Growing engineers: The experiences and reflections of a bursary provider

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The Sasol Inzalo Foundation has awarded bursaries for engineering studies to performing but disadvantaged students since 2010. This paper follows the identity formation journey of the students as they "become engineers", from their initial study choice to their final year, through the vacation work experience, using narratives and self-signified data, and reflects on how a bursary provider can support this journey. It is found that, although the students are very committed to their choice of career, they think of themselves mostly as engineering students and that their understanding of what the work of an engineer entails is concerningly vague, even after they have completed vacation work.

Introduction: The Sasol Inzalo Foundation bursary programme

The Sasol Inzalo Foundation (SaIF) was set up to focus on skills development and capacity building for South Africa in critical areas; one of its mandates is to create tertiary opportunities for South African talent from diverse backgrounds in the fields of Science, Technology, Engineering and Mathematics.

Since 2010 SaIF has awarded bursaries annually for degree studies in the fields of science or engineering at South African universities, 216 specifically for engineering studies. The leading cohort of bursars reached the final year in 2013. Selection criteria for the bursaries were geared toward providing university access to main stream programmes for performing but disadvantaged students, with a bias towards rural learners and a targeted 60:40 female:male ratio. The purpose of the programme is to make students successful in university studies and able to access employment; SaIF strives to achieve completion rates in regulation time that are higher than the national norm and to develop a support model that would consistently deliver this outcome. The comprehensive support programme is continuously adapted, informed by a developmental research programme, as the programme evolves.

The students have been tracked extensively from the time when they applied for the bursaries to the present, using data from their bursary applications, performance data and other evaluations as they progress through their studies. Data collections comprising biographical data and self-signified narratives, evaluation feedback about support activities, etc have been undertaken regularly. The results presented in this paper refer to a career focused data collection from bursars with StudieTrust administered bursaries early in 2013, with references to findings from earlier research (space does not allow a full review of the relevant literature used in this research). For this data collection, 197 responses were received (181 from Sasol Inzalo Foundation bursars), 107 from females and 90 from males. The large proportion of female students made it possible to analyse the data in gender terms.

Engineering study – supporting vulnerabilities

Vosloo et al. (2012) described the vulnerabilities students encounter in their journey through tertiary studies. The SaIF bursary programme tests and incorporates support initiatives to overcome specific hurdles as and when they are identified, e.g. the students receive full funding to prevent financial constraints inhibiting academic success; their vision is tested and glasses provided if necessary. A residential "winter school" for one or two weeks during the winter vacation was introduced, as academic support, engaging students in problem-based learning

around threshold concepts in mathematics and physics, in order to close some of the knowledge gaps the students were known to have. The programme during the day concentrated on academic activities, with "soft skills" taking up the evenings (see further discussion below).

Identity crisis as a vulnerability

Vosloo and Blignaut (2010) reported that many first year students experienced an identity crisis, dubbed the journey "from hero to zero", during the first term of the first semester, e.g. because of having failed a test or exam for the first time in their lives. Similar, though less severe, transitions can occur at the beginning of each of the following academic years. Students experienced a sense of isolation in this situation, due to a perception that they could not discuss this aspect of their experience with their home support structures; they feared disappointing their families and the high expectations held of them. The fear of losing their bursaries also weighed heavily on their minds.

> "Yho being the first time failing, this made me feel like 'i wanna go home already', but bearing in mind the people of my neighbourhood, yhoo they'll talk till i'd actually commit a suicide. So i didn't want go home, so instead i pushed."

> "my family is really proud of me and they just don't believe me when i tell them about how i'm not coping because to them i'm their little daughter who is so smart who never brought a disappointing (report) results who always find a way to be a top student."

Lack of performance threatens the students' identities in another way: it threatens their sense of self-efficacy, thereby causing them to doubt whether they have made the right choice regarding field of study. The career focused investigation underlying this paper consequently probed how and why the students chose to study engineering.

There was little evidence of students simply following inherited patterns (identity foreclosure, Marcia 1966) and only a single case of a student selecting engineering because her parents wanted her to. Students use strong emotional language about their choices, 64 referring to passion (or the lack thereof) and 88 using "love". They strongly indicated that they based their choice mostly on their own opinions, wishes and thoughts (average 2,7 out of 10 representing a scale from "mostly my own" to "mostly other people's"). This may be a natural consequence of the way the bursars are selected: the selection process looks for signs of agency in the applicant and only considers candidates who have shown ownership of their study plans. Many stories indicated that they chose engineering because they heard it was difficult or because they wanted a **challenge** (43 used "challenge" explicitly).

