Tuning
Africa

Design and Implementation of Degree Programmes in Mechanical Engineering

Charles Awono Onana and Venkata Ramayya Ancha (Editors)

Phase II

Design and Implementation of Degree Programmes in Mechanical Engineering

Tuning Africa Project Phase II

Design and Implementation of Degree Programmes in Mechanical Engineering

Charles Awono Onana and Venkata Ramayya Ancha
(Editors)

2018
University of Deusto
Bilbao

The Tuning project is subsidised by the European Commission
This publication reflects only the opinion of its authors. The European Commission may not be held responsible for any use made of the information contained herein.

Editors: Charles Awono Onana and Venkata Ramayya Ancha

Cover design: Fotocomposición IPAR, S.Coop. (Bilbao)

P.O. box 1 - 48080 Bilbao
e-mail: publicaciones@deusto.es

ISBN: 978-84-16982-78-3

Content

Preface

The harmonisation of higher education in Africa is a multidimensional process that promotes the development of an integrated higher education space on the continent of Africa. The objective is to achieve collaboration across borders, sub-regionally and regionally, in curriculum development, educational standards and quality assurance, joint structural convergence, consistency of systems as well as compatibility, recognition and transferability of degrees to facilitate mobility. Harmonisation is necessary for achievement of the African Union vision of integration, peace and prosperity.

Tuning Africa was adopted as a possible instrument to advance the African Union's harmonisation agenda, in collaboration with the EU through the Joint Africa-EU Strategy. Implementing a second phase of Tuning was one of the commitments taken at the 2014 Africa-EU Summit in 2014 in Brussels, as a follow-up to the very successful pilot phase which took place between 2011 and 2013.

At the November 2017 Africa-EU Summit in Abidjan, Heads of State committed to deepening their collaboration and exchange in education, aiming at increasing the employability of young people bearing in mind that investing in youth and future generations in Africa is a prerequisite for building a sustainable future. In this context, further concrete initiatives in the field of higher education which aim to enhance relevance and the quality of education and training will be encouraged.

By contributing to the harmonisation of higher education in Africa, Tuning Africa is complementing Erasmus+, the Intra-Africa academic mobility programme and the Nyerere scheme; thereby enhancing the mutual recognition of academic qualifications and facilitating exchanges and mobility of students and staff across the continent and with Europe. This is instrumental for acquiring key skills and competences that are important for employability, facilitating collaborative research addressing common challenges, and for ensuring relevant and quality education. The dialogue on credits and a common credit system for Africa is another major deliverable for Africa. All these initiatives are in line with the Continental Education Strategy for Africa as well as Africa's Agenda 2063 which calls for an education and skills revolution.

Tuning Africa has provided a platform for dialogue on quality assurance and the improvement of teaching, learning and assessment in higher education. Bringing together academia and employers, and importantly in this second phase, the active involvement of students, has been crucial. The success of Tuning Africa has been the involvement of a critical mass of universities and stakeholders, the ownership and commitment of all involved, as well as a transparent and credible leadership.

The AUC and EC are grateful to all the African and European experts involved in the production of this book, which is an outcome of the Joint Africa-EU Partnership Harmonisation and Tuning Africa 2 initiative.

African Union Commission and European Commission

Chapter 1

Introduction

1.1. Mechanical Engineering in the African Context

Mechanical Engineering (ME) is the discipline that applies engineering, physics, and materials science principles to design, analyse, manufacture, and maintain mechanical systems. It is one of the oldest and broadest engineering disciplines, and it requires an understanding of core areas including mechanics, dynamics, thermodynamics, materials science, structural analysis, and electricity. In addition to these core principles, mechanical engineers use tools such as computer-aided design, and product life cycle management to design and analyse manufacturing plants, industrial equipment and machinery, heating and cooling systems, transport systems, aircraft, watercraft, robotics, medical devices, weapons, and other mechanical objects and systems. It is the branch of engineering that involves the design, production, and operation of machinery.

Although its development can be traced back several thousand years around the world, Mechanical Engineering emerged as a field in the 18th century, during the Industrial Revolution in Europe. Since then, it has continually evolved to incorporate advances in such areas as composites, mechatronics, and nanotechnology. It also broadly overlaps with aerospace engineering, metallurgical engineering, civil engineering, electrical engineering, manufacturing engineering, chemical engineering, industrial engineering, and other engineering disciplines to varying degrees.

Nowadays, Mechanical Engineers also work in the field of biomedical engineering, specifically with biomechanics, transport phenomena, bio-mechatronics, bio-nanotechnology, and modelling of biological systems.

1.2. Importance of Mechanical Engineering for Africa

The importance of Mechanical Engineering explains its strong presence in almost all African countries, with perceptible disparities from one country to another due to diversities in historical traditions of training. However, strong similarities emerge when it comes to the skills expected of Mechanical Engineering specialists trained in the Continent's universities. These similarities are the cross-cutting framework on which harmonisation processes will have to be based in order to achieve comparability of the courses offered by each university in the field of Mechanical Engineering in Africa. This process of harmonisation is now of paramount importance in an Africa where regional integration is becoming a major policy axis, which inevitably leads to a need for mutual recognition of pathways, diplomas and qualifications in the African Higher Education Area.

A career in Mechanical Engineering is one of the most interesting careers to follow as it involves a tremendous variety of fields and activities. Because of its transversality, it provides effective solutions to many problems that these companies face. Mechanical engineers in Africa are also involved in applied research. They design, develop, build, and test mechanical and thermal devices, including tools, engines, and machines. Mechanical engineers design and oversee the manufacturing of many products like manufacturing many products like power-producing machines, such as power-producing machines such as electric generators, internal combustion engines, and steam and gas turbines as well as power-using machines, such as refrigeration and air-conditioning systems. Like other engineers, mechanical engineers use computers to help create and analyse designs, run simulations and test how a machine is likely to work. Mechanical engineering education should produce graduates who understand the critical role of Mechanical Engineering in the economic development of Africa. Mechanical engineers typically do the following:

- Analyse problems to see how mechanical and thermal devices might help solve a problem.

- Design or redesign mechanical and thermal devices using analysis and computer-aided design.
- Develop and test prototypes of devices they design.
- Analyse the test results and change the design as needed.
- Oversee the manufacturing process for the device.

