students</i>	<i>White students</i>
Chemical Engineering	CHA	SCH
Mechanical Engineering	REW	CHA
Electrical Engineering		MAN
Civil Engineering		MEN
		SOC
		CAR
		CHA

Another interesting feature of these results, is that the Social Identity (SID) category is not associated with any particular discipline.

Analysis by institution

A multivariate analysis was conducted with institution as independent variable and race and gender as covariates versus the dependant variable of the eight categories of reasons, and revealed highly significant differences by institution.

To explore this further, the responses of white students at UCT and Stellenbosch were compared, and the only significant difference found was that Stellenbosch students mentioned Manual Activities (MAN) to a significantly greater extent than did UCT students.

When black students at UCT and Peninsula Technikon were compared, significant differences were found in three categories. School Subjects (SCH) and Mental Activities (MEN) were mentioned significantly more by black students at UCT than at the Peninsula Technikon. This is possibly related to the higher Mathematics and Science requirements for entrance to UCT. Furthermore, black students at Peninsula Technikon mentioned Social Identity significantly more than black students at UCT. An explanation of this difference could be sought in the socio-economic background of the students, the culture of the institution and its marketing strategies. For example, during 1997, Peninsula Technikon undertook specific initiatives to attract women into engineering.

DISCUSSION OF RESULTS

The finding that white students mentioned the influence of socializers (SOC) and enjoyment of school subjects (SCH) more than black students can be explained by the prevailing socio-economic conditions and educational inequities in South Africa as a result of previous apartheid policies. The quality of mathematics and science teaching at historically black schools is considerably lower than that at historically white schools. Given the very low numbers of black graduate engineers in South Africa, it is also to be expected that few black students would have engineers within their families or communities. The finding that white students mentioned Manual Activities (MAN) and Mental Activities (MEN) more than black students could be explained in the same way.

Given the situation sketched above it is surprising that no difference was found in the frequency with which reasons related to contact the engineering career (CAR) were mentioned. This finding could be explained by the affirmative action initiatives of educational institutions and companies involving students from communities that have traditionally been underrepresented in the engineering profession.

The finding that Manual Activities (MAN) are mentioned more by males than by females is in agreement with the literature surveyed [4, 6]. The attraction to challenge and variety of engineering (CHA) was the only category of reasons that revealed a significant gender difference but no difference by race. In interpreting this finding, it must be borne in mind that the women in the sample have chosen a non-traditional career and are therefore more likely to be the type of person not put off by a challenge.

The category in which the largest differences are displayed involves the students' views of themselves in relation to their communities (SID), with very few white students (17%) mentioning reasons in this category. An explanation for this finding could be found in the changing political conditions in South Africa, and students' perception of their roles in these developments. Black female students (62%) seem to be strongly aware of potential opportunities in this regard.

I chose this course [because] in the olden days there was a belief that engineering is for men, and woman were excluded. Also men did not give woman a chance to show what they can do. Now as we woman are given a chance it is [in] our interest to show how much we can do. (Black female electrical engineering student)

This study found significant differences in the reasons given by students for choosing the different engineering disciplines. This would appear to be related to the different images that these disciplines have in the minds of students. Furthermore, these images seem to differ substantially for white and black students. Amongst white students, the traditional images of the disciplines are reflected, for example, mechanical engineering is associated with manual and mental activities, while chemical engineering attracts high achievers in the mathematics and science areas. The reasons given by civil engineering students suggest that these students were frequently influenced in their decision by other people (SOC and CAR). The lack of any significant category associated with electrical engineering students might be related to the public image of this discipline, which has no single focus. Except in the case of chemical engineering, the analysis of black students' responses revealed no strong associations with particular disciplines. This could be due to black students being less exposed to information about the different disciplines in the profession.

CONCLUSION

This study has produced a set of eight categories of reasons given by South African students for choosing engineering. These students do not demonstrate a uniform profile in the reasons they give. Male and female students, and black and white students enter the profession for very different reasons, presumably with differing goals and perspectives. For example, while white female students appear to be primarily influenced by their school mathematics and science teaching and a family environment that supports this career choice, the majority of black female students appear to be motivated by the opening up of opportunities to serve their community, and to prove themselves in a career traditionally dominated by white males. The choice of discipline also appears to be substantially different for black and white students, with white students having more specific reasons for choosing a particular discipline.

One category, Social Identity, not previously reflected in studies of this kind, clearly indicates that career choice is influenced by the socio-

political environment. A substantial proportion of black students, and the vast majority of black female students, gave reasons for studying engineering that relate to their social identity in the context of a South Africa in transformation. This finding has implications for the engineering curriculum and environment within which students learn and work. It is felt that failure to ensure that students feel that they are achieving their personal goals could impact negatively on the retention of black students within the engineering profession.

These findings have implications for initiatives aimed at attracting more female and black students into engineering studies. Not only do the social dimensions of an engineering career need to be emphasized in the publicity aimed at these students, but curricula and workplace experiences need to build on and sustain the differing initial motivations in order to retain these students in the profession. Furthermore, efforts to inform students of the options offered by the different disciplines within the engineering profession need to adopt approaches appropriate to the particular student community that they are targeting.

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APPENDIX: CATEGORIES OF REASONS IN CODING SCHEDULE

- **Socializers (SOC).** Recommended by schoolteacher, parents or close family (not necessarily engineers); influence of relatives or friends who are engineers or engineering students; suggested by aptitude test.
- **Contact with engineering career (CAR).** Attended career activities organised by school, tertiary institution etc; contact with engineers and engineering firms; worked in industry; information from media about engineering.
- **School subjects (SCH).** Enjoyed or did well in mathematics or science or technical subjects.
- **Manual activities (MAN).** Want to design and build things; apply scientific principles to real-life situations; enjoy working with hands; enjoy drawing.
- **Mental activities (MEN).** Interested in how things work; enjoy problem-solving; interested in research.
- **Challenge and variety (CHA).** Variety in one job; opportunities to work outdoors and travel; enjoy challenge and hard work.

- **Social identity (SID).** As a female or black student, want to prove that I can do it; want to work as part of a team; want to contribute to the development of the community or country; want to be a role model to siblings or community; want to be different.
- **Career rewards (REW).** Good job prospects including international opportunities; good salary; want career flexibility; want to move into careers such as management; availability of bursaries.

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