Int. J. Engng Ed. Vol. 22, No. 1, pp. 71–78, 2006
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Relevance of Agricultural Engineering Education against the Background of a Changing World—the Case of Southern Africa*

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While training in traditional branches of agricultural engineering has never been in doubt in developing countries because of the agro-based economies, of late, the relevance of this training has come under scrutiny as the world order shifts towards more market-oriented economies with the resultant requirement of efficient resource utilisation, environmental integrity and social equity. Traditional programmes as previously designed based on developed country models are becoming marginal as most conditions do not obtain in developing countries. This paper analyses the relevance of tertiary agricultural engineering education in southern Africa in the face of world and regional dynamics taking place. It will be argued that traditional agricultural engineering education is becoming dated as there is a need for more dynamic programmes. On one hand, many economies in Southern Africa are stagnating, and yet on the other, the requirements of agriculture and agro-industry are changing, leading to the need to review and modify curricula regularly. Formal research and development departments are almost non-existent in industry, but do exist in the informal sector and small and medium enterprises (SMEs) at a very basic level. Developing countries tend to be net importers of equipment and machinery yet training offered is geared towards research and development. The informal sector and SMEs, which are expanding, require entrepreneurial agricultural engineers yet the training is geared towards formal employment. Alternative engineering programmes are coming on line with resultant shrinkage in enrolments in agricultural engineering. It is apparent that the basic tenets of agricultural engineering education need to be revolutionised to serve the real needs of society and for the discipline to remain relevant and competitive. The paper gives examples from agricultural engineering degree programmes from the region including South Africa and Zimbabwe. Suggestions are given on the desirable curriculum reform.

Keywords: agricultural engineering; developing countries; university funding; curriculum reform; entrepreneurial skills

INTRODUCTION

AGRICULTURAL ENGINEERING is generally defined as the application of engineering knowledge and skills to solve problems of agriculture. The agricultural engineering profession dates back to around 1907 and is thus as old as most engineering disciplines [1]. On the world's stage, agricultural engineering has made its mark and contribution to the development of humankind as epitomized by agricultural mechanization being named among the 20 Greatest Engineering Achievements of the 20th Century [2], and also that agricultural engineers should take credit for some of the achievements of the 20th century, namely, contributions in bringing electricity and irrigation to rural areas. The success of agricultural engineering has been anchored in a sound and robust training and education programme. Agricultural engineering training has always been well grounded in the theory and understanding of concepts coupled with practical hands-on training making agricultural engineers productive and adaptable under many conditions.

In recent times, there has been a shift in agricultural engineering training and education in developed countries arising from the fact that the agricultural engineering name no longer adequately described or covered all the areas served by agricultural engineers. The thrust has been towards names that are more encompassing such as biological or bio-systems or bio-resources engineering—where biological (bio) emphasizes the new application in biotechnology and

* Accepted 21 August 2005.

environmental management [3]. While this has been happening in the developed world, the change has been somewhat slow in the developing countries. Training in traditional branches of agricultural engineering has never been in doubt in developing countries because of their agro-based economies. These agricultural engineering programmes were developed based on the models of developed countries in Europe and the USA. Of late, this training and education in agricultural engineering has come under scrutiny as the world order shifts toward more market oriented economies with the resultant requirement of efficient resource utilization, environmental integrity and social equity. Unlike regions like South East Asia and some South American countries where the economies are generally on an upward trend, in southern Africa the agro-based economies are on a downward trend. This paper looks at the relevance of higher and tertiary education in agricultural engineering in southern Africa in the face of world and regional dynamics taking place, and makes suggestions on changes required in the degree curricula to meet the challenges that have arisen from the changing environment.

THE CHANGING ENVIRONMENT

Economies in the developing world, including southern Africa, are shifting towards market-orientation, whether by design or by subtle coercion. In a effort to take advantage of support from the World Bank (WB) and International Monetary Fund (IMF), these economies have had to embrace economic structural adjustment programmes (ESAP). The consequences of ESAP have been far reaching to all sectors of the developing countries, including the agricultural and educational sectors (especially higher and tertiary education under which agricultural engineering falls). Some of the key fall-outs of ESAP are discussed in the following sections.

