Factors influencing learners’ choice of Mechanical Engineering as a career

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Abstract

This study examines the factors that influenced first-year students in the Department of Mechanical Engineering at the University of Cape Town to follow a career in mechanical engineering. The data were collected over two years from first year students during the first week of each academic year as part of a questionnaire that asked various questions relating to the students’ choice of what and where to study. A qualitative analysis of the responses resulted in ten categories of influence being developed: “exposure to engineering career”, “school subjects”, “socialisers”, “if not, then…”, “specific career plan”, “career rewards”, “flexibility and challenge”, “physical activities”, “intellectual activities” and “social identity”. These were subsequently grouped into four macro-categories: “societal influences”, “personal career vision”, “product related activities” and “social/civic responsibility”. A quantitative analysis showed significant differences between the responses on the basis of race and gender. The results of this study show that different factors influence particular groups of learners during their career choice process. Focused interventions around these factors can serve to encourage more learners to follow a career in mechanical engineering.

Introduction

In order for South Africa to compete internationally and succeed in an increasingly demanding trading arena, it is imperative that the country’s tertiary educational institutions produce greater numbers of competent engineers. Such an undertaking is a complex task, given that the educational landscape in South Africa is in a state of change.

It is commonly accepted that it is a different world now to the one that attracted the traditionally white, male engineers of the past. These engineers-to-be grew up before computers and television, and were often tinkerers with hobbies like building Meccano models, crystal radios, model aeroplanes and boats, or keeping an old car in running order. They would build tree-houses, dismantle and reassemble toys (and often other items in their house.) Children today have little exposure to the stimuli described above, but rather spend their time playing computer-games, going to discos, socializing at the mall and watching television. The cost of educational and technological toys is often prohibitive and even when they are available, they are generally modular in design and as such, cannot be “tinkered” with.

To address this situation and to increase the number of engineering students graduating, it is necessary to attract more learners to the engineering field. To do this, one must understand what it is that influences a learner to decide to follow a career in engineering. The study had the aim of developing a model of career choice that would be useful in a South African context.

Models of career choice

A number of researchers across the world have investigated issues relating to the career choice of teenagers. Their focus has been on aspects including “factors influencing teenagers’ motivation to take technological training” (Breakwell, Fife-Schaw, & Devereux, 1988), “factors and influences on high school students’ career choices” (Dick & Rallis, 1991), “exploring the reasons given for studying engineering” (Jawitz & Case, 1998), “career
planning characteristics of engineering students” (Shell, LeBold, Linden, & Jagacinski, 1983) and “factors influencing students’ choice of science and engineering” (Woolnough, 1994).

In these papers, the researchers use terms such as factors, reasons, elements and influencers to describe those aspects that are of importance when it comes to career choice. This paper will use “influencing factors” as the descriptive term that encompasses all of these. A number of the papers also seek to understand the gender and racial issues related to technology as a career option (Jawitz & Case, 1998; Jawitz, Case, & Tshabalala, 2000; Kent & Stublen, 1995; Kubanek & Waller, 1995).

Table 1 is an analysis of the influencing factors described by the researchers in the studies above. Some of the factors they give have been analyzed to show how they relate to the other tabulated factors of influence. For example, Woolnough (1994) gives external factors as one of his influencing factor categories as to why students choose science and engineering. When this factor is dissected it reveals a number of factors that are similar to other studies, but grouped under this one heading. These extended descriptions are listed below the influencing factor category that he defined. A discussion of the researchers’ major findings is described below.

Table 1: Synthesis of factors influencing the career choice of learners

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<td>Pre-college seminar, college eng course</td>
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<td>School subjects</td>
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<td>Socialisers</td>
<td>Manual activities</td>
<td>Experience of family in science based industry</td>
<td>Aptitude test, interest inventory</td>
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<td>Mental activities</td>
<td>Career rewards</td>
<td>Science hobbies &amp; gadgets at home</td>
<td>Salary, status</td>
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<td>Challenge and variety</td>
<td>Social identity</td>
<td>Sophisticated technology in weapons</td>
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Dick and Rallis (1991) developed a framework that was of particular interest in the development of one for this project. They investigated why learners in the USA, who were strong in mathematics or science, did not necessarily follow a career in science or engineering. The model they developed introduced the concept of socialisers (attitudes and behaviours of parents, teachers, friends, etc.) as a central theme. Their model can be summarised as follows.

