# FACTS, FIGURES AND SUGGESTIONS FOR CAPACITY DEVELOPMENT AMONGST ENGINEERING PROFESSIONALS IN LOCAL GOVERNMENT

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## ABSTRACT

Much has been said about the lack of capacity in relation to engineering professionals in local government. Many debates rage regarding the numbers required and available, to design, manage and deliver the infrastructure so desperately needed to address poverty alleviation, if not eradication.

Transformation is also a major challenge, and concerns have been raised at national level regarding the limited numbers of blacks in senior positions. Fast tracking of young graduates is a dangerous practice if it means reduced experience and consequently, a reduced level of competence. Alternatively, placing non-engineering staff in engineering management roles results in an inadequate understanding of the levels of service, maintenance, systems and finances required.

This paper presents actual statistics, and bottlenecks identified as a result of 18 months of detailed research, and seeks to make practical recommendations on ways forward in terms of education, learnerships, training and mentorship to develop engineering capacity at local government level.

## 1    INTRODUCTION

The incongruencies in the employment of civil engineering professionals in industry are well known, debates on 'too few - too many; no experience - no job; no job – no experience; can't find staff - can't get work' etc, have raged for years. At the time of writing a massive research programme, sponsored by the Construction SETA (CETA), is being undertaken to determine supply and demand, in terms of capacity. By the time of the conference, more detailed information will be available and presented.

Investigation into all factors contributing to capacity, competence and availability began in mid 2003 and confirmed a fact that all good engineers already know – a sound structure requires a sound foundation! Unless the standard of education and training from cradle to grave is adequate, competence in engineering can never be achieved or maintained. Worldwide, changes in lifestyle and the approach to education and training have resulted in declining standards, and several aspects require attention, from English and school mathematics, all the way through tertiary education, and support for continuing professional development.

The challenges facing South Africa in this regard are exacerbated as a result of the legacy of Bantu Education, Apartheid and the urgent need for rapid transformation.

## 2    MATHEMATICS AND SCIENCE

Research undertaken by the Human Science Research Council (HSRC) has shown that students who successfully complete technical or financial studies and achieve professional registration have strong numeracy and literacy skills when entering tertiary educational institutions. This confirms that higher-grade passes in mathematics and science are important criteria for entrance to engineering degrees.

There are many professions and careers other than engineering with similar requirements; these include accounting and commerce, medicine, science, statistics, and as well as other industrial disciplines. The approximately 14000 university graduates in these fields in 2002 would have required higher grade mathematics to enter university. Given that there is a one third attrition rate through universities, some 20000 with higher-grade matric mathematics would have had to enter first year. This seems to indicate that the higher-grade mathematics pass figures of approximately 19300 in 1999/2000 limited the number entering universities for professions requiring proficiency in numeracy in those years.

Further more, simply having passed HG Maths does not necessarily mean that the student is adequately prepared for tertiary studies. Most Institutions require at least a C symbol in Maths. This probably explains the 30 percent attrition rate at Universities and an even higher rate at Technikons!
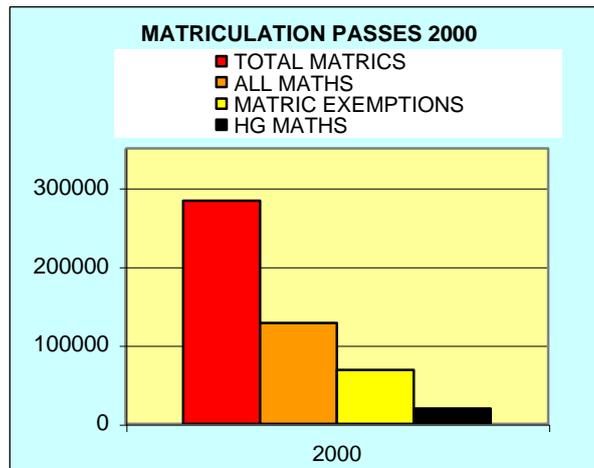


Whilst the total number entering the professions is limited by matric higher-grade mathematics results, the requirement to transform the professions represents an even greater challenge. Less than 30 percent of the higher grade mathematics passes were achieved by blacks i.e. less than 6000 and less one quarter of these achieved A, B or C symbols! This will most certainly be a major stumbling block in the transformation of all these professions.

