World Transactions on Engineering and Technology Education
Vol.1, No.2, 2002

North-South collaboration in technological advancement: the Sweden-South Africa Engineering Education Collaboration Project

Zola Mbanguta†, Kim Bolton‡ & Göran Gustafsson*

National Department of Education, Pretoria, South Africa†
University College of Borås, Borås, Sweden‡
Chalmers University of Technology, Göteborg, Sweden*

ABSTRACT: The Sweden-South Africa Engineering Education Collaboration Project began at the turn of the century with the aim of promoting North-South collaboration in technological advancement and is underpinned by the ultimate goal of bridging the gap between the developed and developing countries with specific reference to Sweden and South Africa. Several institutions of higher education have already participated in the project with regard to engineering education curriculum, laboratory equipment, pedagogical and assessment methods and research through staff and student exchange programmes. The aim of this article is to disseminate information on the project's activities and publish the results. The article gives a full background to the project and briefly but critically reviews related literature on North-South educational collaboration. It also explores the action research methodologically-based project implementation and expansion whilst declaring the results and findings.

INTRODUCTION

Despite widespread poverty, the threat to ecological systems and the economic stagnation (if not regression) that prevails in a large number of countries, development is the pre-eminent challenge of our times. Positive conditions exist for strengthening international cooperation for development, while steady growth in global output and increasing trade opportunities offer possibilities for progress. This is grounded on a past of innovative thinking about development, which brought North and South to the negotiating table [1]. Technical cooperation programmes assist developing countries in overcoming practical obstacles to sustainable development.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) has acknowledged that the second half of the last century would go down in the history of higher education as the period which saw the gap between the industrially developed countries and the developing countries, with specific reference to the least developed countries, becoming wider with regard to access to and resources for higher learning and research [2]. The World Bank advised developing countries to institute policies that would enable them to narrow the knowledge gaps that separate them from the rich countries [3]. This is supported by Patterson, who discourages North-North collaboration that gives *handouts* to the South, and rather promotes North-South collaboration [4].

North-South collaboration in education can help close the divide based on differing conditions and resources. With regard to North-South educational collaboration, Simonsen, Myklebust and Karlsen suggest that commitment from universities in the Nordic countries towards degrees taught in English for students from the South enhances the relevance and quality of programmes and the models of virtual learning [5]. Hareide states that a well functioning educational system is a precondition for development not only for the North, but also for developing countries [6].

The globalisation process that is taking place within the world of education and research makes the education and research sectors increasingly open to international cooperation and to participation in international development programmes. The continuous movement of students and researchers between the two hemispheres should be ensured to enhance the quality of education and research. Strand suggests that the success of the collaboration between developed and developing countries should be based on mutual interest, benefit and respect, that is, ideally, cooperation between equal partners [7].

Sweden's unemployment rate is 3.8% in a population of around 8.9 million, while South Africa's unemployment rate in a population of around 40 million is about 30%. The 2002 World Competitiveness Scoreboard places Sweden at eleventh spot, which is a slight decline given that it was ranked at eighth position in 2001. South Africa has, during the same time improved by three positions to the thirty-ninth, as compared to the previous year's rank of forty-two, and is the only African country that is rated among the first 49 countries of the world.

Sweden has always had a history of high advancement and leadership in engineering and technology education among developed countries. South Africa has always held its own on the African continent and among developing countries, hence its position as the tenth most industrialised country in the world during the period between the early 1960s and mid-1970s. Presently, Sweden produces about 1,500 engineers per million population [8]. The corresponding number for South Africa is not higher than 32 [9]. However, South Africans are riding the crest of a wave on the automotive engineering front, almost equalling their Swedish counterparts, as they export locally made vehicles to countries such as Japan and the USA [10].

BACKGROUND

The Swedish academic life is highly internationalised through personal contacts, faculty and student exchange programmes, as well as joint research projects with publications in scientific journals and participation in international conferences. However, until 1994, academic collaboration between Sweden and South Africa was limited, particularly in comparison to the extent of Swedish academic contacts with other English speaking countries.