Learners’ attitudes are influenced by socialisers and past experiences. The cultural milieu in turn impacts on these socialisers. A learner’s perception of these socialisers, and their interpretation of past experiences, impacts on their self concept and career values. Their career choice is then influenced by these self concept and career value issues.
Their model can be simplified to four primary categories as the basis for a students’ career choice:

- their perception of the attitudes and expectations of socialisers (parents, friends, counselors, etc.)
- the interpretation of past experiences
- their beliefs about the relative values of different careers as determined by both intrinsic factors (such as intellectual interest) and extrinsic factors (such as salary expectations)
- their beliefs about themselves and their own abilities

Two other significant studies were the work done by Woolnough (1994) and Shell, et al. (1983). Woolnough’s (1994) work was based on the hypothesis that learners’ career choices would be affected by their ability and personality, their experiences in and out of school and the value that society places on engineering. His study was done using a questionnaire format with 1180 learners from “successful schools in science” in the UK and resulted in six categories influencing career choice, namely:

- extracurricular activities
- the way science is taught in class
- career aspirations
- external factors including family background, hobbies and sophisticated technologies
- difficulty of the subject and amount of work involved
- ease of entry and possibility of sponsorship

Shell, et al. (1983), as part of the National Engineering Career Development Survey in the USA, surveyed 1229 students (freshman and sophomores) and developed a number of categories to define the factors that may have encouraged these students to pursue engineering as a career. The categories they developed were:

- work characteristics
- educational experiences
- people
- technical experiences.

Given the complex issues in the post-apartheid South African context, Jawitz & Case (1998) attempted to establish whether the factors influencing career choice might differ from those identified in the above overseas studies. They sampled 531 first year engineering students at three universities in the Western Cape to investigate the reasons they gave for studying engineering. They drew extensively from the work done previously by Dick & Rallis (1991) and found that the reasons South African students chose to study engineering could be described by the following categories:

- **Socialisers**: 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**: Attended career activities organized by school, tertiary institution etc; contact with engineers and engineering firms; worked in industry; information from media about engineering.

- **School subjects**: Enjoyed or did well in mathematics or science or technical subjects.

- **Manual activities**: Want to design and build things; apply scientific principles to real-life situations; enjoy working with hands; enjoy drawing.
• **Mental activities**: Interested in how things work; enjoy problem solving; interested in research.

• **Challenge and variety**: Variety in one job; opportunities to work outdoors and travel; enjoy challenge and hard work.

• **Social identity**: Want to prove themselves; 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. (This category was especially important to female and/or black students.)

• **Career rewards**: Good job prospects including international opportunities; good salary; want career flexibility; want to move into careers such as management; availability of bursaries.

Of note with the Dick & Rallis (1991) categories was the specific focus given by the students to the category *social identity* (see Table 1), which appeared to reflect specific issues related to the South African context.

The present study, in attempting to answer the question, “What factors influence learners to follow a career in Mechanical Engineering?”, drew upon these existing studies by using the above categories as a starting point in the data analysis of students’ responses.

**Method**

The research was based on a questionnaire given to first-year mechanical engineering students at the University of Cape Town during their first week at the university that probed various aspects of their choice of what and where to study. Only one question was analyzed for this study, namely “What made you choose mechanical engineering as a career?” The data were collected over two years from two different groups of students with 94 students completing the questionnaire in the first year and 106 in the second. There was only enough space given to students for at most three sentences to be written as the answer to this question. Although this had the effect of limiting the amount of detail in the response by the student, it did serve to ensure that the reasons that first came to mind were described.