Globalisation and market liberalisation of agriculture

Agriculture in southern Africa is now increasingly influenced by the world economy and market liberalization. For agriculture that was long managed by central government (input supplies, produce price setting, and the like) this globalization has exposed African agriculture to forces that were previously unknown in terms of competition and subjection to the vagaries of world price fluctuations. While agriculture in developed countries is protected somewhat through subsidies, that in developing countries is not and thus exposed to widely fluctuating prices and pressures on a world scale [4]. The common pressure is that of reduced prices of most agricultural produce on the world market leading to low returns for African agriculture, and the consequence of a poverty cycle for those whose livelihoods depend on agriculture as is the case for rural populations in southern Africa (where more than 70% of the total population reside in rural areas). Training in agriculture needs to take these changes into account.

Downsizing of the public sector

One of the main thrusts of the ESAP programme, on implementation, is the downsizing of the public sector. ESAP proponents argue that the public sector in most developing countries is far too large and gobbles up a sizeable proportion of the GDP and thus needs to be trimmed down. The consequence of this downsizing of the public sector is the abolishing of a huge number of civil service posts, including those for agricultural engineers, meaning reduced employment prospects for them [5]. These changes have significant consequences on the training of agricultural engineers, and hence the need to review agricultural engineering curricula more frequently to meet the needs of a changing environment.

Reduced public sector support to agriculture (and education)

Concomitant with downsizing of the public sector is reduced public sector spending in agriculture (and education). This is manifested in diminished government support towards production inputs (fertilizer, seed, agrochemicals), commodity prices, research and extension. This reduced spending puts pressure on the sector and those who service it to find new ways of doing business, or risk sinking into oblivion. Agricultural engineering as one of the disciplines that services agriculture is duly affected and has to adapt.

Reduced role of government

Under ESAP, government increasingly plays only a facilitatory role and its operations are supposed to incorporate a cost recovery element. In its facilitatory role, government is supposed to create an enabling environment for the private sector, non-governmental organisations and others to participate. Also government is expected to provide demand-driven services, like extension, for a fee rather than for free. This reduced role and cost recovery thrust calls for a different breed of service provider in agricultural engineering, meaning graduates have to be trained differently to fully operate under these changed conditions.

CHANGING WORLD ORDER AND IMPLICATIONS ON AGRICULTURAL ENGINEERING EDUCATION

Even before the changing world order, agricultural engineering the world over as well as in southern Africa faced a plethora of problems both at the professional, individual and programme level [6, 7]. The ESAP-induced changes only add to these challenges and the agricultural engineering discipline has to double

its efforts to remain relevant and competitive. The changing environment under ESAP has several consequences that have a direct impact on agricultural engineering education. These are discussed briefly in sections that follow and are subsequently revisited at the end, as they become the driving forces in the proposed or suggested review of curriculum in agricultural engineering in southern Africa.

Reduced funding to higher education

One of the key and heavily felt consequences of reduced government spending under ESAP has been massive cut backs of funding to higher education. Over the years, there has been a steady and discernible reduction in government appropriation to universities in southern Africa. While figures are not readily available, suddenly universities and hence degree programmes find themselves seriously under funded. In some cases the cuts have been so deep that departments only have money for salaries and benefits of staff and nothing more. The consequence of this has been a cutback on key teaching activities such as practicals and field trips due to lack of funds. Real spending per student has been declining in Africa [8]. This is a serious development that has impacted on degree quality and preparedness of graduates to successfully deliver services.

The converse of reduced funding to degree programmes is increased competition from other programmes for the same government dollars. Regrettably agricultural engineering has not fared well in this competition with the consequence that, more often than not, it has been 'swallowed up' by more visible engineering programmes. A case in point is South Africa where now only one of the traditional universities offers an undergraduate degree in agricultural engineering out of quite a number that used to not so long ago [9].