## Improving the results
When John Perlman recently interviewed a number of education authorities, they cited the reasons for poor mathematics performance in our schools as follows:
- o   The dropping of mental arithmetic from the syllabus.
- o   The fact that OBE does not develop competence
- o   The fact that mathematics is not perceived to be a learning subject
- o   The obsession with 100 percent matric pass rates means that graduates are encouraged to take standard grade mathematics

Gone are the days when the times tables were printed on the back of every exercise book and numbers were drilled until they become second nature. This gives rise to the following two problems:
- o   Numbers are not internalised, so relative values are meaningless; the difference between 100 and 1000 is simply a zero and not an order of magnitude larger. This is a major problem in terms of engineering judgement - engineers must be capable of deciding whether loads, deflections, pressures, flows, prices etc are within reason or unrealistically large or small!
- o   Memory training is much reduced, hence not only are numbers not remembered, but students have a reduced ability to remember everything else as well! Further, fewer neural connections are made in the brain – the very connections that contribute to our intelligence.

Research carried out by the Council for Development and Enterprise (CDE) indicated that regardless of the locality and wealth of a school, if it was well disciplined, and students were well drilled in basic numeracy, matric results were good! It is time to start teaching your children or grandchildren their times tables again!!

Competence in the language of instruction has also been found to be a major stumbling block in grasping complex subjects such as mathematics and science. These were the findings of Sarah Howie, of the University of Pretoria, in her PhD thesis, "*English language proficiency and contextual factors influencing mathematics achievement of secondary school pupils in South Africa*".

If it is necessary to increase the number of professionals and transform, a major effort will be required to dramatically increase the number of adequate matric results. Interventions are required at three levels:

### 2.1 Long term
- o   Curricula reform in mathematics teaching at primary level to develop competency in dealing with numbers
- o   Improving competency in English, which would go a long way to improving results overall. (The alternative of teaching subjects in the mother tongue dictates that tertiary institutions should also offer their courses in all official languages, which is clearly not practical)

### 2.2 Medium term
o   Increasing the number of teachers competent to teach higher grade mathematics and English is essential
o   Influencing Grade 9 learners to take mathematics at higher grade is key to increasing the number of higher grade matriculants

### 2.3 Short term
o   Nurturing those students currently in the system is essential. Intervention is required from Grade10, as students failing their first Grade 11 higher-grade tests are dropped to standard grade, to ensure that they pass at the end of Grade 12.

## HOW CAN LOCAL AUTHORITIES CONTRIBUTE?

Some R200-R300m per annum is spent by South African business, NGOs and donors on mathematics interventions, but with limited results. The problem is that many interventions are just corporate social responsibility - too many 'do gooders' making ineffectual attempts to intervene. These actions actually intimidate and demoralize the teachers.

The engineering profession is not experienced in secondary education so rather than intervening directly we should support the experts in this field. To help increase the number of black students passing higher grade mathematics, Local Authorities should consider the following:
o   Contribute towards the purchase of textbooks and library books – generally learners at under resourced schools are hungry for any reading material and benefit greatly from improved resources
o   Run city wide campaigns aimed at collecting books no longer required by learners who have left school, and distribute them to schools
o   Approach the Department of Education in their province for details of teaching interventions which have yielded the best results in terms of mathematics improvement and then contribute towards growing those initiatives that in your view have produced the best results. To determine this it will be necessary to contact the various organisations carrying out training and to carry out an audit on their activities and the achievements. Study the before and after results, and actual before and after symbols. Also be sure that mathematics teaching is coupled to extra English tuition.
o   Role models motivate students and help them make career choices. Set up a roster for your young black engineering professionals to visit the schools you have adopted to talk about engineering as a career.

## 3    TERTIARY EDUCATION

With your assistance the learner will have overcome the easiest hurdle in his or her career! Moving into tertiary institutions, particularly from under resourced schools or from rural communities is overwhelming and intimidating! The S A Institute of Chartered Accountants (SAICA) has found that the average pass rate for their black students at University is only 20 percent They have also realized that mixing these rural students with more sophisticated urban students in first year places too much pressure on the new recruits who cannot cope socially or with course work. So many issues need to be addressed…..

### 3.1 Dropping out
Many of the black students from comparatively poorly resourced schools, who get selected to study engineering at Universities, are the top scholars from their respective schools. Many of them would have taken English as a second language and their grounding in mathematics and science is generally not comparable to that made available to students from better resourced schools. Moreover, such students are often deficient in common technical vocabulary and general know-how, and they get a shock when put in the same class with better prepared students. They become withdrawn, are afraid to ask questions when they fail to grasp what the lecturer is saying, lose self-confidence and end up failing and hence dropping out.