The results were analyzed using both qualitative and quantitative techniques. The categories that resulted from the qualitative data analysis form a major part of the outcome of the study. The categorization process drew on the framework proposed Dick & Rallis (1991) and refined by Jawitz and Case (1998). Due to the relatively small sample, statistical analysis of the resultant categories is only significant in certain instances. The tabulated results given later in this paper (Table 2) do however allow comparisons to be made across the defined categories.

**Results of the qualitative analysis**

The method of constant comparison (Corbin & Strauss, 1990) was used to develop the 10 distinctly different influencing factor categories that are show below:

- exposure to engineering career (EEC)
- socialisers (SOC)
- specific career plan (SCP)
- flexibility and challenge (FAC)
- intellectual activities (INA)
- school subjects (SCH)
- if not, then… (INT)
- career rewards (REW)
- physical activities (PHA)
- social identity (SID)

Peer validation using a sample of 8% of all the responses categorized was used to confirm these categories. A further analysis of these categories showed that they could be logically grouped according to various characteristics:
A number of the categories were seen to consist of the outside influences that societal factors have on a learner during the career decision-making process. These were an exposure to engineering as a career (EEC), school subjects (SCH) and socialisers (SOC). These factors were grouped together in a macro-category referred to as “societal influences”.

There were categories that related specifically to learners’ desire to interact with a specific aspect of their future career, such as the flexibility and challenge of the career (FAC), having a specific career plan (SCP), the potential career rewards (REW) and choosing mechanical engineering as a fallback option (INT). These factors have been grouped together as the macro-category “personal career vision”.

“Product related activities” groups together two categories. The first is physical activities (PHA) that relate to a learners actual physical interaction with products in some way and the other is intellectual activities (INA) that relates to a learner engaging cognitively with issues around how things work. These are factors that are of influence from within a learner.

Only one element is included in the macro-category “social/civic responsibility” and that is the idea of one’s social identity (SID) playing a key role in influencing the learner to follow a career in mechanical engineering.

**Macro-category 1: Societal influences**

*Exposure to Engineering Career (EEC)*

The direct or indirect interaction a learner had with professionals in the field of mechanical engineering while they were in the process of deciding on a career path is included here. A number of students indicated that they had worked in industry in some form or another. For example:

*I worked as an engineering helper for one year. Then I developed engineering skills in welding, using a torch (cutting), gas welding and using the lathe machine. I did some construction work in the mines.*

Visits by the learners to mechanical engineering industries also played an important part in the decision making process. For example:

*In the past I have visited companies e.g. Sasol, Natref, Kimberly Mines (De Beers) etc and the information I gathered from there i.e. the process they follow, the plants that perform the operations etc, was based mainly on my interest.*

Career talks, both at school and in other settings, by engineers impacted on the students. In one instance, it was a talk by a civil engineer that was cited as the catalyst to do mechanical engineering:

*We had a talk at my school by a Civil Engineer, but he spoke on all types of engineering. I was interested in the aeronautics that he mentioned.*

Articles in the media written by mechanical engineers impacted on a number of the students. For example:

*When push came to shove, I decided to do it because I saw a picture of the chassis of the Ferrari F1 2001. I knew I wanted to do something like that.*
The factor in this category that was most frequently cited was the exposure of the students to the Department of Mechanical Engineering at UCT through its Open Day and Winter School (Discovery Week) activities while they were still school learners. An example of this impact on the career decision process follows:

*After I went to the Winter School I knew that Mech Eng would enable me to create and design things involving physics and technology, which was exactly what I wanted, therefore BSc (Mech).*

**School Subjects (SCH)**

The influence that mathematics, physical science and the technology subjects had on the process of career selection is reflected here. The first grouping relates to where the students indicated that they either liked, or were good at, mathematics and/or physical science at school.