When the political situation in South Africa changed, there was increased interest from Swedish institutions of higher education to establish more stable relations with their South African counterparts for a number of reasons. The situation towards the end of the 1990s was such that:

- Sweden was involved in a number of official development projects in South Africa through the Swedish International Development Cooperation Agency (Sida).
- Major Swedish industrial companies were established in South Africa through sales offices and production plants.
- The South African Air Force was in the process of upgrading its fleet and negotiated to buy a number of military airplanes from the Swedish manufacturer Saab, a deal that would not only involve the manufacturing of parts of the airplanes in South Africa, but also included a large number of contracts between other Swedish and South African engineering and technology companies (the deal was later signed).
- The Swedish Prime Minister led a large delegation of government, business and academic officials to South Africa in 1999 where extensive cooperation agreements between Sweden and South Africa were signed. One result was the Sweden/South Africa Partnership Fund that supports cooperation in a number of development areas including science, engineering and technology.
- Due to a large expansion in Swedish university education, an increasing number of students from non-academic backgrounds had, in the past few years, entered domestic academic institutions and sought to identify how the education and academic environments in general could be modified to give them maximum support in their studies. Since South African universities had, at the same time, begun to increase their enrolment of so-called underprivileged students, it was of interest to Sweden to learn more about how the needs of these students were catered for.

At the same time, Technikon Free State in Bloemfontein, South Africa, contacted Karlstad University, Karlstad, Sweden, and enquired about potential collaborations involving education towards Bachelors degrees in engineering. At that time, Karlstad University already had established relations with a number of universities in other English speaking countries, such as Australia, Canada, Ireland, New Zealand, the United Kingdom (UK) and the USA.

Furthermore, there was no cooperation with any South African university or any university on the African continent at that time. It seemed natural to make an attempt in developing cooperation in engineering education, especially since cooperation and technology transfer among Swedish and South African industries were on the increase.

Since Karlstad University, in this sense, was somewhat of a pioneer in Sweden, the plans were presented to the National Swedish Group for Engineering Education, which is a collaborative organisation for Swedish universities with Bachelor of engineering education. It was then discussed within the Group if it was of general interest among the members to seek academic collaboration with South Africa and, if so, identify how the Group could best support these aims.

THE PROJECT AND ITS AIMS

The outcome of the discussion in the National Swedish Group for Engineering Education was a decision to send two of its members, Dr Göran Gustafsson, then at the Karlstad University, and Dr Matts Håstad to South Africa to meet with South African academics. Their mission was to investigate general opportunities for organised engineering education cooperation at the Bachelors degree level between Swedish universities and South African technikons and universities. In preparation for the trip, contact was established with Dr Zola Mbanguta, Chief Engineering Education Specialist at the National Department of Education in Pretoria to gain more background information about South African engineering education in general.

The trip was undertaken during one week in February 1999. Dr Gustafsson and Dr Håstad first met with Dr Mbanguta in Pretoria and were given an extensive overview of the national education system and the ongoing and planned reforms aimed at changing it. They, in turn, presented how the academic engineering education is organised in Sweden and announced the Swedish interest to establish Bachelors degree engineering education exchange programmes with South Africa. Besides the Technikon Free State in Bloemfontein, they also visited an engineering college and several technikons and universities in and around Pretoria, Johannesburg and Cape Town. During meetings, presentations, tours around the facilities and discussions with management, faculty and students they acquired strong practical insights into how South African engineering education is planned, organised, offered and executed. Later in the year, Dr Manie Wolvaardt, Director of International Affairs at Technikon Free State, visited Karlstad University to follow up the contacts that had been established between the two institutions.

Later in the year, the National Swedish Group for Engineering Education discussed how to proceed with the South African contacts. The positive results from the trip by Dr Gustafsson and Dr Håstad made the group decide to send a larger delegation to South Africa the following year, with representatives from many Swedish universities offering engineering education at the Bachelor level, to establish a wider network. A note of gratitude was sent to Dr Mbanguta for his efforts with a further request to prepare for the visit of the larger group. He undertook intensive consultations to set up meetings with different relevant South African organisations.