1.3. Mechanical Engineering Curriculum Reform and Modernisation

An analysis of ME programmes reveals the variety and extent of national aspirations: better service to African economies, and assistance and support in meeting higher education goals; self-sufficiency; effective and efficient implementation of core programmes; and contribution to development. Tuning methodology includes a stakeholder consultation process and provides a foundation on the basis of which to identify strategic goals, objectives and actions, and to build a robust and far reaching curriculum reform.

The diversity of ME programmes in Africa represents both a challenge and an opportunity for the Tuning Project to set the pace and standard for curriculum harmonisation, quality assurance, and enhanced coordination and networking. The broad nature of ME means that effective and efficient curriculum reform would have far reaching outcomes for many other engineering disciplines, thus contributing to their development.

1.3.1. *Strategic Direction*

The main strategic focus of curriculum reform and modernisation should be to build the capacity of African universities to provide quality higher education and to facilitate access to increasing numbers of young people on the continent in order to contribute significantly to increasing the engineer to population ratio. Strong relationships need to be developed among both regional and sub-regional bodies, and university communities within and outside Africa. A new emphasis on university-industry linkages has the potential to meet the educational and development needs across the continent.

In these education reform efforts, an optimum balance must be found between a focus on the knowledge and skills that students are required to learn (higher order thinking skills such as problem solving and industry relevance) and a focus on basic engineering skills and subject theory. The following should be considered: Standards, Higher Order Thinking Skills, Depth Not Breadth, and Link with Industry (industry connection).

1.3.2. *Implementation*

- Identify goals of engineering curriculum change.
- Identify barriers and key success factors in those change efforts.
- Identify attributes of new engineering graduates.
- Assess the success programmes have had instilling those attributes in graduates.

In summary, concerning the Mechanical Engineering, the African development priorities focus on skill acquisition and deal with:

- Mobility within and outside of Africa.
- Recognition of curricula in Africa and abroad.
- Global and social dimension of engineering curricula.
- Quality assurance programme.

The main objective is to train more and more new engineers, with regards to the future. Those engineers are supposed to face global needs and not local ones only. Without neglecting the technical aspect of the training, the following competences should be included:

- Management [and learning?] skills in order to face unemployment.
- Respect for others.
- Innovation and ability to build new products.
- Adaptability to all African countries and outside.

- Flexibility.
- Professional ethics.

According to the Association of African Universities (AAU), "higher education in Africa has been affected by a range of economic and social problems: comparatively low enrolment at all levels; stretched institutional facilities and capacities; insufficient economic, political and logistical support for higher education from African governments and corporations; weak private sector support and an undeveloped culture of private contributions to universities; underdeveloped linkages among universities, industry and governments, and the social and productive sectors of the economy; and human capacity issues such as an ageing faculty and the 'brain drain'."

This is the environment within which development of ME programmes in an African country must occur. Table 1.1 below attempts to draw connection between the structure of African economies and the overall unemployment and poverty levels on the continent.

Table 1.1
A comparative assessment of economic indicators

Countries	Industry's portion of GDP (%)	Agriculture's portion of GDP (%)	% of the labour force in agriculture	% of population below poverty
Egypt	37.4	14.7	32	20.0
Ghana	27.4	24.6	56	28.5
Zambia	33.5	20.0	85	64.0
Malawi	16.9	29.6	90	50.7
South Afrlca	32.1	2.4	9	50.0
Cameroon	30.9	19.8	70	48.0
Ethiopia	14.6	46.6	85	29.2
RD Congo	25.9	38.3	N/A	71.0
Tunisia	28.2	10.5	11.7	15.5

With the notable exception of South Africa, Tunisia and Egypt, other countries possess highly agrarian economies, where most of the labour is employed in the agricultural sector but the contribution of that sector to total GDP is hugely and disproportionately low. The proportions of the populations in the respective countries below poverty level are unacceptably high and linked to the low figures for industrialisation.

This calls for a huge degree of mechanisation and a shift in the structure of the productive sector of African society to a more manufacturing industry-based, value-adding economy. This is where the development of an engineering culture through a conscious effort to increase the engineer to population ratio can play a role and make a difference.

Higher education courses in Mechanical Engineering are offered at the first, second and third cycles in these institutions, usually leading to the award of a Diploma, Bachelor or Master's degree (MSc / MPhil) and PhD in Mechanical Engineering and its related fields. The duration of the first-cycle programmes varies from three to five years, the duration of the second-cycle programmes varies between one and two years, while completing the PhD may vary from three to five years depending on the specific country and university. A typical programme offers broad-based general training for the first two or three years with specialisation in a particular area of Mechanical Engineering occurring in the final stages of the bachelor's degree programme.

Among the challenges facing Africa today is the failure of many African Mechanical Engineering graduates and professionals to work effectively with SMEs, bringing to bear on Mechanical Engineering practices in industry the skills and competences that they are expected to have acquired in their various institutions. It is our belief that the development challenge can be solved if Mechanical Engineering graduates acquire the necessary skills and competences that can help them to revolutionise age-old, traditional Mechanical Engineering by focusing modern skills, competences and technology to improve Mechanical Engineering production and processing across the continent. The project has therefore been committed to identifying the series of generic and specific competences that have, as their primary goal, the advancement of Mechanical Engineering education towards modern reforms.

1.3.3. *Member Countries of the Tuning Africa Mechanical Engineering Subject Area Group*

Mechanical Engineering was identified as a priority subject area. The composition of the Mechanical Engineering group covered the five regions of Africa and the participating universities are referred in Annex (List of Contributors -**List of participating countries, Universities and their representatives).**

The map below gives an illustration of the distribution of Mechanical Engineering training in the Continent. It illustrates on the one hand the richness of the training offer in this field and, on the other hand, its diversity.

The countries in orange are those where we have not identified Mechanical Engineering training: Guinea, Sierra Leone, Equatorial Guinea, Central African Republic, South Sudan and Somalia.

All the other countries have training in Mechanical Engineering with the particularity that those in green are countries where some universities participate in the Tuning Africa project (Author's presentation).

Figure 1.1
Member countries participating in Mechanical Engineering Tuning Project in Africa

Akli Mohand Oulhadj University of Bouira

Akli Mohand Oulhadj University of Bouira (Algeria) obtained university status on June 2012**.** Today, the University structure consists of 6 Faculties, 2 Institutes, 23 Departments and more than 24,000 students, 800 teachers, and about 500 administrative staff, renewed scientific libraries, 8 research Laboratories including 32 research teams on: materials and sustainable development, management and development of natural resources and quality assurance processes for materials, energy, water, environment, computing, mathematics and physics for agriculture and forests, literary and linguistic studies, education, work and guidance, modern sciences of sport and physical activity.