18% of the respondents described engineering as their **true passion**. They were always experimenting when they were younger, have always had a strong interest in finding out how things work and tell stories of causing explosions and taking apart their toys. This investigative interest did not automatically guarantee academic success, however; only 60% of the students indicating interest in taking things apart when growing up are still on track to finish their degrees in minimum time. 64% of those who liked creative writing are still on regulation time, as is 67% of those who liked reading, investigating nature or designing and building things (also typical engineering pursuits), and 69% of those who liked mental pursuits like debating and playing chess.

Another group (11%) indicated that engineering was **not their first choice**, but because they could not study something else they decided on engineering instead (one student wanted to become a pilot but could not due to poor eye sight; some students were not accepted at university for their first choice, one could only get a bursary if he studied engineering). They

indicated that they had to work extra hard to "grow into" the study and their future career paths but succeeded, some saying that they should have chosen engineering from the beginning.

The largest group of students in the study (46%) decided to study engineering because they **enjoyed physics, chemistry and science subjects** in high school the most and wanted to do something in the field of science. These students spent time towards the end of high school self-reflecting on their likes and dislikes, strengths and weaknesses, and doing research about the prospective career. They benefited from career days at schools and the advice of teachers or career counsellors. This level of self-awareness and research about careers represents a shift from the early days of the programme.

A smaller group (6%) had some interest in the field and decided to study engineering because of an **experience** they had, such as visiting TRAC labs, seeing a poster, finding a book, a company visiting their school, etc. Three students attended technical high schools and became interested there. Nine students mentioned as an influential event a conversation with a brother, cousin, uncle or aunt who is an engineer.

The last category of students chose engineering for reasons that do not directly relate to engineering at all. Quite a number (10%) of students motivated wanting to study engineering because they want to "make a difference in the world". A few mentioned reasons like wanting to make a lot of money and 12 female students were motivated by gender considerations:

> "I grow up at community where there was gender stereotyping. I remember the day I first built a wire car by my own. I was very happy and I showed it to my aunt. The response from her was very discouraging; she told me I should focus on "girl stuff". From this day onwards I knew that I wanted to do something in a man dominated field in order to show that I can do anything that I put my mind to it regardless of my gender."

Vosloo et al. (2012) used a theory of asset accumulation to describe how one of the children of a family getting a degree and a secure job, e.g. as an engineer, is often a family strategy for breaking out of poverty. These expectations determine the role of the bursars in their families ("I am a daughter" when asked about her life role), and Vosloo et al. (2012) describes the tensions these expectations set up in the student. In the present study, it was noted that, although 16% of the students selected "**financial security**" as their main wish to have achieved when they graduate, in the narratives financial security is most often mentioned as an additional benefit of an engineering career in addition to other, more intrinsically motivating factors. Only one student mentioned financial responsibility to their family in relation to the decision whether to change course or not: "I would remind my friend of the family responsibility to achieve economic freedom".

Once the students enter university, their experience is skewed towards "very different than I expected". The response graph is, however, skewed towards the positive half of the scale, namely "I am pleasantly surprised, it is much better than I thought it would be" as opposed to "I am disappointed".

Students were asked to recount a moment when they either thought that they had made the right, or the wrong study choice. 98% of the students confirmed that there had been such moments; in 33% of the narratives there is a clear link between their results and having made the right or the wrong choice, demonstrating the link between performance, self-efficacy and identity (Bandura 1977), while 19% commented on the work load:

> "I think this is the most popular statement for most students in the first few months in university. When the average mark for all your scripts from your first tests is 30%, you are

> most likely to say "I should never have chosen this course""…. "It was my 1st test in mechanics 1, I got a disappointing 26% and it broke me into pieces and made me feel like I don't belong in this course."
>
> "I have experienced both. … Moments like that are when you have done some cool design and it works out and you sit back and look at it smiling, and realizing that you actually just really enjoyed doing that. Or looking at a demonstration of water channels and wave refraction and just thinking "This is awesome. Wow!" Even when I see and realize how what we learn can better the lives of other people, I also think "Yes, this is the right study choice". Though unfortunately there are moments were I think "I should never have chosen this course". Those moments are especially when I'm really struggling or drowning under the workload, when I can't anymore and am so tired."