Proliferation of a complex stakeholder structure

With ESAP there has been an emergence of a complex stakeholder structure. Whereas traditionally agricultural engineering served government and private sector in the main, now it has to contend dealing with a fragmented informal sector and small to medium enterprises, an under-capitalized private sector, a cost recovery conscious public sector, and an agricultural sector without a coherent or long term policy. Such a situation has placed a heavy challenge on agricultural engineering education as the graduate must be trained to serve such a complex mixture of stakeholders.

Reduced employment

Traditionally agricultural engineers were employed in a wide range of fields that include academic, research and development in private sector and government research stations, agricultural production, equipment sales and service, financial management and consultancy. For less developed countries like southern Africa, by far the largest employer was government with the private sector employing a few. With cut-back in the public sector, a number of employment opportunities have been eliminated creating the need to train agricultural engineers who are self starters and do not look to formal employment [5]. This has implications on the curricula for agricultural engineering in southern Africa.

Increased pressure on resources

Increasing populations in southern Africa have increased the pressure on resources, especially under the relatively 'free-for-all' ESAP environment. This increased pressure on resources demands neater or efficient production processes to maximize returns on the little that is available. Efficient production processes requires agricultural engineers who are adequately trained in such processes, meaning the curricula must reflect on this. However, operating under the informal sector militate against clean production processes as the set-up is hardly regulated, and the desire is for quick returns in a short term without due regard to the long term consequences on the environment.

Reduced research and development funding

With reduced spending in government and a disaggregated private sector, there has been a marked decrease in R&D funding in agricultural engineering. Actually, formal R&D departments have ceased to exist in their old form, but now do exist in the informal sector and the small to medium enterprises, albeit at a very low level of capitalization. The R&D in this sector is self-serving with little consideration for long-term information generation and sustainable development. New designs, processes and equipment are rushed to the market, before they are thoroughly tested, in an effort to capture narrow 'product windows' requirements. In any case, there are neither the funds nor the will for long term R & D investment, thus shortening the product cycle.

The agricultural engineering graduate is expected to work with a constrained budget and a tight program, most likely on low-level technologies. The graduate needs to have been trained to operate under such conditions without getting frustrated and losing site of the long-term objective of contributing to improved productivity in agriculture.

Weak academia/industry linkages

With a disaggregated industrial base in southern Africa, the academia–industry linkage has further been weakened leading to a blurred and increasingly interactive and iterative characteristic to the research–dissemination–adoption spectrum [10]. This in itself requires a new breed of agricultural engineer who can balance both technical subject mastery and the socio-economic issues that go with technology dissemination to rural stakeholders.

Diversity of employment prospects

With the proliferation of a complex stakeholder structure, so have been the employment prospects. A wide array of previously unimagined job prospects for agricultural engineers now exists in southern Africa. These range from development of appropriate and affordable technologies in the informal sector, through sales of such equipment, to project management at both the local and national level. The agricultural engineer now needs to be trained in a wide range of disciplines such as project management, budgeting and finance, over and above the core engineering and technology subjects. Agricultural engineering curricula need to reflect this new demand on their product.

DEALING WITH THE CHALLENGES IN AGRICULTURAL ENGINEERING CURRICULA

Given the above set of new developments brought about by the changing world economic order, providers of agricultural engineering degrees in southern Africa cannot afford to sit on their laurels. They need to be dynamic and adopt a pro-active approach in dealing with the problems faced so as to remain relevant and competitive.

At the institution level, there is a need for a leadership that is outward and forward looking [11]. University leadership should, of necessity, form strong working relations with the public sector (even though there is diminished support from that quarter), the private sector (even though that sector is fragmented), and the donor community (even though in places like Zimbabwe, such relations are strained). The idea is to try and get as much support (financial and otherwise) from these sectors, while at the same time getting to know their needs so that curricula can be reformed appropriately. Such leadership will ensure that universities have the flexibility to be demand-responsive to the needs of employer institutions rather than sticking to the tried and tested ways of doing business [12].