The University provides training according to the professional and academic Licence, Master and Doctorate (LMD) system, and Licence, Magister and Doctorate in Classical in the following fields: sciences and applied sciences, nature, life and earth sciences, literature and languages, social and human sciences, economic, commercial and management sciences, law and political sciences. Taking into account the modern needs of the society, the university updates its specialties and specialisations. The university staff works productively at enlarging the achievements of Akli Mohand Oulhadj University and world pedagogical science, forming the state intellectual potential, creating all the conditions for creative self-realisation and cultural development of the teachers' personality. As a part of the academic and research activities, the university cooperates at all levels, including with the Ministry of Higher Education and Scientific Research.

University of Yaoundé I

Université de Yaoundé I (UYI) is the largest university pole in Central Africa. Its 95-hectare campus is located in the heart of the city of Yaoundé, capital of Cameroon, an agglomeration of 3 million inhabitants. The UYI has 57,000 students and 1,300 teachers. The UYI has successfully accredited its trainings internationally. Bilingualism (French-English) is its particularity. Its commitment to the process of internationalisation and harmonisation is marked by its active participation since the beginning in the Tuning-Africa project and several other interuniversity networks. Its experience of hosting international students led it to develop its procedures (administrative facilities, visas, housing, insurance, payment of scholarships). UYI has been selected by the World Bank as a Centre of Excellence in Information and Communication Technologies (CETIC) for its strong positions in IT, Telecommunications and Mechanical Engineering. Several UYI teachers were awarded the African Union Kwame Nkumah Award for their achievements in science.

University of Lubumbashi (UNILU)

The University of Lubumbashi (UNILU) is a public university in the Democratic Republic of Congo, located in Katanga Province, Lubumbashi City. Founded in 1955, the university is successively named: Official University of Congo and Rwanda-Urundi, State University of Elizabethville, Official University of Congo, National University of Congo / Lubumbashi Campus, National University of Zaire / Campus from Lubumbashi and finally Lubumbashi University. It has nearly 33,000 students in 10 faculties and 4 colleges. The language of instruction is French.

Egypt-Japan University of Science and Technology (E-JUST)

Egypt-Japan University of Science and Technology (E-JUST) is a research-oriented university with the ambition to cultivate an academic environment and become a benchmark for Egypt and other African countries in Education. It was first established as a bilateral agreement project between the Egyptian and Japanese governments in May 2009 and later in 2010 it was ready to accept its first batch of students and make the dream a reality. Also, E-JUST is planning to open undergraduate school in September 2018 and is preparing 7 programmes, including the "Mechatronics" programme. E-JUST has been able to participate in the Mechanical Engineering SAG of Tuning Africa, Phase II.

Cairo University

Cairo University is one of the universities that participated in the Tuning Africa project, in both phases. It is the oldest university in Egypt (established in 1908) but the Faculty of Engineering is older than the university. It goes back to the beginning of engineering education in Egypt, in 1816. The building of the Faculty of Engineering (Building College now at Giza) was established in 1905 and the mechanical study specialisation started in 1916.

The Faculty of Engineering of Cairo University participates in the Tuning Africa project by revising and improving the Mechanical Design Engineering programme. This is a new programme that has been established, using a credit hour system, in 2008.

Jimma University

Jimma University (JU) established in December 1999 by the amalgamation of Jimma College of Agriculture (founded in 1952), and Jimma Institute of Health Sciences (established in 1983), is Ethiopia's first innovative Community Oriented Education Institution of higher learning. It has four campuses located in Jimma city, 352 km southwest of Addis Ababa, with an area of 409 hectares. JU has more than 100 undergraduate, 30 postgraduate and 3 PhD programmes, which are offered in different disciplines including Medicine, Engineering, Agriculture, Business, Social and Natural Sciences. The core philosophy of JU is integration of teaching, research and service. It is structured under 5 colleges, one school and two institutes, of which the Institute of Technology is one. Currently it is ranked second among 42 federally funded universities in Ethiopia but consistently standing first for overall educational performance for the past few years. It has a student enrollment in excess of 43,000 with an academic staff of 1,300 and an administrative staff of 1,800. JU aspires to become the leading public higher educational institution in Ethiopia, renowned in Africa and recognised in the world.

Eritrea Institute of Technology (JiT)

Faculty of Technology in JU was established in September 1997, restructured as College of Engineering and Technology in 2009 and it became JiT in the year 2011 consequent to the greater thrust and order of magnitude increases in student admissions to Engineering-related programmes. Currently, it has a student enrollment of 9,500 in 8 undergraduate programmes and 6 Master Programmes in addition to sandwich Ph.D programmes. The academic staff number around 263 with 445 administrative staff. Mechanical Engineering, one of the founding departments in 1997, stands out for the best overall performance, with a student enrollment at present of 1,650. This Faculty has participated in Tuning Africa, Phases II.

Kumasi National University of Science and Technology

KNUST located in Kumasi, Ghana is a regional academic centre of excellence, spearheading West Africa's pursuit of technological advancement. It started as the Kumasi College of Technology

(KCT) which was established in 1951. KCT became a full-fledged University and was renamed Kwame Nkrumah University of Science and Technology in 1961 by an act of parliament. It has a student population of over 45,000 with six colleges (Agriculture and Natural Resources, Architecture and Planning, Art and Built Environment, Engineering, Health Sciences and Science) as well as a vibrant Institute of Distance Learning. The College of Engineering has nine departments (Agricultural Engineering, Chemical Engineering, Petroleum Engineering, Petrochemical Engineering, Civil Engineering, Geological Engineering, Materials Engineering, Materials Engineering and Metallurgical Engineering) and two research centres (Technology Consultancy Centre and The Brew-Hammond Energy Centre).

The Mechanical Engineering Department at KNUST runs the following programmes: BSc in Mechanical Engineering, BSc in Aerospace Engineering, MSc in Sustainable Energy and Management, MSc in Renewable Energy Technologies and PhD in Sustainable Energy.

University of Malawi

Malawi has four public Universities and about thirteen private Universities. The University of Malawi is the oldest University in Malawi, established in 1964. It is abbreviated to UNIMA. It has four constituent colleges situated in the three cities of Blantyre, Zomba and Lilongwe. University of Malawi - The Polytechnic is one of the constituent colleges of UNIMA, situated in Blantyre. It is the main institution offering higher education in engineering in Malawi since 1965. The College has five academic faculties, 17 departments offering 1 certificate programme, 16 diploma programmes, 45 bachelor's programmes, 23 master's programmes and 16 PhD programmes. The Polytechnic enrolls a student population of about 6,500. There are 256 academic members of staff, and 224 administration and support staff.