To support students through these identity crises, the Foundation introduced support by a continuously available, anonymous, telephonic counselling service, which can be followed by face-to-face counselling when needed; students who make use of the service report it to be beneficial, but not all students who need psychological support make use of the service.

A peer mentoring programme was introduced and supports students in this situation, with materials and social support being built on senior students sharing their experiences and advice with junior students.

The winter school was found to play a big role to restore students' sense of self-efficacy after the challenges of the first semester of the first year. The residential nature of the programme taught students who had been isolating themselves to make friends and the opportunity to share experiences contributed to restoring students' confidence.

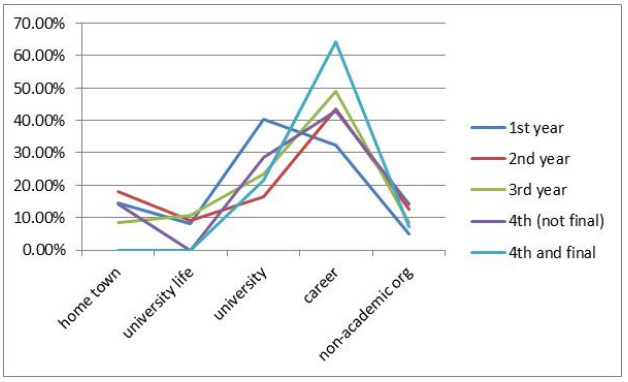
Of the 216 engineering students on the bursary programme over the last three years, 14,6% have changed course since they started. 10% changed courses while staying on the programme as their new courses still fell within the ambit of the SaIF programme (0,9% changed to Education, 3,7% changed to Science, and 5,5% changed within the engineering field, e.g. from mechanical to electrical engineering). Of the remaining 4,6% who were forced to change course because they failed, 2,8% decided to continue in the engineering field but on a National Diploma level, whereas 1,8% changed to a completely different field of study (e.g. Law, Medicine, Risk Management). These students did not participate in the survey.

To probe whether the students in the survey would consider changing course if they concluded that they had made the wrong choice of studies, they were asked what advice they would give to a friend who is not coping and calling his choice of course into question. 11% of the students would advise him or her to change course immediately as "you are going to have a miserable life", while 31% would advise not to change as, to quote one respondent, "There's Sesotho word saying "Le pele di na le baji", meaning: if u run away from a problem instead of facing it, then u gon encounter a bigger one wherever u going". 58% would advise to evaluate the situation properly before making a decision, taking into account their passion and considering the initial motivation to study engineering. If they already study that which is their passion, they should let nothing come in the way of this. If they do not study something they are passionate about, they must change immediately, since one cannot keep up doing something in the long term if you don't enjoy what you are doing.

Students were asked to indicate on a scale of 1 to 10 to what extent they were committed to the path they have chosen, as opposed to exploring other career options (identity moratorium, Marcia 1966). 65% of the students assigned a score of 9 or 10 out of 10 to being committed and not exploring further.

Identity development through the years of study

Students were asked questions about whom or what they identify with most to probe identities based on category or group association and role association (Stets and Burke (2003)).



Firstly, they were asked to choose a t-shirt they identify with to wear to a "getting to know each other" party. 42% of the respondents selected a t-shirt with a stereotypical joke about their prospective careers (32% of first years, 44% of second years, 49% of third years, 43% of fourth years who are not yet final years and 64% of final years – an increasing degree of association with their future careers as they approach graduation). Amongst first year students, the largest group, 40% of them, identified most with their specific university or university sports team, more than those identifying with their future careers (32%). 8% of the students preferentially identified with university life in general, 9% with a non-academic campus organisation and 14% with their home town (none of the final years did).

If asked by a stranger what they do for a living, 66% of the students would respond with "I am studying to become an engineer" (61% in the first, 68% in the third and 79% in the fourth years), while 14% would say "I am at university and enjoying it", 14% chose "When I've qualified, I will be an engineer" while 6% chose "I'm trying to make sense of life at university" (sample sizes of those choosing other options than the first are too small to interpret trends according to year of study). This agrees with the Foundation's experience that in general students first associate with being a student, linked to a specific university. Later they associate with specifically being an engineering student, as they experience that engineering study places different demands on them than some of their fellow students' experience, increasingly starting to think of themselves in terms of being engineers as they near graduation.