### 3.2 Foundation training
Foundation courses not only improve competence in mathematics, science and literacy, but also help students become computer literate, learn to drive a motor vehicle and understand the banking system among many other life skills. These courses are clearly needed, but are not fully funded by the Department of Education.

### 3.3 Bursaries
There are limited bursaries available for first-year students and in many cases the money is insufficient to cover all the student's expenses. Sponsors prefer to take on students from the second year of study onwards. Often a learner's parents can afford little more than the academic fees, so he or she frequently goes hungry and has to share a room with many

others, with no place to study. Earlier in 2004 it was discovered that a student had been sleeping in a university library every night for three months. This was really dedication to his chosen course of study!

The disbursing of bursary funds is another major stumbling block. As matric results only become available in early January, the final selection of those who qualify for bursaries is only made during the month of January and students are not always advised in time to start at the beginning of the course. Having been selected does not mean that the funds are immediately available. Many sponsors only pay tertiary institutions later in the year. Few institutions allow students to commence without paying tuition, residence and book shop deposits, hence the student still needs to raise several thousand rand within a few weeks of starting tertiary studies – an amount that he or she was not prepared for, and certainly cannot afford – hence the first casualties drop out at an early stage!

## HOW CAN LOCAL AUTHORITIES CONTRIBUTE?

o   Encourage the tertiary institutions in your area to pool their experience and resources in terms of foundation training, to hone their foundation courses into top quality stepping-stones to higher education. If possible make funding available to supplement the limited funds available from the Department of Education. Some Metros are encouraging all tertiary institutions in their jurisdiction to open bridging colleges, which will prepare students for entry into all professions

o   Tertiary education requires that students gain experiential training during holidays and at technikon for a full year at the end of first year. If students do not receive company bursaries, they are frequently unable to get experiential training.  Adopt more students, but to reduce your risks, appoint someone to do career guidance and screen learners at Grade 11, and ensure that they are receiving additional assistance during their Grade 12 year.
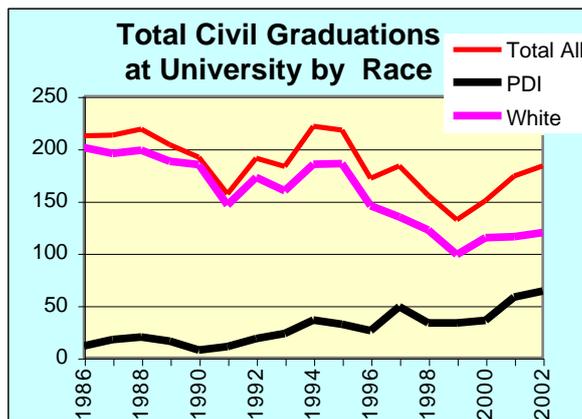


Despite all the problems, transformation is taking place in tertiary institutions as can be seen in the graph above, and with the type of help outlined, we will eventually see full transformation with growing numbers of young black professionals rising through the ranks.
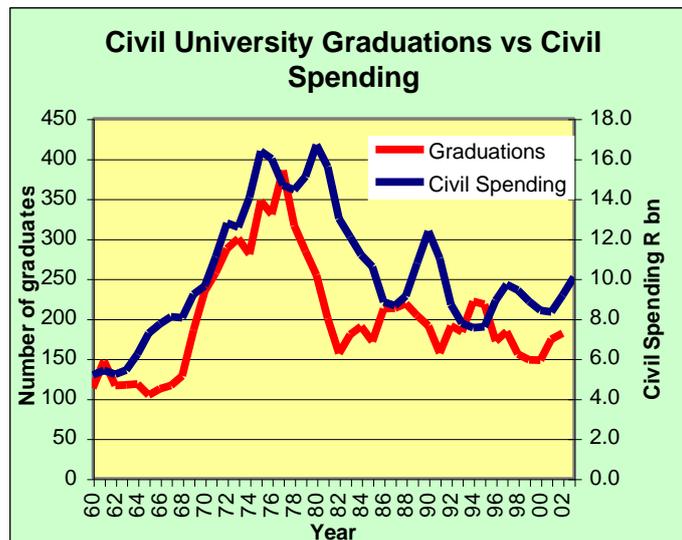
Civil engineering graduations over the past 35 years, indicates that an average of about 200 per annum is the norm, except for boom periods such as occurred in the late seventies. The number of previously disadvantaged therefore needs to treble in order for the civil engineering profession to be truly representative of the population.