The Faculty of Engineering was established in 1965. The first engineering programmes offered were Diplomas in Engineering with some limited measure of specialisation in Civil, Mechanical and Electrical Engineering. In 1980, a general six-year engineering degree was introduced. Specialisation in Civil, Electrical and Mechanical Engineering was introduced later in 1987 and the duration of the degree programme was reduced to five years. The Faculty now offers fourteen specialised undergraduate programmes in: Civil Engineering – Water, Structures, and Transportation; Electrical Engineering - Electrical and Electronics, Electronics and Computer, Electronics and Telecommunications, and Biomedical; Mechanical Engineering, Industrial, Energy, Automobile; Mining Engineering, Geological Engineering, Metallurgy and Mineral Processing. The Faculty also offers postgraduate programmes: MSc, MPhil and PhD in Infrastructure Development and Management; MSc in Sustainable Engineering Management specialising in Facilities, Water, and Mining; and PhD in Industrial Engineering; Energy. Current student enrolment for Bachelor's programmes is 210 per year of which 27 percent are female students. There are 60 members of staff in the Faculty of which five are female. The Faculty also hosts the following units/centres: Transport Technology Centre; Water, Sanitation Health and Appropriate Technology Development Centre and Polytechnic Commercial and Technical Services unit. The Civil Engineering Departments also offers a commercial materials testing centre. In addition, the Faculty has a Design Studio.

Cape Peninsula University of Technology

The Cape Peninsula University of Technology was established on 1 January 2005, when the Cape Technikon and Peninsula Technikon merged. This merger was part of a national transformation process that transformed the higher education landscape in South Africa. However, the institution has humble beginnings in the Cape Technikon and Peninsula Technikon, which dates back to the early 1900's.

Today, this institution, based in Cape Town, is the only university of technology in the Western Cape and is the largest university in the region, boasting more than 30,000 students, several campuses and service points, six faculties offering more than 70 programmes. The six faculties are: Applied Sciences, Business and Management Sciences, Education, Engineering, Health and Wellness Sciences and, lastly, Informatics and Design.

The Faculty Engineering consists of the following departments in alphabetical order: Construction management and Quantity Surveying, Chemical Engineering, Civil Engineering, Clothing and Textile Technology, Industrial and Systems Engineering, Geomatics (Surveying and Cartography), Mechanical Engineering and Mechatronics.

The Faculty of Engineering covers a broad range of engineering disciplines, which are currently being reformed to respond to the demands of regional, national and global industry priorities in engineering education. Through a range of multi-disciplinary research institutes and centres, the Faculty aims to integrate its education and research programmes into a cohesive system, providing students with modern technology platforms for relevant and industry-responsive education, with a high degree of work-integrated learning. These platforms include the Product Life Cycle Management Competency Centre, providing state-of-the-art education in product design through simulation and life-cycle management, the Advanced Manufacturing Technology Laboratory, and the Centre for Substation Automation and Energy Management Systems, to mention a few. Through this approach, the Faculty aims to emerge as a major driver of socio-economic change in the region.

The Mechanical Engineering department offers the following programmes: National Diploma (ND); Bachelor of Engineering Technology (B.Eng. (Tech)); Bachelor of Engineering Technology (B.Eng.(Tech)(Hons)); Masters in Engineering (M. Eng) and Doctor of Engineering (D.Eng).

National Engineering School of Tunis (ENIT)

Founded in 1968, École Nationale d'Ingénieurs de Tunis (ENIT) is the oldest of the technological engineering schools in Tunisia. Since its creation, it provided Tunisia, which had just recovered its independence, its senior technical staff who designed and built the country's first civilian and industrial infrastructures (road networks, works, dams, electricity, factories, etc.). The training offer of ENIT since then has constantly evolved to meet the needs of the Tunisian economy for engineers capable of production, enterprise and innovation. Since its creation, ENIT has trained around 12,000 engineers, many of whom hold positions of high technical or managerial responsibility at the head of public services, public and private companies both in Tunisia and abroad. Admission to ENIT is mainly through the National Exam for Entry to Engineering Schools. Those admitted to ENIT are among the highest ranked candidates in the competition. In the framework of double degree agreements with prestigious French engineering institutions, each year about 60 engineering students (about 15% of the cohort) go to France to obtain a second degree.

Open to the world and to society, well equipped to address economic problems related to enterprise and with a strong scientific and technological background, ENIT graduates are able to perform functions with high technical, scientific and managerial added value in different economic sectors: equipment, transport, management, urban services, companies producing goods and services, environment, energy, sustainable development, and new technologies.

In September 2017, the EUR-ACE Master label was awarded to the nine (9) engineering degrees from ENIT for a maximum duration of 6 years. This label means, on the one hand, that the training meets international quality standards, and on the other hand that it has been accredited by an agency that meets the most demanding European standards. This accreditation guarantees the scientific and academic quality of the engineering degree programmes and also guarantees their relevance for the practice of engineering. These guarantees are an advantage for both students and graduates.

Copperbelt University

In Zambia there are four categories of engineering-related professionals: engineers, technologists, technicians and those in the craft trades. Three institutions offer Mechanical Engineering degree programmes, five offer diplomas and ten offer craft trade certificates. With the number of engineering degrees granted annually standing at 500, an estimated 100 Mechanical Engineering degrees are granted annually, which translates into one Mechanical Engineering degree granted annually per every 130,000 Zambian citizens. A National Qualifications framework is in place and a Higher Education Authority began in 2013, while TEVET, a governmental authority, regulates engineering and technical education. A person must obtain a degree from a recognised university to qualify him/herself to be called an engineer, and the title “engineer” is protected by law. All engineers, as well as engineering firms, must be registered with the Engineering Institute of Zambia to be allowed to practise. Membership is renewable on a yearly basis. In addition, a firm must reach a minimum number of engineers before it can be called an engineering firm.

The countries and the universities participating in the Mechanical Engineering SAG, along with the names and contact details of their representatives are presented in Annex.