The average response indicating ease of communication with lecturers on a scale from easy and comfortably to "not unless I need to" is 5,1, i.e. balanced about in the middle. Final years are somewhat more comfortable with lecturers, awarding an average of 3,7. The average response regarding the ease with which they follow lecturers' arguments and bring across their own, interpreted as conversing comfortably in the language of the discipline, as opposed to struggling with explanations and terminology, did not differ across the first 3 years (average scores of 6,6 to 6,7) but was an average of 7,6 out of 10 in favour of comfortably engaging with lecturers for final years.

As mentioned above, when students were asked to indicate on a scale of 1 to 10 to what extent they were committed to the path they have chosen, as opposed to exploring other career options, 65% of the students assigned a score or 9 or 10 out of 10 to being committed and not exploring further. A further 9,6% assigned an 8, while final years assigned an average of 9,7 out of 10 to indicate a very strong commitment to their chosen career path.

That level of commitment does not translate automatically to having established a career identity, however. The narratives exposed much more uncertainty about their career choice than the above commitment scores would suggest:

> "I don't know what I want to do the rest of my life, so for now I'm living in the present situation, until it becomes clear to me what and where I should be" … "Although I am in my

> third year I am still not sure whether 'Chemical Engineering' is for me I am willing to explore other options but I do want the degree"

In summary, the strongest association amongst first years is with their specific university; association with their chosen career increases from first to second to third to fourth year. In general, the bursars associate most with being engineering students. The third year students are the least positive about the course being better than they expected, but still mostly pleasantly surprised. Fourth years associate the most of all year groups with their chosen careers, are very firmly committed to that career, are the most comfortable engaging with lecturers and also most comfortable using the discourse and terminology of their fields. However, they cannot yet be said to have established a strong career identity.

> "I still wonder if I would enjoy the engineering work I shall be doing after Varsity but the study program is definitely the right choice for me."

Developing a career identity as an engineer – the students' perspective

Students were asked to explain to a young nephew what they would be doing when they graduate. Responses covered a range from the mundane, "I'll be fixing where there is a power cut", to the idealistic "to make civilisation more advanced". Google defines engineering as "the branch of science and technology concerned with the design, building, and use of engines, machines and structures". 18% of the answers were at roughly this level of detail, while 38% were more vague, e.g. "an engineer solves problems for money". 28% of the responses were specific, including practical examples of what the actual work looks like. Summarizing the type of description by year of study gives an unexpected picture: 44% of the first year students provide a 'vague' description, compared to 48% and 55% of the third and fourth year students respectively. A 'specific' description is provided by 38% of the first year students, compared to 25% and 17% of the third and fourth year students. This indicates that a majority of the fourth year students in this survey cannot provide a specific description about their future jobs, something one would expect to become better over the academic years. A fourth year engineering student describing his future job as follows is worrying: "I'm going to design a whole new world someday when he grows up and want to be a big part in changing peoples lives." These findings illustrate a new gap that needs to be closed, the transition from student to professional.

Other students exhibited an appreciation of the different career paths open to them, but were still unclear about the specifics of the path their careers would take:

> "Well, I'll be building bridges and dams, or maybe roads. I could even be building structures. And I've also considered not actually building stuff but designing the roads network system. Or I could also do port and harbor engineering and look after our coast. Doesn't that one sound like fun. No to be honest, I'm not quite sure what I'll be doing yet. Definitely something that involves a lot of calculations and a very good understanding of the problem or project at hand."

> "Because of the nature of my field of study [Computer Engineering] I may end up having a job that did not exist a few years ago. To predict what I am going to do one day is impossible".

One would expect that doing vacation work would improve students' grasp of the work of an engineer. In the present study, 51 of the respondents (26%) have done vacation work, about half of those to meet the requirements of their course of study, a few to earn money and the other half to learn more about what the work entails. As engineering students need to complete a mandatory vacation work assignment in order to graduate, while the target group of the SaIF

bursary scheme may lack the social network to secure vacation work placements for themselves, a system was piloted to enable placements for the students in 2012, of which 26 students made use (10% of the students having to do vacation work found their own placements).