Transformation at the technikons is more marked, with the black male numbers outstripping those of white males in 1998 for all professions in the Built Environment.

# 4    PROFESSIONAL LIFE

Having progressed through tertiary education does not mean that the next step will be easy for young graduates…

South Africa has recognized that to be competitive on the global stage, technical leadership is of key importance. The Skills Development Strategy launched in February 2001 has this stated objective as follows.  "To equip South Africa with the skills to succeed in the global market and to offer opportunities to individuals and communities for self-advancement to enable them to play a productive role in society."  The skills Development Act of 1998 aims to develop and improve the skills base of the South African workforce. Two objectives of the act as stated in Section 2(1)© is to encourage employers to:

o    Use the workplace as an active learning environment; and
o    Provide employees with the opportunities to acquire new skills.

However, in our workplace this is not happening, it's simple: no skills – no work, no work – no skills. Our graduates do not seem to be able to get work because they have no experience! The government has created systems to promote training at all levels, yet there are millions of rands from the skills levies building up in the SETA (Sectoral Education Training Authority) coffers. This money could and should be used to help us with taking on and training qualified, but inexperienced engineers, technologists and technicians, but we are not using the system! So how should we conduct training?

## 4.1    The myth of fast tracking

Many theories have been developed and many books written on fast tracking skills development. US mentoring programmes are designed to do just that. Based on the premise that traditional senior management and leaders have had the same experiences many times over, the process seeks to expose protégés to each necessary experience only once, and then ensure that they move on. Further some of the steps are only explained rather than experienced.

In terms of the Stage 2 qualification for registration as a Pr Eng, Pr Tech Eng or Pr Techni the following unit standards have been defined:
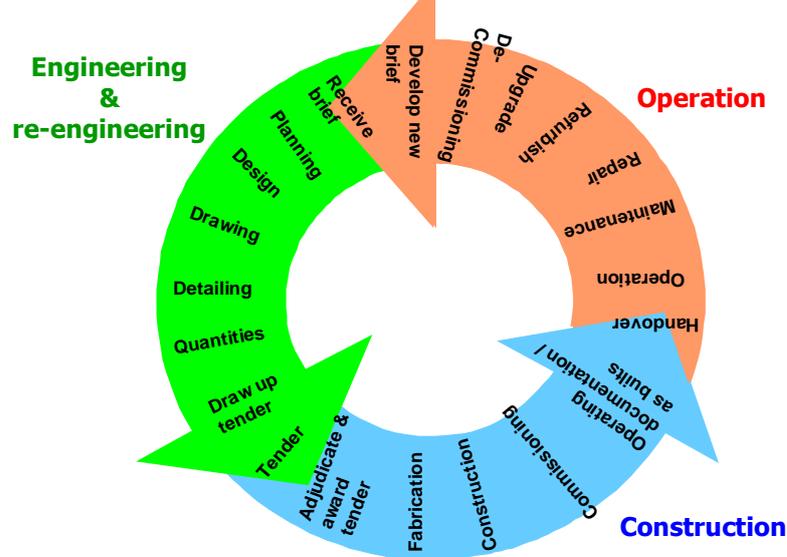
| Stage 2 Engineer | Stage 2 Engineering Technologist | Stage 2 Engineering Technician |
|---|---|---|
| Management  **and**  Design  **and**  Investigation  **and**  An elective | Management  **and two of:**  Design  Investigation  Operations Management  **and**  An elective | Management  **and**  Design or Investigation  **and**  Construction Management **or**  Operations Management  **and**  An elective |

A graduate engineering professional has had little or no experience and needs to experience as much of the life cycle of engineering projects as possible, in order to become proficient in his or her role.

In terms of sustainable development, not only must the graduate develop technical skills as described in the diagram below, but must also understand many more facets of projects, including political, socio-economic, institutional, environmental, health, financial and management issues.

It is rarely possible for graduates to develop this range of skills in more than two fields of civil engineering. Furthermore, graduates rarely have repeat experiences in terms of planning, design, working as a resident engineer etc as the training phase is relatively short. As a result there is little scope for fast tracking the practical experience phase. On the contrary it needs to be as intense and as comprehensive as possible.