Agricultural engineering departments need to revisit their vision and mission statements and aim to excel in few key strategic areas [13], as well as seek to pool resources and outsource expertise they may not have. Academic staff time needs to be clearly apportioned among the three key areas of teaching, research and extension services, and staff need to be held accountable to output in key result areas.

Agricultural engineering degree programmes need to be re-examined in line with the changes that have taken place and the pressures that have come to bear on the programmes and their products. A key question that has come about in recent times in the southern Africa region is whether the degree should be agricultural engineering or agricultural (engineering) technology or agricultural systems management. The agricultural engineering degree requires all the fundamental engineering science foundation, and produces a qualified engineer, whereas the technology-based degree is more for those who have an interest in applying technology to the agricultural sciences or business [14]. The conditions prevailing in southern Africa may actually require the latter degree.

At the programme level, more importantly, there is need to reform curricula in agricultural engineering to meet the needs of a changing environment. As such, agricultural engineering departments probably need to review their curricula frequently, maybe every 5 to 10 years. The review cannot be any shorter than this because it takes anything from 3 to 4 years to complete a degree and from 6 to 8 years before new entrants to the engineering profession are able to contribute effectively and efficiently to society [15].

AGRICULTURAL ENGINEERING CURRICULUM REFORM FOR SOUTHERN AFRICA—SOME SUGGESTIONS

As already alluded to, changing times require that degree programmes be dynamic and change with the environment. Agricultural engineering curricula in southern Africa need to change. One may ask in what direction this change should be. In essence, the change must be demand driven to meet the needs of the stakeholders, the change must make the degree more visible, and the change should make the degree more competitive so as to be able to attract more funding and students and stay ahead of other engineering degree programmes. Agricultural engineering curricula should be modified not only to serve traditional clients better but also explore new areas needing their service [15]. At this stage one cannot be too prescriptive about it in terms of setting out how much actual time should be allocated to cover the proposed materials. Suffice to say is that adequate time should be worked out to do justice to these proposed areas.

Agricultural engineering or agricultural technology degree

As agro-based economies in southern Africa evolve, and generally decline and fragment, the question is often asked when it comes to servicing agriculture whether there is a need for agricultural engineering or agricultural (engineering) technology graduates. Without engaging in semantics, agricultural engineering and agricultural technology graduates both work in the same environment, but there is a distinct difference with the work they do [16]. The engineer is trained to analyse and design a process, system or mechanism, while the agricultural technology or agricultural system specialist is able to identify system problems, formulate possible solutions, analyse the impact of alternatives (including social and economic

dimensions) and then implement the best solution [16]. When comparing technology or systems management to engineering, the former degree programmes are less theoretical and more practical, emphasizing application experiences and most courses have practicals and laboratory or recitation sections. Students focus on the application of engineering principles, the study of agricultural technology and the integration of business management concepts. In the USA, such a degree is ideal for those graduates interested in technical sales, being a technical manager for an agricultural related business involved in production, processing, service or manufacturing [16].

This degree programme would find wide applicability in the southern African set-up where the industrial base is now much more fragmented and based on a small unit concept. Some of the technologies that are demanded by the clientele are on a small scale and require more of a technologist than an agricultural engineer. These technologies include low (affordable) drip irrigation kits [17, 18], ox-drawn ridgers [19], light donkey drawn ploughs and cultivators, and the like. These technologies are in demand but their development, testing and eventual purveying requires a technology or systems management minded person rather than an agricultural engineer (the latter being more interested in designing, developing, and testing but leaving the marketing to someone else). Thus institutions in southern Africa need to look at offering this technology-based degree rather than agricultural engineering. It is interesting to note that such a trend is already underway in Zimbabwe. Not so long ago there was only one university in Zimbabwe but now there are over 10 universities in the country. One of these universities, Chinhoyi University of Technology, recently launched a number of technology oriented degrees, including Bachelor of Technology degrees in both Agricultural Engineering and Irrigation Engineering. These degrees are being offered as a direct response to the agrarian and land reform exercise taking place in Zimbabwe since 2000.