57% of those students in the study who have already done vacation work indicated that it helped them in getting a better idea of work as an engineer; worryingly, only 21% of the students who had done vacation work could give a specific description of what engineers do every day. 18% of the students who have done vacation work said that it helped to put their university subjects into perspective. 10% of them realized that the work requires them to work hard and that they have a lot of responsibility in the workplace; not all of them were excited by that. 10% of the students had a negative or neutral experience and did not benefit from it. Lastly, 5% of the students emphasized that it was inspirational working with other people in the engineering field; "What I found most surprising is how I already recognised their way of thinking and I liked it; it gave me peace and comfort". This student has already internalized engineering discourse; the concern is that only 5% of the students responded in this way.

Development of professional engineering identities will most likely only happen once they have entered employment and participate in a graduate engineer development programme; these programmes typically facilitate social embedding and include a mentoring relationship between a graduate and a professional as in Sullivan's (2004) model of professional identity development.

Supporting career readiness as a bursary provider

In becoming an engineer, each transition to a next stage is regulated by meeting minimum requirements. However, SaIF and StudieTrust believe that the formal requirements to pass a certain hurdle (the "pass criteria"), though necessary, are not necessarily sufficient; preparing learners for university or students for the workplace should produce candidates who are **ready for success** at the next stage, not only pass the minimum **requirements for entry** into the next stage. Consequently SaIF needed to appreciate what success in an engineering career entails. The following view of engineering careers was developed by the first author while playing a key role in the talent management function of a major South African employer of engineering graduates.

An engineering qualification is seen by many in the world of work as an entry qualification into the workplace, not a description of the work that the graduate will do for the rest of their careers. In one internal study (personal notes) it was found that roughly 25% of the engineers in the company moved out of technical roles, mostly into managerial roles, i.e. becoming business managers, by mid-career. An engineering background is also considered valuable in a range of more business-oriented careers, from marketing of technical products, to following technology-oriented companies as a financial analyst, or protecting technical intellectual property as a patent lawyer. The initial choice of an engineering career will thus typically be followed by a whole series of further choices, each with its own requirements and consequences.

Often the first choice of employer is predetermined by whatever bursaries the graduate had received while at university, but engineers can work in large companies, for small entrepreneurial outfits, or for institutions like universities. They have a choice of more technical career paths, more business orientated careers or of knowledge careers, e.g. as academics or consultants. Within the technical field, especially early in an engineering career, there are the options of working in research, in development and design, in a project and construction environment, in facility and process operations and more.

A critical choice looms: to pursue a career in management or as a technical specialist. To advance up the managerial ladder requires the ability to manage people, and for more senior business management positions, experience in all the aspects of a business, e.g. in operations and marketing. For a role as a technical specialist it is more beneficial to gain in-depth knowledge of the area of specialization, perhaps pursue post-graduate study and play a role in professional societies. Many careers have become stranded because these choices were not made at appropriate times, leaving the aspirant lacking in crucial experience required for promotion.

Quick advancement up the career ladder requires that the engineer be recognized as a "high potential employee". A composite definition of a "high potential employee" from various sources includes "having the ability, capability, organizational commitment, engagement, motivation and aspiration to rise to and succeed in more senior, critical positions, two levels above their current position, or two other departments across the organization". Ability in this definition means that the employee is recognized as an expert, has excellent people skills and emotional intelligence, requires minimal supervision on new and unfamiliar tasks, and gains new and complex/higher competencies at a quicker pace than his or her peers. Willingness and ability to learn new competencies in order to perform under first-time, tough or different conditions is called "learning agility" by Lombardo and Eichinger (2000); the ability to adjust to new demands when making the transition from school to university was also found to predict success in the first year of university (Vosloo 2011a). **Learning agility** therefore is a critical success factor both for university and an engineering career (Vosloo 2011b).

Readiness for a successful career as an engineer therefore includes the factors in Table 1; the support programme should enable the development of these aspects of the prospective engineers' identities.

When the first cohort of bursars reached the third year and a winter seminar for third years had to be presented, it was no longer thought possible to assist them academically; instead a new programme was designed to start orienting them towards the world of work and their future careers. A programme was put together consisting of two days of technical project work (building robots using Fischer Technik kits) in teams, a one-day business simulation game (also in teams), a workshop on career choices and career decisions, followed by a life design workshop. The technical project work and business game served a dual purpose, namely to give the students experience of some of the critical work place skills like team work, as well as to give them an opportunity to reflect on their own preference towards technical or business thinking. The workshop on career choices explored the ideas summarised above in this paragraph to convey the need to consciously manage their careers to the students, and to create awareness of the many options open to them once they have graduated.