1.4. Types of Degree Programmes in Mechanical Engineering

In the past, the number and size of ME Programmes offered in African universities have been low: in Ghana only one university offered ME at the degree level for over 40 years but now, as in Zambia, there are three, and the number of ME graduates has increased correspondingly. A similar picture can be painted of Ethiopia where great strides are being made in changing the Science and Technology/Social Science enrolment ratio from 30:70 to 70:30, translating directly into increases in the yearly enrolment in ME Programmes (from 800 average to 5,000 average) in the coming few years. In Algeria, they are more than fifty schools and universities providing graduating courses in mechanical engineering. In Cameroon, general enrolment figures have exceeded existing capacities, now reaching 150 engineers per year. Even though Malawi has only one university offering HE in engineering, there, too, the numbers have shot up. However, in a few countries such as Egypt and South Africa, there are relatively high numbers of engineering bachelors per capita which places them not far behind countries like the USA and Germany. Even so, in South Africa there are still plans to boost the numbers of engineering graduates from 7,888 to 15,000 per year by 2014. In 2009 alone, 1,459 ME degrees were granted at the BSc level plus 111 at the postgraduate level. In summary, for many years there have been relatively small and few ME programmes in African universities but in recent years the numbers have been increasing, albeit slowly. There appears to be an interesting confluence of efforts in African universities to boost the number of ME graduates by either increasing the number of universities offering such programmes or by increasing the intake into existing ME programmes.

These signals progress and highlight the need of restructure ME programmes and their curricula to meet future challenges. Countries that grow at a rapid economic rate are known generally to have higher engineer to population ratios. This ratio also determines the success (in extent and quality) of a country's infrastructure development programme. Comparatively speaking, African countries in general have engineer to population ratios that lag far behind developed and other developing countries. Africa owes this disproportion to its reliance on a predominantly agrarian economy as well as on foreign technical expertise. Even though growth of engineering graduates is increasing, this growth is far from adequate and is not enough to meet Africa's need for Mechanical Engineering skills.

1.5. Core Elements of Mechanical Engineering Studies

The Mechanical Engineering (ME) group agreed that first cycle degrees (bachelor or undergraduate) facilitate professionally qualifying studies in ME suitable for early professional careers (professional qualification), as well as providing quality graduates for advanced scientific degree programmes or for additional degree programmes in areas other than Mechanical Engineering. The professional profile of ME was discussed in detail for width and depth concerning specialisations within the field. The core specialisations in ME, to be found in most of the universities, are shown in the figures given below along with the key professional tasks associated with them. The core tasks entail the acquisition of knowledge (integrative capability) by the student through the profiling of ME curriculum.

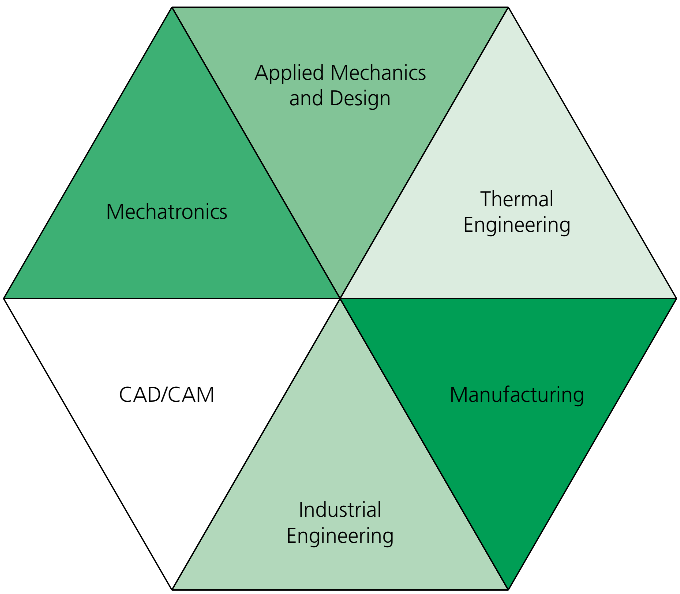


Figure 1.2
Core Specialisations in Mechanical Engineering

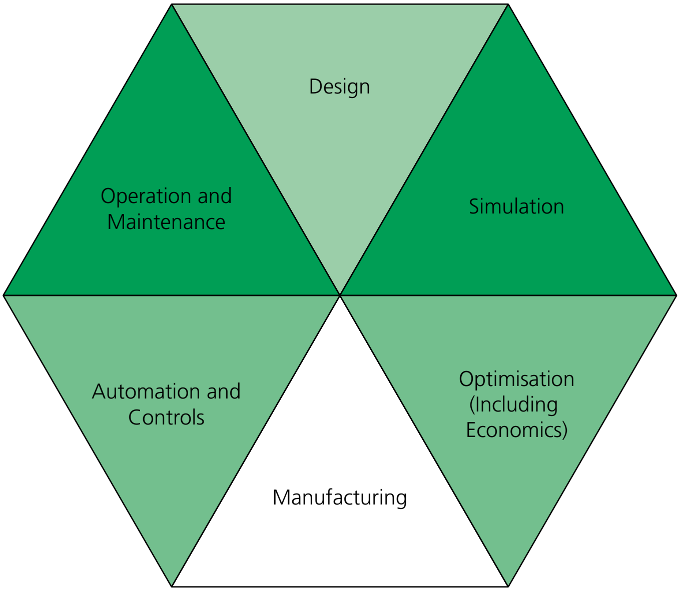
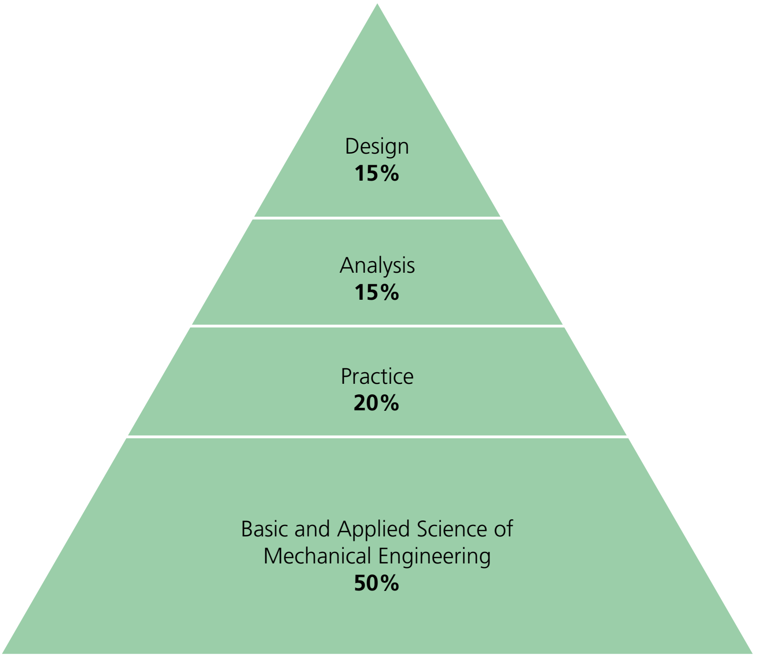


Figure 1.3
Core Tasks in Mechanical Engineering

After taking an overview of the degree profiles from the participating universities and considering the specific learning outcomes for ME first cycle study programmes, a consensus has emerged with regard to the core elements of ME curriculum. These are depicted, below in the form of a pyramid, with their weightings in percentages on an average.