A group of 23 people visited South Africa between 26 February and 4 March 2000. All but four members were representatives of Swedish universities: two came from the Copenhagen College of Engineering in Denmark and two represented the Swedish Association of Graduate Engineers. The group visited engineering education schools, colleges, technikons and universities around Pretoria, Johannesburg and Cape Town. Special visits were made to the Engineering Council of South

Africa, the South African National Science and Technology Forum, the large De Beers Mining Company and the South African Chapter of the African Renaissance. An exchange of information was achieved through meetings, workshops and short tours around the campus of each institution. Many new contacts were established to primarily discuss the exchange of staff and students as a first step towards a possible deeper cooperation. A few universities and technikons had already proceeded past the first contact stage and started to make plans for direct collaboration.

Later in the year, Dr Mbanguta visited Sweden for discussions with representatives of some of the universities that were represented in the delegation. He found that two universities had come far and were now about to commence the exchanges with their South African partners, while others had more vague plans and no specific schedule. As a result of the abovementioned activities, a project had now emerged with the aim to promote North-South collaboration with specific reference to Sweden and South Africa, with the ultimate goal of bridging the gap between developed and developing countries through human development and technology transfer. This was, and still is, to be achieved by engaging universities, technikons and colleges of both countries in staff and student engineering education exchange programmes through joint curricula and programmes development initiatives. Indeed, exchanges of various kinds have now been established between several Swedish and South African universities and technikons, some of which is detailed further below.

TECHNOLOGICAL ADVANCEMENT AS A RESULT OF NORTH-SOUTH COLLABORATION

It is estimated that 60-70% of the developed world's economic growth comes from new scientific and technological knowledge, and this rate nullifies Africa's economic growth rate that comes from new scientific and technological knowledge generated [11]. This can be attributed to various factors such as the relatively little assistance obtained from the World Bank in the development of scientific and technological knowledge in Africa, despite the large amounts of financial assistance that have already been directed towards East Asia and Latin America since the early 1980s [12].

It has been acknowledged that, with very few exceptions, the generation, dissemination and application of knowledge had not been a major attribute of the African universities. Sawyerr suggests that this will have to be a principal function of Africa's leading universities if Africa is to survive and thrive in the knowledge society of the 21st Century [13]. On the African continent, South Africa is the leading country that generates 10% of its economic growth from scientific and technological knowledge [14]. International experience shows that when a government spends at least 0.5% of the country's Gross Domestic Product (GDP) on civil research and development, private companies are stimulated to start their own research and development programmes, in many cases in partnership with institutions of higher learning. Therefore, developing countries are advised to consciously develop knowledge, as those countries that capture knowledge will succeed while those that do not will fail.

In true North-South cooperation, technological advancement invented and enjoyed by countries in the northern hemisphere and transferred to and shared with their counterparts in the southern hemisphere has brought about more relaxed management attitudes that, in turn, have led to more flexible working hours in countries in both hemispheres [15]. These flexible working hours, which have been adopted by many large companies and the public sector in developed and developing countries, have led to job-sharing, part-time working and flexi-time or home-working. This situation gives parents the opportunity to pay more attention to their young children yet also being productive at work, while simultaneously allowing them to be paid according to what they do rather than the hours they work. They find themselves working fewer hours but being more productive; furthermore, the quality of service has improved as well [16].

In most situations, developing countries pay a huge cost because of the low, or lack of, beneficiation capacities, even though most of them are endowed with enormous mineral resources. For example, despite the fact that South Africa is one of the world's biggest producers of diamonds, only about 1,200 diamond cutters are employed by the industry while about one million diamond cutters are employed in the rest of the world, notably India, Belgium and Israel [17].