Engineering content

For southern Africa, as anywhere in the world, there is a need to ensure that the engineering science is adequately covered in the curriculum. It is not acceptable to cut back on this fundamental requirement. As such, no change is proposed in the engineering content of the degree programmes. The quality of the degree needs to be of a certain standard so that graduates from such programmes would be acceptable at any other institutions for further training. If the programmes are going to produce engineers, then these should be appropriately accredited by engineering bodies, anything short would be a disservice and unacceptable.

Emerging technologies

More and more, graduates now need to contend with emerging technologies of a diverse nature. While traditionally agricultural engineers tended to focus their energies on tractor-based systems, societal demands have shifted significantly in southern Africa to animal-based and low cost systems. As the farming unit has shrunk from hundreds of hectares to a few, so have been the technological needs. The emerging technologies, that graduates have to work with include, among many, treadle pumps [20], low cost drip systems [17], hand-operated oil expressers [21], peanut butter machines, solar driers, light cultivators, small dams, rainwater harvesting, and soil moisture conservation. The new agricultural engineering curriculum must reflect these technologies because these are what graduates would meet in the workplace. Failure to do so would produce agricultural engineering graduates who are partially irrelevant to the existing socio-economic order. There is really probably no need to spend many contact hours learning about an articulated four-wheel drive tractor or an auto-levelling combine harvester when the graduates are most likely never going to work with such equipment in their entire working lives.

Coupled with emerging technologies is the need to incorporate and infuse indigenous knowledge systems into everyday learning for agricultural engineers. There is so much knowledge out there with the farmers and producers that is very relevant to agricultural production but has for long been ignored by traditional agricultural engineering curriculum as being retrogressive and not high-tech enough. Incorporation of indigenous knowledge systems is likely to enhance the effectiveness of graduates as well as improve the uptake of any new technologies that are based on such knowledge systems.

Entrepreneurship

As conditions change in southern Africa, demands are such that the agricultural engineering graduate is now expected to have entrepreneurial skills. With a large informal sector and small to medium enterprises, the agricultural engineering graduate has to be able to work with the whole product (technology) cycle—from conceptualization through development and testing and finally marketing. It is no longer adequate to be content with design, develop and testing and assume that someone will market the product. Actually it is this mentality that has led to a lot of sound technologies that were developed failing to be adopted by farmers because of the weak link between research and extension. Furthermore, the product cycle is now considerably much shorter. With diminished employment prospects in the formal sector, the agricultural engineering graduates have to create employment as well as being self-employed [5]. Such requires entrepreneurial skills including the ability to write bankable proposals, relate to client needs, and market new products directly. Likewise the curriculum in agricultural engineering in southern Africa must be infused with material on

entrepreneurship. Failure to do so will produce graduates who will walk the streets seeking non-existent formal employment.

Information management

Today there is generally an over abundance of information, especially with the advent of computers and Internet connectivity. This is irretrievably influencing lives, even in southern Africa where Internet connectivity is trailing way behind that of Europe and North America. Agricultural engineering graduates need to be able to handle and manage large amounts of information. This is more so for people who are not 'readily computer literate'. Even with limited connectivity, it is quite easy to be overwhelmed by such simple activities as surfing the web, e-conferencing, and undertaking Internet searches, leading to frustration and low work productivity. Agricultural engineering curricula must of necessity equip graduates with such skills. Time must be made available in the curricula for information management. It is not good enough to assume that agricultural engineering students will get or make the time, given the limited resource endowment of many institutions in the region resulting in students failing to access computers. This is even more important in cases when classes are very large.