The figure above shows in a simplistic way the complexity of Mechanical Engineering training which takes into account both basic and applied science elements as well as more specific elements such as design, analysis and practice.

Mechanical Engineering is the body of knowledge related to mechanics, the physical sense of movement science and the technical sense of the study of mechanisms. This field of knowledge ranges from the design of a mechanical product, through its manufacture, maintenance and recycling. The difference from one mechanical engineering training system to another is clearly dependent on the weighting assigned to each of the rubrics of basic training, business practice, design and analysis.



Two important lessons can be drawn from this chapter: the first being that in the context of facilitating the mobility of students and teachers in a harmonised African higher education area, questions of comparability of curricula are of vital importance. The Tuning Africa methodology, which raises the problem of comparability in terms of the skills acquired by the learner during the learning period, is a means of maintaining a constructive dialogue between universities that does not overlap with the specific training traditions of each university or to each country. Better yet, Tuning Africa defines a framework of consultation that also involves companies in the process of curriculum development. This is where the second lesson is specific to Mechanical Engineering because the progress of African countries towards economic development makes it imperative to train technologists who can lead projects of industrialisation. Mechanical Engineering, which deals with the design, analysis, manufacturing, installation, operation and maintenance of mechanical systems, appears in a good place for the sectors to be developed by these countries wishing to have a strong and productive industrial sector. All this explains why this discipline is so widely spread in African universities.

It is easy to understand that to be effective, this training needs to be structured in order to respond adequately to the needs of companies. The advantage of the Tuning Africa methodology is to clearly and effectively involve companies in the process of curriculum development, which in the case of Mechanical Engineering is fundamental to employability.

This chapter shows precisely that, even in a context where the traditions of formation are different, it is possible to reach out in a consensual way metaprofiles which highlight the main articulations on which can build a curriculum acceptable to all.

Chapter 2

Definition of Generic Competences: A Thematic Perspective

As far as ME is concerned, the process of defining the generic competences at the level of BSc or MSc was implemented by the Tuning Africa Mechanical Engineering Subject Area Group following a round table meeting and extensive brainstorming among group members based on a scope of Mechanical Engineering and the professional profile of a Mechanical Engineer as well as a broad description of the required competences. A touch of African flavour was added at this stage by including perspectives from specific programme profiles from some specific African countries, resulting in 18 generic competences to cover all subject area groups on the basis of commonality and universal relevance as shown in Table 2.1, here below:

Table 2.1
List of Generic Competences

1	Ability for conceptual thinking, analysis and synthesis
2	Professionalism, ethical values and commitment to UBUNTU*
3	Capacity for critical evaluation and self-awareness
4	Ability to translate knowledge into practice
5	Objective decision making and practical cost effective problem solving
6	Capacity to use innovative and appropriate technologies
7	Ability to communicate effectively in official /national and local language
8	Ability to learn to learn and capacity for lifelong learning
9	Flexibility, adaptability and ability to anticipate and respond to new situations
10	Ability for creative and innovative thinking
11	Leadership, management and teamwork skills
12	Communication and interpersonal skills
13	Environmental and economic consciousness
14	Ability to work in an intra and intercultural and/or international context
15	Ability to work independently
16	Ability to evaluate, review and enhance quality
17	Self-confidence, entrepreneurial spirit and skills
18	Commitment to preserve and add value to the African identity and cultural heritage

* UBUNTU (respect for the well-being and dignity of fellow human beings).

2.1. Brief Analysis of the 18 Agreed Generic Competences from a ME Perspective

1. *Ability for conceptual thinking, analysis and synthesis*

A key function of Mechanical Engineering, like many other disciplines, is to provide solutions to real-life problems. This competence corresponds to the ability to construct mental representations of possible solutions to a problem (an ME problem in an ME context), taking into consideration the various dimensions and implications as well as the relevance of each possible solution.

2. *Professionalism, ethical values and commitment to UBUNTU (respect for the well-being and dignity of fellow human beings)*

This is the ability to ensure compliance with accepted norms and guidelines governing the practice of a profession, bearing in mind what is right and fair to all parties to a transaction, project or system (including an ME system) from a legal, moral or human dignity perspective.

3. *Capacity for critical evaluation and self-awareness*

This is the ability to carefully and correctly assess and appraise identified systems or situations with a view to determine their merits, value or shortcomings and present an overall picture of such systems (and by extension ME systems) as a basis for decision making.

4. *Ability to translate knowledge into practice*

This relates to the capacity to adjust, modify or adapt acquired knowledge and connect it to a real life problem or situation. In the ME context, such knowledge must lead to the solution of an ME problem.

5. *Objective decision making and practical cost effective problem solving skills*

This is the ability to make straightforward, unbiased (ME) and cost-effective decisions, with the understanding that problem solving should not be influenced by friendship, emotion, retaliation, or other such factors that might otherwise cloud the process or reduce its validity in the eyes of the persons concerned.

6. *Capacity to use innovative and appropriate technologies*

This represents the ability to find or discover new technologies or follow up (ME-related) developments thereof, put them to good use or adapt them to a given situation.

7. *Ability to communicate effectively in official/national and local language*

This is the ability to easily and effectively express or make known one's own or a group's thoughts and feelings, or give information either in writing, orally (in official, national or local language), or by some other means, such as diagrams, pictures or objects pertaining to a particular discipline, so that the target group can appraise and understand the message.

8. *Ability to learn how to learn and capacity for lifelong learning*

This is the readiness, willingness, and capacity to assimilate, update, upgrade, and enhance (ME) knowledge on a continuing basis throughout one's life.