Feedback from the third year students was only positive and called the seminar a great contribution to career and future, indicated that it stimulated self-growth, gave an idea of what to expect as an engineer and helped putting things into perspective.

Table 1.

Factors required for a successful career as an engineer
Basic engineering skills, as encapsulated in the first five of the ECSA exit level outcomes
More generic workplace skills like communication, team work and professionalism, as in the last five of the ECSA exit level outcomes
Learning agility, i.e. the capacity for independent learning and the ability to rapidly "find your feet" and perform in new, unknown or difficult situations
Ability to manage one's career in order to meet one's career objectives
Specific sets of knowledge, skills and competencies depending on the career path within the engineering profession one wishes to excel in
Proficiency in the use of English in general, and accepted engineering discourse specifically (Casale and Posel 2012).

However, the fact that only 15% of final year engineering students in the study could define their chosen career with what could be regarded as adequate detail and clarity, showed that a need exists for further career readiness interventions to contribute to developing fully-fledged identities as engineers, to avoid experiences like the following:

> "At the end of matric I had everything planned out: I wanted to complete my degree in chemical engineering and then continue with my post graduate studies in biomedical engineering at some university overseas. Now it seems that these four years have passed by so quickly and as if I have just let life happen to me instead of making things happen. Now I don't know how to reach the dreams I once had and even whether those are still the things that I want now",

Their low level of understanding of the career of an engineer at this late stage would suggest that they are not ready for the next stage, i.e. entering the work place, and are at risk of experiencing another difficult transition, as when they originally entered university. The lack of an adequate linking of the parts (the engineering curriculum and related experiences) with the whole (the anticipated career) speaks to one of the requirements in Table 1, namely a lack of learning agility. A workplace orientation workshop is therefore being designed for the first fourth year cohort, and will include a focus on learning agility as a critical success factor for success in the engineering profession.

According to Mitchinson and Morris (2012), development areas related to learning agility are innovating, performing, reflecting, risking and (not) defending. The planned seminar will specifically include tools for innovating (interrogating long-held assumptions in the light of new ways of thinking and doing), reflecting (examining one's own assumptions and behaviour) and the cultivation of a non-defensive stance as a vital ingredient of participatory leadership styles and career success.

Differences between male and female students

67% of the female students in the study are on track to finish their studies in minimum time, as opposed to 61% of the male students.

Regarding the reasons for studying engineering, wanting to **make a difference** in this world

was an achievement wish for 52% of the female and 37% of the male students. 50% of female students (43% of males) chose engineering because they liked science in school. The preference for taking things apart was more common amongst boys, but by no means absent amongst girls (16% of female students and 31% of male students). Female students preferred reading when they were young (33% compared to 17% of males). 15% of female students as opposed to 7% of male students indicated that engineering was **not their first choice**, while 18% of female as opposed to 13% of male students cited financial security as a motivation. As described above, 12 female students mentioned gender considerations when choosing to study engineering.

The most common reason for female students to doubt their career choice was academic results (36% of females, as opposed to 29% of males), while males were more prone to doubt because of their experience of the subjects they are taking (30% of males vs 21% of females).

The most common advice to a doubting friend amongst female students was to persevere (28%, as opposed to 19% amongst males), closely followed by critical evaluation (26%). Critical evaluation was the most common advice amongst male students (29%), followed by the advice to follow your passion if that is the conclusion from your analysis (25%).

The ability to describe the work of an engineer was equally poor for female and male students (37,4% vs 37,9% vague definitions).

Conclusion

The support programme evolves from year to year based on experience, and now stands on three legs: personal attention and interest, belonging to a community, and skills-building; the authors have over the years come to the conclusion that the main role of the support programme is to hold the students through their periods of self-doubt, to support their sense of self-efficacy so that they can continue with their studies. A student in the current study summarised the "Hero to Zero" experience thus:

> "I was depressed and confused when my results came out end of my first semester in university. … I thought I had lost trust of my family, former teachers and my sponsor. Later on I regained my confidence and focus through positive feedback and encouragement"

A real concern emerging from the current study is the lack of clarity and understanding of the career of an engineer amongst final years, especially after having done vacation work; the winter seminar to be conducted at midyear will be designed to try and influence this in order to improve the readiness of the students for the transition to the work place.

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