One example of UK-South Africa technological advancement cooperation, which involves the UK-based Quarterly Hall and the South African-based FFE Minerals-Vecor engineering groups, the South African engineering group imports knowledge and technology in the form of product design and expertise from the UK. It carries out the product manufacture and assembly of the systems and equipment in South Africa in collaboration with local manufacturers and with the raw material obtained locally. This can be compared to the cooperation between the same UK-based company and the Bulyanhulu gold mine in Tanzania, where the product knowledge and design, manufacture, supply and supervision of the product installation is imported from the UK [18]. Tanzania, one of the poorest African countries, has to carry the high import costs that come as a result of the country's depreciating local currency.

METHODOLOGY

The visit by Dr Gustafsson and Dr Håstad in 1999 constituted the first of three cycles in an action research approach to develop the exchanges [19][20]. The actions taken during the project have always been based on the findings from previous steps, as action research by nature is situational, collaborative, participatory and self-evaluative. The second cycle, which sought to strengthen and take forward the results of the first cycle was the trip by the larger Swedish-Danish delegation in 2000 [21]. The third cycle covered the implementation, ie the exchange activities themselves, which are now underway.

EXCHANGES

Exchanges that have taken place so far have been between Karlstad University (Sweden) and Technikon Free State (South Africa); the University College of Borås and Potchefstroom University (South Africa); and the University College of Borås and the University of Natal (South Africa).

Karlstad University and Technikon Free State Collaboration

Karlstad University and Technikon Free State developed their contacts by sending one staff member from each university on a

visit to the other for one week during 2001, to prepare for and plan the exchanges that would follow. On their visits, the staff members identified mutual areas of interest, including those subjects of cooperation in Bachelor degree engineering education programmes that would be best suited for further development. They also undertook quality assurance procedures involving the checking of facilities, course plans, the area of the faculty's competence and foreign student support services of the partner university, as well as the identification and interviewing of a number of candidate staff members for exchange.

Several exchanges of staff and students have taken place thus far. Two Karlstad University students performed their BSc thesis work in Energy Engineering at Technikon Free State during half a semester in 2000, working on a solar energy application. A third Karlstad University student spent a full semester at Technikon Free State in 2001 as part of his studies towards a BSc in Mechanical Engineering. Two Karlstad University staff members in Electrical Engineering spent a month at Technikon Free State in 2002 and two Technikon Free State teachers went to Karlstad University for one month's duration in May 2002. A third Technikon Free State staff member is also scheduled to go to Karlstad later in 2002.

All performed and planned staff exchanges have been financed through Linnaeus-Palme grants from the International Programme Office for Education and Training (in Sweden), and two of the three Karlstad University students received Minor Field Studies grants from Sida to support their stay at the Technikon Free State.

University College of Borås and Potchefstroom University Collaboration

Dr Kim Bolton from the University College of Borås (Sweden) was involved on a strategy to implement the University College of Borås's interests for North-South collaboration. Three Borås chemical engineering students expressed interest in performing their MSc projects in South Africa. Potchefstroom University was chosen as the university to represent South Africa in a partnership with the University College of Borås through Dr James M. Hlongwane of the SA National Science and Technology Forum and Prof. M. Zibi of Potchefstroom University. Dr Bolton and Prof. Everson (Potchefstroom) became the partnership coordinators.

The three University College of Borås students were placed at Potchefstroom University, where they completed a semester of their projects for the completion of their degree, from 1 September 2000 to 31 March 2001. Their projects concerned methods to recycle valuable or poisonous chemicals of relevance to South African industries. One of the projects studied the pervaporation separation of methanol and methyl tertbutyl ether using a zeolite membrane, while the other two projects investigated the removal of heavy metals from industrial effluent water, either by adsorption on maize cobs or by micro filtration. The first project has relevance to the South African oil industry and the second project potentially offers considerable economic savings to many South African water purification industries. The three projects, which were supervised by academic staff from Potchefstroom University, had a high educational standard and all three students have subsequently obtained their MSc degrees.