9. *Flexibility, adaptability and ability to anticipate and respond to new situations*

This is the ability to think fast and foresee how (ME) systems may change or new (ME) situations may arise, and how to respond appropriately in order to protect or preserve the systems.

10. *Ability for creative and innovative thinking*

This is the ability to originate completely new ideas (or concepts in ME), or ideas which, though not new, may be applied to new situations to solve problems.

11. *Leadership, management and team work skills*

These skills (including ethics, duty consciousness, personal integrity, efficiency and planning skills) underscore one's capacity to effectively work in a team or in a group (including ME work groups) especially, where one has the responsibility to steer and manage the group.

12. *Communication and interpersonal skills*

Universally, this is basically the ability to be clear and articulate in verbal and body language expression as well as the ability to relate smoothly with people. In the ME context, communication extends far beyond verbal expression to include proficiency in communicating technical information through such media as engineering drawings, sketches, symbols and models, as well as correct understanding and use of technical terms in verbal communication itself.

13. *Environmental and economic consciousness*

This is the ability to develop a keen awareness of the link between economic activity and environmental degradation and take measures within one's power to mitigate or limit such degradation where possible. For Mechanical Engineers, this means fully understanding the environmental implications of Mechanical Engineering products, activities and installations and the responsibility that this places on them to ensure preservation of the environment.

14. *Ability to work in an intra- and intercultural and/or international context*

This is the ability to work well with people of all races or ethnic backgrounds, whether in one's home or in a foreign setting. It calls for understanding of cultures other than one's own and may require adapting to the idiosyncrasies pertaining to those cultures. For Mechanical Engineers, this requires familiarity with local and national norms and standards as well as international standards governing ME design and manufacturing, such as those issued by national standards institutions and ISO.

15. *Ability to work independently*

This is the ability to work well, i.e. efficiently and effectively, under no supervision. It requires being knowledgeable about one's work and which sources to consult for further information, the ability to plan, and the ability to direct and manage time effectively to achieve desired results. For a mechanical engineer, this means imperatively knowing what sources, including handbooks, to consult for technical information without depending unduly on colleagues, especially on small projects.

16. *Ability to evaluate, review and enhance quality*

This is the ability to determine the quality status of an entity and take appropriate measures to enhance that quality. For a Mechanical Engineer, it is the capacity to use appropriate tools to assess the quality status of a ME system or product and to use similar tools such as statistical quality control/assurance techniques to enhance the quality of those ME systems/products.

17. *Self-confidence, entrepreneurial spirit and skills*

This is the quality of being sure of oneself in terms of acumen and ability to deliver good results from a business point of view. For mechanical engineers, such self-confidence is usually the result of the authority conferred by one's technical competence and professional skills. It therefore requires the ability to learn fast on the job to drive out the self-doubt syndrome usually associated with first-time practitioners and to progressively build the required authority which can ensure self-confidence without drifting into overconfidence.

18. *Commitment to preserve African identity and cultural heritage*

This is the pride of the African in his/her cultural heritage and an enduring commitment to preserve that heritage through differentiation where possible or necessary so that the African identity can stand out in bold. For the African Mechanical Engineer, this means pride in bringing out this difference as and when appropriate, in order to reflect Africa's identity in ME products.

2.2. Important Aspects not Considered in the Initial List of Agreed Generic Competences

1. *Commitment to safety*

This competence was initially proposed by the ME group for inclusion in the list of generic competences but was not chosen. Perhaps this neglect may be a reflection of the generally low safety awareness in most African societies. However, the ME group later included it in their list of subject-specific competences to highlight its importance in Mechanical Engineering systems.

2. *Ability to negotiate and resolve conflicts*

This aspect is not explicitly addressed. However, it could be argued that possession of good managerial and interpersonal skills, which are adequately addressed by the selected generic competences, may imply that conflict situations can be minimised or effectively handled whenever they arise.

3. *Ability to undertake research at an appropriate level*

Research skills in African societies are generally undeveloped and should receive high priority and urgency. Because of the low importance accorded to research and development, product related innovation capacity is correspondingly low in most African cultures.

4. *Skills in the use of ICT*

Though the overall Generic Competences set ignored the importance of ICTs, the ME group included it in their list of subject-specific competences to underscore its importance in mechanical engineering product conceptualisation, design, analysis, and manufacturing.

2.3. Conclusion

This chapter addresses an issue that for a long time has been the stumbling block between African universities in the process of mutual recognition of curricula and degrees. For many of these countries, the basic criterion of comparability was the duration of studies which conveys the idea that the longer the studies, the more the learner has acquired knowledge.

By presenting in an exhaustive manner the question of generic competences and subject-specific competences, the elements underlying the comparability of Mechanical Engineering courses, which are perfectly understandable by companies, are thoroughly examined. Even beyond the broad spectrum of training covered by Mechanical Engineering and clearly detailed in the literature, it is important to understand that what is most important to the learner is the question of employability at the end of the training process and that to guarantee this employability, companies make a fixation on the competences acquired by the learner.

Chapter 3

Identification of Subject-specific Competences

The members of SAG Mechanical Engineering held fruitful and extensive deliberations during the Tuning Africa meeting held at Yaoundé, Cameroon, on 23-25 January 2012, in order to agree on a common definition of Mechanical Engineering in Africa and thus developed an appropriate professional profile of the graduate Mechanical Engineer.

Earlier Tuning projects (Europe, Latin America and Russia) did not include Mechanical Engineering, so the Mechanical Engineering SAG used, as its key institutional reference, the set of competences for Mechanical Engineering training employed by the American National Accreditation Board for Engineering Training (ABET, 2020). In addition, the working group consulted specific programme profiles from Ethiopia and NARS regulations from Egypt. Nineteen subject-specific competences were agreed by the ME subject area group. They are presented in Table 3.1 below along with a brief definition of each one.

Subject-specific competences refer to the knowledge, skills, abilities and values that should be possessed by individuals who have gone through a period of certified study on a particular subject. The Mechanical Engineering Subject Area expert group deliberated upon the competences that they expect their graduates to possess after going through the first-degree programme in Mechanical engineering.