*Maths and science [are my] favourite subjects, therefore [I] chose engineering.*

There were also those students that had performed well in these subjects:

*I have always done well in Maths, Science and Drawing so Engineering was always on the cards.*

**Socialisers (SOC)**

“Socialisers” refer to the influence of people - who are not necessarily engineers - but are either family or in their social circle. Career advice from (non-engineering) parents, relatives, friends or teachers appears as a frequent response to the question of career choice:

*I wasn't too sure if Mech was the right type to choose for me (sic) but advice from family/friends helped me choose.*

On some occasions the “socialisers” themselves were engineers:

*My father is an Engineer and my uncle (who is currently in Antarctica) is specifically a Mech Engineer.*

Another influencing factor in this category involved career aptitude testing:

*Broadly, I chose engineering because of, firstly, career guidance advice.*

**Macro category 2: Personal career vision**

*If not, then... (INT)*

Factors that define mechanical engineering as essentially the second choice or the least offensive option during the decision making process are in this category. The first grouping of responses related to instances where mechanical engineering was seen as the better alternative to other stated options. For example:

*I was going to do medicine, but it was too long. I think that they are pretty much the same, but people are worse than machines.*

The second related to instances where the students specifically stated that they did not want to follow a particular career and mechanical engineering was the alternative position:

*I can't imagine myself doing a Commerce or Humanities course.*
Specific Career Plan (SCP)

“Specific career plan” relates to those learners that had a very clear understanding about what they wanted as a career or how mechanical engineering could help them get to the career they wanted. An example of the students that had a clear view of mechanical engineering as their future career:

*The industry of car design is one in which I hope to make a mark in. This is what made me choose Mechanical Engineering.*

Many of the students indicated that studying mechanical engineering was a means to an end. They wanted to do a specific type of job and this degree would allow them access to it. For example:

*Primarily Formula One Racing, is the main reason for choosing Mech Eng. Always been interested (a fanatic) about racing and by doing Mech Eng I felt I would have a chance to be involved in my favourite sport at a high level.*

Another important factor indicated by the students was using this degree as the route/path into another career:

*My dream is to go to NASA and become an astronaut. On my enquiries I was informed that you have to be an engineer, doctor or scientist before you apply.*

Career Rewards (REW)

The idea of “career rewards” was prevalent in many of the responses from the students. The first grouping under this section relates to the possibility of mechanical engineering giving graduates alternative career options outside of mechanical engineering. For example:

*Engineering is also a good degree that earns you lots of respect and also opens the door to lots of opportunities.*

Another influencing factor was the perceived earning potential of mechanical engineers in industry:

*He told me about the advantages of having a degree in engineering so I could also earn the 'big' bucks.*

Local and international employment possibilities were identified as important by a number of students as follows:

*Another reason for Mech Eng is the fact that world wide engineers are in short supply and the job market is apparently one of the best worldwide.*

Flexibility and Challenge (FAC)

“Flexibility and challenge” relates to the intellectual stimulation and options for diversification within the career. One of the dominant areas of influence to arise was the job flexibility that was perceived to be available within the mechanical engineering environment:

*It is a diverse course with much scope. Mechanical engineering is incorporated in most industries and their services are readily required.*

The challenge of the discipline was regularly cited as critical in their decision making process. For example:

*Engineering as a career is challenging.*
The final section of this category relates to the variety of working environments (outdoors, etc.) where learners expect to work in the future:

I need to work in an outdoor environment.

**Macro-category 3: Product related activities**

*Physical Activities (PHA)*

“Physical activities” as a response was prevalent amongst a large number of students. It relates to their actual interaction with technology and the sciences while growing up as factor that influenced the choice of a career in mechanical engineering. The first grouping relates to students taking things apart, modifying and interacting with products.

*Love for tinkering, taking things apart and rebuilding them and for taking gears from broken clocks and making gadgets made me believe that this was what I wanted to do.*

The students also indicated that design, experimentation and construction were significant influencing factors while deciding on mechanical engineering as a career. For example:

*I design my own radio-control gliders with a high degree of engineering - (specific wing section, camber etc) etc. I like to play with CAD, experiment with electronics etc.*

*Intellectual Activities (INA)*

“Intellectual activities” relates to a learner’s cognitive interaction with the products that they grew up with. The first common area to arise under this category concerns those students that have a desire to know how things work.