In addition to advancing the students' engineering education, the trip gave them a unique opportunity to make contact with South African colleagues and learn the South African culture and lifestyle. This type of international contact has immense benefits to students, in both their personal and professional development. This is evident by the fact that in order to maximise the national benefits of this type of exchange, one needs a continual two-sided exchange programme similar to that established between Karlstad University and Technikon Free State. This would ensure a deeper understanding of the partner country's social, educational and economic structures, as well as their technological interests and challenges. In addition, it would allow for a long-term perspective and interest in collaborative projects that would maximise the advancement made in these projects.

Continual overlap of staff and students in the two countries would also contribute to advances in the educational structures and curricula in both countries. The Borås-Potchefstroom collaboration project also showed that it is beneficial to have formal and planned meetings for cultural (and not just engineering) exchanges to enhance this type of interchange between the countries.

University College of Borås and Natal University Collaboration

During the visit of the Swedish delegation to South Africa (as part of the second cycle), Dr Bolton visited the University of Natal in Durban where he made contact with Prof Deresh Ramjugernath, Head of the Thermodynamics Group in the Chemical Engineering Department. It was immediately evident that a combination of the experimental expertise in Durban and the computational expertise in Borås could make a significant contribution to education and research in both countries and, in the long term, to chemical industries in South Africa. Using computers instead of laboratory experiments to obtain industrially relevant information potentially offers large economic savings.

A three-year collaboration between these institutions, financed by Sida and the National Research Foundation in South Africa, began in March 2001. In September 2001, Prof. Ramjugernath and one of his PhD students visited Borås to learn more about the computers and computer programs required for the project. This was followed in November 2001 by a visit to Natal by two computer-engineering students from Borås who installed a powerful supercomputer and the necessary computer programs. There have been, and will continue to be, regular visits between the two groups to ensure that good progress is made.

A Natal PhD student is presently using the computer programs to study the thermodynamic properties of chemical systems and, in collaboration with Borås, will extend the computational methods to study more complex chemical systems, such as those of interest to the South African steel and oil industries. As with the Borås-Potchefstroom project, it is imperative that the Borås-Natal project does not come to an end after three years, but that competence in computational chemical engineering is continually advanced in both Sweden and South Africa.

RESULTS AND FINDINGS

A project report on the status was prepared and circulated to all project members at the beginning of 2001. Zuber-Skerrit urges

all action research practitioners and researchers to be critical and self-critical of their enquiry and to be accountable by making the results of their enquiry public [22]. Good and encouraging comments were received from the members.

The visits by the Swedish delegations to South Africa, the South African visits to Sweden, as well as the exchanges undertaken, have revealed the following:

- Differences have been identified in engineering education curricula, pedagogical and assessment methods, as well as laboratory equipment between Sweden and South Africa. These differences indicate that Sweden's system, as a developed and advanced country with respect to science and technology, is directly aligned to industrial needs and its universities' research advances the economy while South Africa is lagging behind.
- The fact that South Africa was once rated as the tenth most industrialised country in the world still shows in some areas of engineering and technology where a lot of invention still takes place.
- The strict registration of engineering technicians, certificated engineers, professional technologists and professional engineers by the Engineering Council of South Africa (a statutory body that functions through an Act of Parliament, the Engineering Professions Act of 1990) was a good lesson for the Swedes.
- The exchanges so far between Karlstad University and Technikon Free State were very interesting and valuable to those who took part in them. They teachers and students have learned much about the similarities and differences between the educational systems of the two countries and universities, and learned things that they can apply in their own work at home. The teachers from each university were also able to give valuable and appreciated help to their colleagues at the other University on special topics in their own fields of expertise.
- The Borås-Potchefstroom project was extremely beneficial to the three Borås students involved. A continual and overlapping stream of staff and students between Sweden and South Africa is necessary if these types of short-term projects are to make an impact on the educational, technological and social advances in these countries.
- The Borås-Natal project has been successful in introducing relevant computational skills at the Chemical Engineering Department of Natal University and in stimulating research in this area at the University College of Borås. The long-term success of this collaboration, which is important for the impact on education and research in both countries and to help industrial and social advances in South Africa, depends critically on the renewed sponsoring of research students and supervisors for this and associated projects.
- Overall, problems related to the exchanges have been few and small, and mainly due to cultural differences and different ways of performing and administering engineering education in the two countries. However, these differences are minor and are by no means obstacles to a continuation and an expansion of the exchange scheme. It should be noted that Swedish and Afrikaans (one of the eleven official South African languages) are both Germanic languages, and that the common language in South Africa, English, is the primary foreign language in Sweden, and consequently well-understood and spoken at institutions of higher education. Textbooks in English have become standard literature in many Swedish university programmes, and lectures given by English speaking teachers are not uncommon.
- In most cases of exchange, external funding has been and will continue to be necessary to supplement internal university resources in order to cover the extra costs incurred when sending faculty and students abroad.