**Engineering, Construction & Operation is a Continuum**

**Engineering & re-engineering**

Receive brief, Planning, Design, Drawing, Detailing, Quantities, Draw up tender, Tender

Develop new brief

**Operation**

De-Commissioning, Upgrade, Refurbish, Repair, Maintenance, Operation, Handover

**Construction**

Adjudicate & award tender, Fabrication, Construction, Commissioning, Operating documentation / as builts

### 4.2 Graduate training of the past

Prior to the introduction of information technology (IT), the design office production team included tracers, draughtsman, and detailers. They produced the working drawings for every project. The engineer explained his requirements to these members of the team, who would faithfully produce the final drawings. In this way the production team became a knowledge centre for the organisation and could support the training of young graduates.

### 4.3 The demise of training programmes

In the past 15 to 20 years the effort put into formal training has been greatly reduced, and in many instances has completely disappeared as a result of a number of factors:

#### 4.3.1 Information Technology

The introduction of IT has meant that the size of the technical team has been reduced. In particular, tracers and draughtsman, whose responsibility it was to produce working drawings, and who had an invaluable wealth of practical knowledge, were the first casualties of the IT era. CAD systems and design programmes, which automatically generate working drawings, meant that engineers and technologists could produce drawings as a by-product of their design work.

The size of companies has, however, not reduced substantially as the IT department has replaced the lower levels of technical staff in all departments. Unfortunately the IT department is process oriented rather than output oriented, and staff capable of training junior staff have been replaced by process staff.

#### 4.3.2 Time

The development of information, communication and technology (ICT) has resulted in the "instant" world. The "**www**" has meant that information is always available. E-mail and fax communication allows information to travel around the world in a matter of seconds. The result is that the business environment expects instant answers. There is therefore little time to reflect, spend quality time on training, and matters of detail. Senior staff is expected to work at an exceptionally high pace and have no time to train their young graduates.

#### 4.3.3 Non-technical senior staff

In many quarters, senior technical staff have been replaced by staff trained in other fields such as marketing, management, law, finance, town planning etc. As a result there are fewer or sometimes no senior staff with engineering knowledge capable of training young graduates.

#### 4.3.4 Affirmative action

There are simply not enough black graduates entering all the professions to satisfy the needs of affirmative action. The industry requires all age groups and levels of experience and the strict enforcement of affirmative action in engineering posts has meant that young black graduates are placed into very senior posts, for which they are not yet equipped, battle to cope and often leave the profession. This is not fair on them.

The older professionals who have lost their posts as a result of affirmative action are often not prepared to train their successors. This means that organizations not only lose the experience, but also lose the chance to develop their young employees into competent professionals for the future. Mao Tse Tung uttered very wise words when he said, "All genuine knowledge originates in direct experience". Young black graduates must be given the opportunity to gain experience in a controlled environment. Creating barriers and lack of co-operation due to affirmative action policies has reduced capacity, rather than built it.

## WHAT CAN LOCAL AUTHORITIES DO?

In order to re-establish skills development at this level local authorities can:
o    Implement detailed training programmes
o    Develop learnerships
o    Put mentorship programmes in place

### Detailed training programs
The Stage 2 qualification soon to be registered, needs to cover planning, design, draughting, detailing, investigation, troubleshooting, reporting, the procurement phase and time on site. Graduates will have to be moved around and be given sufficient support to learn. In addition if they are found to be weak in an area, additional coaching or courses must be considered. For instance, one of the problem areas to-day, for previously disadvantaged and the computer/TV generation graduates, is that their written language is often inadequate. There are excellent web based literacy courses spanning 2 to 4 months, which require daily exercises and submissions, ensuring on-going improvement in literacy.

### Development of learnerships
A learnership is the formalization of the training programmes of the past. As already mentioned, qualifications are being developed to cover the graduate-in-training, known to-day as the candidate phase for technicians, technologists and engineers. Having been registered with SAQA, it will then fall to employers to define the curriculum and develop training material. For formal courses, training material would typically include slide presentations and course notes that delegates keep.