*I am interested in both how things work and in the concepts involved in making them work.*

There were also learners that grappled with theoretical conceptions about the products that they interacted with while growing up and now want to research them further. For example:

*I continuously formulate theories in my mind and design mechanical devices (self controlled models - complex gyro assemblies) also on a large scale.*

**Macro-category 4: Social/civic responsibility**

*Social Identity (SID)*

“Social identity” includes a number of aspects that relate to an individuals interaction with society at large. The first is the challenge for the female learners to compete and make an impact in a male dominated environment. For example:

*I wanted to venture into the so called mans (sic) world and I wanted to prove to people who think engineering is for males, that I can do it and I can be the best.*

The second grouping relates to the social impact that their career will have on society and the ability to make a contribution to the development of the community:

*[My] desire to be able to create something that could benefit the community pulled me towards Mech Eng.*

The final aspect of the category is a desire of learners to impact on the economy of the country. For example:
There are a limited number of Mechanical Engineers and I believe by becoming a Mech Engineer I will increase the number of engineers thus helping to uplift the economy of this country.

Results of the quantitative analysis

The response frequency by category of reason, as developed in the previous section, is shown in Table 2. Descriptive names of the elements shown are given in a key below the table. The descriptor “black” refers to a racial categorization of all students that are black African, coloured and Indian. This grouping has been made to be consistent with the categorization used in the study by Jawitz & Case (1998). A chi-square test for each category was used to check for any association between the two variables. Indicated on Table 2 are those relationships that are significantly different at the 95% confidence level. The results have been interpreted in terms of the macro-categories defined above. Comparison with the results obtained after one year of data collection can be made by referring to a previous publication (Reed & Case, 2002).

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

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<td>n</td>
<td>EEC</td>
<td>SCH</td>
<td>SOC</td>
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<tr>
<td>All</td>
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<td>12%</td>
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| Male | 170 | 12% | 14% | 12% | 9%  | 37% | 15% | 12% | 28% | 35% | 6% *
| Female | 30  | 10% | 10% | 20% | 17% | 27% | 20% | 23% | 17% | 33% | 27% *
| White | 100 | 11% | 11% | 13% | 15% | 37% | 18% | 8%  | 23% | 44% | 5% *
| Black | 100 | 13% | 15% | 13% | 5%  | 34% | 14% | 20% | 30% | 26% | 14% *
| White male | 89  | 11% | 12% | 10% | 13% | 38% | 19% | 8%  | 25% | 43% | 3% *
| Black male | 81  | 14% | 15% | 14% | 4%  | 36% | 11% | 17% | 32% | 27% | 10% *
| White female | 11  | 9%  | 0%  | 36% | 27% | 27% | 9%  | 9%  | 9%  | 55% | 18% *
| Black female | 19  | 11% | 16% | 11% | 11% | 26% | 26% | 32% | 21% | 21% | 32% *

Key to Table 2

A = Societal influences

| EEC: Exposure to engineering career |
| SCH: School subjects |
| SOC: Socialisers |

B = Personal career vision

| INT: If not, then… |
| SCP: Specific career plan |
| REW: Career rewards |
| FAC: Flexibility and challenge |

C = Product related activities

| PHA: Physical activities |
| INA: Intellectual activities |

D = Social/civic responsibility

| Social identity (SID) |

Level of significance

* < 0.05
** < 0.01
*** < 0.001
In the macro-category personal career vision, there are three associations at the 5% level of significance. In the if not, then (INT) category, both gender and race show significant differences. The third is in the flexibility and challenge (FAC) category where there is an association with race. The intellectual activities (INA) category (in the macro-category product related activities) is associated with race at a 1% level of significance. The split between the male race groups in this category is significant at the 5% level. In the macro-category social/civic responsibility, the social identity category of influence is associated with race at a 5% level of significance and to gender at the 0.1% level of significance.

**Discussion and conclusions**

This paper has described the development of categories that encapsulate the responses of students being asked the question, “What made you choose mechanical engineering as a career?”, with a further investigation into any significant associations between the variables within the categories.