CONCLUSIONS

The success of the University College of Borås and Potchefstroom University Project, the University College of Borås and Natal University Project and the Karlstad University and Technikon Free State Project have demonstrated that the efforts of North-South engineering education practitioners and researchers, who operate from limited resources, have paid off. These projects involved matters in the engineering education curriculum, pedagogic assessment, university laboratory equipment and a strong element of industrial involvement. Cultural and language matters and varying historical and political backgrounds of the two nations have also manifested themselves in the collaboration, and were a good part of the lessons learned by members from the two nations.

The future of the collaboration mainly depends on two factors: personal interest among the faculty and students of the five universities, and adequate resources to finance it. A decision to attend a university on another continent to work or study must always be a voluntary and deliberate action by the person concerned. It cannot be commanded but rather must be the result of a natural interest to undertake it. However, the positive impressions by those who have participated in the exchanges have thus far served as good examples for others to follow. A threat to future activities may be inadequate economic resources at the universities, since the internationalisation of academic life is certainly not for free.

In sustaining and expanding the present North-South educational collaboration, lessons can be learned from the abundant literature on developmental cooperation. However, decisions on the continuation of the exchanges have to be based on continuous assessment and evaluation of past and present activities.

Possible extensions are to send students for longer periods, eg to study complete engineering programmes in the other country, and to have staff work full semesters or academic years at the partner institution. That would add another dimension to the collaboration, but also introduce new practical and economic problems. Long-term stays are more costly and difficult to arrange than short-term stays, and being away from the home university and country for a long time differs considerably in several ways from a shorter absence. Nevertheless, if the present exchange activities continue to be successful, it will probably become natural to cooperate more closely in the future.

The North-South collaboration in engineering and technology education enables developing countries to access innovative techniques that afford a dramatic reduction in costs. This is coupled with far greater recovery and enhanced safety as sometimes workers do not have to enter danger zones in the manufacturing and mining industries [23].

RECOMMENDATIONS

North-South collaboration in higher learning and research should be intensified so as to promote and leave a legacy in developing countries, particularly in the areas of education, product design, manufacturing, assembly and maintenance. This will have a direct effect on existing engineering education curricula, pedagogical strategies and assessment methods. The relevance of the laboratory equipment itself needs to be constantly checked and updated.

The involvement of other important partners, including governments in some situations, is imperative for the assurance that the cooperation benefits the development and retainment of local skills for the sustainability of the project. Furthermore, it will focus response to local demands, establish an economically viable good manufacturing practice operation and grow a strong research and development atmosphere and environment to promote the empowerment of the locals with specific reference to the developing countries.

In reiterating the Acting Deputy Director General of the South African Department of Arts, Culture, Science and Technology, Dr Adi Paterson's statement that South Africa has to emulate the Scandinavian countries and invest in knowledge, the authors call for greater involvement of not only Swedish-South African institutions of higher learning, but that all institutions of higher learning in the northern hemisphere should engage in vigorous debates on how to engage their counterparts in the southern hemisphere in bridging the technological gap.

ACKNOWLEDGEMENTS

The authors express their deepest gratitude to Dr Manie Wolvaardt and Prof. Gerrit Jordaan of Technikon Free State, Bloemfontein, Prof. Ray Everson of Potchefstroom University, SASOL Oil Company, and Prof. Deresh Ramjugernath and Mr Tyrone McKnight of the University of Natal, Durban, for their help in establishing the exchange programmes and for the friendly reception and excellent assistance they have given to faculty and students from Sweden who have visited their institutions in preparation for, and as part of, the project.