Soft skills

The changing socio-economic environment in Southern Africa requires that agricultural engineering graduates have a wide range of soft skills. These, though often regarded as being trivial, sometimes spell the difference between success and failure of agricultural engineering graduates in the workplace. These skills include communication, scientific and general writing, personal attire and presentation. Gone are the days when the welfare of engineers was looked after by others, simply because one was an engineer. Engineers now need skills in communication so that they can argue out their cases eloquently, be it salary negotiations or request for budgetary funds. They also need skills in writing—important in making impressive applications, especially when there is cut-throat competition for funds and other resources. Writing skills are important for agricultural engineering graduates to communicate their ideas and findings to the rest of the world. In this communication, they have to know how to deal with all the noises that emanate from language and technical context of subject matter [22]. Time has to be put aside for agricultural engineering students to learn communication and writing skills. It is no longer adequate to set aside a couple of hours during the first semester of their degree programme for someone from the English or Humanities departments to come and talk about communication. Agricultural engineering students need to partake in seminar presentations, recitations and public speaking. Personal attire is also important for agricultural engineering graduates, as impressions are critical in competitive environments. The idea is not to turn agricultural engineers into fashion models, but know how to be presentable as occasion demands.

The Faculty of Agriculture at the University of Zimbabwe is currently going through a curriculum reform and one of the areas being addressed is that of soft skills. This came about because of the proliferation of many new universities when previously there was one, and graduates are meeting with previously unknown or unexpected competition for even fewer jobs [23]. The agricultural engineering curriculum is also being reviewed during this exercise.

Experiential learning and life long skills

The socio-economic environment in southern Africa is changing rapidly and likewise agricultural engineering curricula need to prepare graduates for this change. The training approaches need to evolve and graduates need to be imparted with life-long skills. Training methods need to be more interactive and less top-down (from lecturer to the student) [24]. Graduates need to be imparted with skills that would allow them to learn and adjust as they go through their working lives. Interactive and experiential learning allow graduates to acquire analytical and adoptive skills as well as learn from exposure and experiences, and be able to apply the lessons to different or changing circumstances. Agricultural engineering graduates must be able to go from conceptualization of problem through to solution formulation in both the abstract and practical sense. Some of the required approaches include participatory techniques [12], and systems orientation.

It is interesting to note that experiential learning techniques are already being practiced in agricultural engineering related training in Southern and East Africa. In the training of irrigation, designers organized by FAO in the planning, design and implementation of smallholder irrigation, the approach is with farmer participation and training is by experiential learning [9]. More of these need to move into the agricultural engineering curriculum and learning methodologies.

CONCLUSIONS

The changing economic order in the agro-based economies of southern Africa is presenting major challenges to agricultural engineering teaching and education in the region. The changing environment is casting doubt on the relevance of formal traditionally developed agricultural engineering programmes. The challenges that have come about include reduced funding by central government to degree programmes, reduced formal employment prospects for graduates, emergence of a fragmented and complex stakeholder base with a strong informal sector and small to medium

enterprises, a weakened academic–industry linkage and reduced research and development funding. Agricultural engineering needs to evolve with the times to remain relevant and offer degrees that meet the requirements of the stakeholders.

At the institution level, there is now a need more than ever before of a committed and forward looking leadership that will forge stronger links with both the public and private sector to harness resources as well as get feedback that will direct the way the institutions evolve. At the next level down, agricultural engineering departments need to be dynamic and change with the times. The departments need to re-look at their mission statements and focus on key strategic niches in which they can excel and deliver output (graduates, research and extension) at a competitive advantage. The departments need to aggressively seek and increase external grant funding, increase income generating activities, and focus their research activities to areas they have requisite expertise and form complimentary partnerships with others at both the local and international level. At the degree level, departments in southern Africa need to ask if they need an agricultural engineering or agricultural (engineering) technology degree. Conditions obtaining in the region seem to point towards an agricultural technology degree as being more appropriate.

It is without doubt that there is a need for a reform of the agricultural engineering curriculum. This reform ought to take into account the demands of the region. Whilst there is no suggestion to compromise on the core engineering science principles, a number of new areas need to be included in the curriculum. These include the needs of emerging technologies and indigenous knowledge systems, information management, soft skills, entrepreneurship, and interactive and experiential learning.

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