The category social identity (SID) was first described by Jawitz and Case (1998). The sample in this study can be seen as a “subset” of that population as the students are from one of the tertiary institutions analyzed in their study. However, as this study takes place 6 years after their study, and since South Africa has gone through such a rapid and significant transformation in all sectors, the socio-economic factors present in the Jawitz and Case study may have changed and influenced the results obtained. Social identity (SID) has been characterized under its own macro-category social/civic responsibility and not grouped with societal influences as the former is the student’s desire to influence the outside world while the latter macro-category is the outside world influencing the learner in the career decision process. More females than males (at the 0.1% level of significance) indicated that this was an influencing factor in their decision to do mechanical engineering. The significance of the previous statistic could result from the way that the category was defined to include females’ desire to compete and make an impact in a male dominated environment. However, the data reveals that there are a number of females that indicate that they want to make a social impact on their community or country. Table 2 indicates black students to be more influenced by social identity (SID) than white students. In their responses, black students indicated that they feel that they can make a difference to the lives of their community. As an influencing factor, this could possibly be further explained in terms of some of the disadvantaged communities that students come from, and with students growing up wanting to make a difference in improving the situation of their community.

The macro-category societal influences contains categories similar in definition to those in the Jawitz and Case (1998) study. The fact that black and white students appear to be equally influenced by the socialiser (SOC) category, i.e. by teachers, friends and family, is interesting in the context of the recent apartheid regime in South Africa. A young black child growing up has probably not had the opportunity of being exposed to engineers in his or her community, as there have been so few black engineers graduating from tertiary institutions in South Africa. It could be expected that the lack of black engineering role models would have influenced these results more strongly. The same is not necessarily true for the white children, yet both groups indicate the same level of influence.

In the macro category personal career vision, two new categories have emerged from the data. These categories have not appeared in previous literature but are highlighted in the responses by the students in the study. The first of these categories has been defined as if not, then (INT). White students, in particular white males, are significantly more inclined to indicate this category and this finding may indicate a trend towards mechanical engineering being seen as the “path of least resistance” when faced with a dilemma of which career to
follow. This category is in effect a negative selection of mechanical engineering as a career as it was often indicated that the choice was in place of either an unavailable or more unpleasant option. Other students had a specific career plan (SCP), the second of the new categories, and chose engineering as a career because they had always seen themselves as such or saw mechanical engineering as the route to another career that appealed to them. Even though this category was most often mentioned as the reason for doing mechanical engineering as a career (36% of responses), there was no group that was more influenced than others. It could be argued that this “reason” given by the students as an influencing factor could be further dissected to reveal the actual underlying influences.

In the product related activities macro-category, it is interesting to note the similarity between the race/gender splits where the black students appear to place importance on physical activities (PHA) such as taking things apart, building things and interacting with artifacts and the white students appear to place importance on intellectual activities (INA) such as thinking about how things work. Given the fact that it is more likely that white children have had access to “educational” toys, gadgets and other such items more so than black children, this categorization may appear inverted. It is suggested that since white children most likely have access to toys, etc. they take having them for granted and may place more importance on the less tangible aspect of thinking about the workings of the toys and other artifacts. Black children could have had to think about how things work because they may not have had access to such toys and thus may place more importance on actually taking things apart when they do have access to them or perhaps building their own toys.

**Concluding remarks**

The study described above further informs the debate on how more learners can be encouraged to follow a career path in not only mechanical engineering, but technology in general. By understanding what factors influence different groups, it is possible to impact on these groups’ career choice through the use of targeted programs. The results of the study have particular relevance to the black and female groups that are still under-represented in engineering in that specific influencing factors have been identified that could sway their decision to follow a career in mechanical engineering. Effort in these targeted areas could begin to address this lack of representation in engineering. This study is the first stage in a larger project that plans to expand the group investigated from just mechanical engineering students to encompass technological careers in general. In addition to the comparisons between different groups as discussed above, it is intended that this further study look at the influencing factors in respect to various economic and social groupings.

**References**