Gratitude is also expressed to Dr James M. Hlongwane, the CEO of the SA National Science and Technology Forum, for the role he played in accepting and introducing the project to the SA national engineering and technology education stakeholders.

The support given by the International Programme Office for Education and Training (in Sweden) through Linnaeus-Palme grants that have enabled Swedish and South African academic teachers to work at each other's institutions is also appreciated.

The Swedish International Development Cooperation Agency (Sida) is also thanked for providing research funding and Minor Field Studies grants to Swedish students for studies in South Africa.

REFERENCES

1. United Nations Conference on Trade and Development (UNCTAD), *Technical Co-operation: Meeting the Development Challenge.* Paris: United Nations Conference on Trade and Development (2002).
2. The United Nations Educational, Scientific and Cultural Organization (UNESCO), *World Conference on Higher Education: World Declaration on Higher Education for the 21st Century and a Framework for Priority Action for Change and Development in Higher Education.* Paris: UNESCO (1998).
3. World Bank, *World Bank Report: Knowledge for Development-Including Selected World Development*. New York: Oxford University Press (1998).
4. Patterson, M., *North-South Differences in Technological Capabilities: How Do We Collaborate?* Colorado Springs: Global Mapping International (1996).
5. Simonsen, J.G., Myklebust, J.P. and Karlsen, H., Editorial. *NUAS-NUS Conf. Proc.*, Bergen, Norway (1999).
6. Hareide, K.A., Higher education and research cooperation with institutions in the South: back to international solidarity? *NUAS-NUS Conf. Proc.*, Bergen, Norway (1999).
7. Strand, T., How can we enhance Nordic cooperation with institutions of research and higher education in the South? *NUAS-NUS Conf. Proc.*, Bergen, Norway (1999).
8. Statistics Sweden, Education and the Demand for Labour: Prospects for the Years up to 2008. Stockholm: Statistics Sweden (2002).
9. Kahn, M., Engineering under stress. *Mail & Guardian*, 25-31 July (1997).
10. Creamer, M., Moves to end roll-over rot, latest on Abalone Project, Zambia's Copperbelt crisis. *Engineering News*, 22, **12**, 3 (2002).
11. Campbell, K., Generating enthusiasm for local research and development. *Engineering News*, 22, **12**, 5 (2002).
12. Thulstrup, E.W., How can research capacity be created and used in developing countries? A strategy for the next decade. *NUAS-NUS Conf. Proc.*, Bergen, Norway (1999).
13. Sawyerr, A., Does Africa really need her universities? *Codesria Bulletin*, 3-4, 20 (1998).
14. National Productivity Institute, *Technical report by the NPI.* Pretoria: NPI (2002).
15. Swan, J., *New Ways to Work.* Johannesburg: Juta Publishing (2002).
16. Carrington, L., Technological advancements mean new flexible working hours. *Saturday Star*, 20 April (2002).
17. Venter, I., Russia gem deal a lesson for SA? *Mining Weekly*, 8, **13**, 8-9 (2002).
18. Calver, A., UK tech, SA-made mining equipment. *Mining Weekly*, 8, **13**, 5 (2002).
19. Kemmis, S. and McTaggart, R., *The Action Research Planner.* Geelong: Deakin University (1988).
20. Cohen, L. and Manion, L., *Research Methods in Education.* London: Routledge (1995).
21. Harris, S.V. and Zuber-Skerrit, O., Identifying the Gap between institutional expectations and the needs of graduate professionals in continuing education. *Society for Research into Higher Educ. Conf.*, London, England, UK (1985).
22. Zuber-Skerrit, O., *Action Research in Higher Education: Examples and Reflections.* Brisbane: Griffith University (1992).
23. Ferreira, P., New excavation technologies developed. *Mining Weekly*, 8, **13**, 15 (2002).