In terms of in-service training, it would seem that training material would not be appropriate. However, as a result of the huge loss of experienced senior staff it is perhaps time that the Institution of Municipal Engineers of South Africa (IMESA) put together a team of "wise fathers" to develop the 'Practical Encyclopaedia of Municipal Engineering' covering all the practical advice which was previously passed on from senior to junior – such as the practical size of a manhole and why; the heavy bucket problem – why a community stand pipe must have a supporting structure etc.  Dig up the standards of the past now forgotten because of IT. The practical tips are missing, engineering judgement is not being developed and an understanding of the whole project process needs to be re-developed.

This material would be an invaluable investment for the future well being of Municipal Engineering in South Africa. Similar exercises need to be carried out for all fields in civil engineering.

### Mentorship
To be meaningful, mentorship should not be a token quarterly meeting of a senior with a junior. Mentoring is a structured relationship between a learner and a person with more experience, with the purpose of growing personal and professional proficiency. Essentially the mentor is a supervisor, but the negative connotations of the word "supervisor" in South Africa dictates that the term Mentor is preferred.

In to-day's fast changing world where our young generation knows nothing, but change and the mentor generation battles with change, mentor and mentee can benefit greatly from each other and ensure that both grow in the industry and increase their respective values to their organisations.

Whilst the mentor clearly has much to share with the mentee, the mentee is a technology "kid" who can master any technology without instruction. Mentors, let your mentees mentor you in ICT! In the drive to transform, the chances are that you will be mentoring someone from a different culture. Learn from him or her.  We have to deliver infrastructure to all our population and cultural practices often dictate a different approach to design from those, which would have been employed in the past. And by the way learn the verses of the national anthem you can't sing from those who can.

The mentor needs to:
–    Assist with career path planning and guide the graduate through the steps required by the Engineering Council of South Africa (ECSA)
–    Guide employees to do for themselves - i.e. promote self-development and self-sufficiency
–    Ensure that line managers are performing the coaching function, or do it themselves, motivating graduates to learn, grow, work hard, work as team, use their time effectively, be productive, produce quality work etc.

- Ensure that workplace trainers and supervisors are available to check, explain and supervise the mentee's work. This may be achieved in the following ways:
  - The mentor himself may have the time and technical knowledge to do all supervision and checking
  - Staff in the department may have the capacity to do this but the mentor must ensure that it is happening
  - The mentor must identify resources elsewhere in the organisation to do this if necessary
  - The mentor needs to identify and ensure that the organization hires external staff with appropriate skills to oversee work and carry out training.

  Staff used to assist with training could be a team of in-house, external or retired people, including draughtsmen, detailers, technologists, engineers, suppliers etc.
- Ensure that the mentee attends appropriate external courses to improve his technical skills where necessary
- Ensure that the mentee is also schooled in all the business skills required for the career he has chosen

Dr Tjaart van der Walt, your new president, was quoted as saying, "The two most important aspects of being a good manager/parent/custodian are to be fair and to care. We seem to fail in both respects. We bring up our children with enormous effort and care from primary school through to university, yet we abandon them when they need us most. Medical students cannot even hope to become doctors without practical experience; neither can engineering students become engineers without acquiring the practical skills".

To change the culture of suspicion and lack of co-operation, mentor/mentee workshops with a motivated leader will go a long way to breaking down barriers and set the new, more structured training process in motion.

## 5 CONTINUING PROFESSIONAL DEVELOPMENT (CPD)

Learning is now critical to everyone. In the same way that radio-active materials are only half active in a set time, so people's skills now have a half life. At the beginning of the 21$^{st}$ century, it was estimated that the skills 'half life' had reduced to three years. That is, half the knowledge that you have accrued will not be relevant within three years, and it will be necessary to keep learning, to keep abreast with these changing times.

For senior professionals to keep apace with changes in technical, political, socio-economic, institutional, environmental, health, financial and management approaches, it is essential that they be encouraged to attend workshops, seminars, courses etc. If they drop behind and feel inadequate they will be demotivated and may even consider moving to organisations where they are better supported and their needs are met, or even worse, leave the profession.

It is essential that all employee needs are understood and met in order to motivate and retain staff.

To ensure the growth of professionals:
- Start training and supporting professional development at all levels now!
- Start explaining the reasons for your decisions and requests to staff at all levels
- Start understanding your staff at all levels

## 6 CONCLUSION

It is time to take the challenge of the skills development seriously, to look closely at all levels of education and training for current and future engineering professionals, to develop initiatives, and to take action now!

## 7 REFERENCES

[1]    Source of education statistics – Dept of Education
[2]    Source of civil spending - SAFCEC