Table 3.1
Subject-specific Competences Identified

1	Ability to apply knowledge of the basic and applied sciences of mechanical engineering.	This is the ability first to draw, and second to understand a connection between a real-life situation or problem and the Mechanical Engineering (ME) sciences and how these sciences can be used to model and/or solve those real-life problems.
2	Ability to identify, evaluate and implement the most appropriate technologies for the context in hand.	This is the ability to recognise the needs of any given situation with a capacity not only to assess the Mechanical Engineering requirements of such situation but also to be able to apply the simplest, most efficient and cost effective Mechanical Engineering solutions to them.
3	Capacity to create, innovate and contribute to technological development.	This is the ability to contribute to the improvement of technology through the introduction and implementation of new concepts or ideas that work to make the technology better.
4	Capacity to conceive, analyse, design and manufacture mechanical products and systems.	This competence enables a Mechanical Engineer to originate the idea for a new Mechanical Engineering product or system and to take it systematically through the full gamut of product realisation activities / procedures until a real ME product or system is actualised.
5	Skills in planning and executing mechanical engineering projects.	These are skills in Project Management such as planning, scheduling and logistics mobilisation applied to Mechanical Engineering works and assignments.
6	Capacity to supervise, inspect and monitor mechanical engineering systems.	Ability to be in full charge and control of active Mechanical Engineering systems with capability to track closely the behaviour of such systems to effect appropriate adjustments to maintain the system at a desired level.
7	Capacity to operate, maintain and rehabilitate mechanical engineering systems.	Given an existing Mechanical Engineering system, this is the capability to cause the system to function properly as designed and to retain it in a state fit for continual use.
8	Skills in evaluating the environmental and socio-economic impact of mechanical projects.	This is the ability to understand and appreciate the environmental degradation potential and implications of Mechanical Engineering products, activities and installations and the adverse environmental effects that can be caused by the end-of-life retirement of such systems.

9	Capacity to model and simulate Mechanical Engineering systems and processes.	This is the ability to evolve acceptable representations of real Mechanical Engineering systems that can be studied for purposes of optimisation of the key performance parameters of such systems.
10	Skills in selecting, mobilising and administering material resources, tools and equipment cost-effectively.	Possession of practical knowledge of the properties, structure and behaviour of Mechanical Engineering and related materials, components and equipment that enables one to properly select and mobilise them for acceptable functionality while achieving cost and quality optimisation.
11	Capacity to integrate legal, economic and financial aspectsin decision-making in Mechanical Engineering projects.	Capacity to design, manufacture or operate Mechanical Engineering products or systems within legal constraints while ensuring that the design principles for economic manufacture and assembly are followed.
12	Capacity for spatial abstraction, graphic representation and engineering drawings.	Capacity to conceptualise 2- and 3-dimentional mental representations of mechanical systems and translate these into solid and other models using either the computer or manual engineering drawing methods.
13	Providing mechanical engineering solutions to societal problems for sustainable development.	Ability of the engineer to relate and connect well with his / her socio-economic setting as a foundation for offering practical, real solutions to real problems in the community.
14	Skills in safety and risk management in Mechanical Engineering systems.	Skills in safety management imply an ability to appreciate and anticipate all the safety loopholes in a Mechanical Engineering system and take appropriate, systematic steps to ensure their elimination or protection against them by actual action. Risk management skills involve identifying all possible risks, classifying or rating them in terms of their magnitude and frequency and taking appropriate steps to mitigate them, paying attention to the most threatening ones.
15	Skills in using information technologies, software and tools for Mechanical Engineering.	This is the ability to leverage information and communication technologies, including computer software, to impact the Mechanical Engineering function in its dimensions for the purposes of achieving speed, higher quality, consistency and repeatability as well as cost reduction.

16	Capacity to interact with multidisciplinary groups towards developing integrated solutions.	This represents the ability to learn fast and to have a fair knowledge of the disciplines that commonly interact with Mechanical Engineering systems so that when working within a multi-disciplinary environment, the Mechanical Engineer will be literate enough to communicate effectively with engineers and professionals from other disciplines.
17	Skills in employing quality control techniques in managing materials, products, resources and services.	An appreciation and understanding of Total Quality principles that assure quality in Mechanical Engineering products and systems from conceptualisation to system realisation. These must include knowledge of statistical methods of quality assurance and control.
18	Capacity to conduct life cycle assessment for products and systems.	This is the ability to consider in detail, all the important stages in the life of Mechanical Engineering systems in terms of their individual, as well as their collective and total impact with regard to issues such as product development, acquisition, installation and usage costs, as well as product / system end-of-life retirement and disposal costs and how these activities might impact adversely on the physical environment.
19	Capacity to employ Mechanical Engineering skills to transform local natural resources into products or services through value addition.	Ability to Mechanical Engineering by working together with other engineers to come out with Mechanical Engineering systems that exploit local natural resources by converting them into commercially useful products and systems.

Generally speaking, in the field of Mechanical Engineering, there is a very wide range of training available in Africa leading to the issue of a parchment called a Mechanical Engineering Diploma. Bachelor of Science (B.Sc. or BS), Bachelor of Science (B.Eng., BE), Bachelor of Science (B.Sc. or BS), Bachelor of Science Engineering (B.Sc.Eng.), Bachelor of Technology (B.Tech.), Bachelor of Mechanical Engineering (BME), or Bachelor of Applied Science (BASc.) Degree in or with emphasis in Mechanical Engineering. Before the degree can be awarded, a student must complete 3 to 6 months on the job in an engineering firm. Similar systems are also present in South Africa and are overseen by the Engineering Council all over the Continent.

This chapter shows that in the context of teamwork between universities from different countries, it is possible to arrive at a shared definition of the essential skills that characterise successful training in Mechanical Engineering.

Chapter 4

Consultation and Reflections

Introduction

The stakeholder consultation process is one of the key steps in the Tuning Africa approach. It all starts with the definition of generic skills and specific skills for a given field of study. After this step, there is the question of what is the relative importance of each skill. The answer to this question, in the case of Tuning, is through a process of consultation with stakeholders at training. The statistical processing of the data thus collected makes it possible to rank the skills in order of importance and to consider the crucial stage of the construction of metaprofiles, which will be discussed in the next chapter.

4.1. The Consultation Process

The Mechanical Engineering Subject Area Group carried out an extensive consultation with stakeholders by means of a questionnaire. Questionnaires on generic and subject-specific competences were sent to academics, students, employers and graduates. Respondents were asked to rate the importance of the eighteen generic and nineteen subject-specific competences and the extent to which they thought these competences are currently being achieved. Respondents were also asked to rate each of these two kinds of competences on a four-point scale in which 1 = "none", 2 = "weak", 3 = "considerable" and 4 = "strong".

A total of 4,323 respondents provided answers to the Generic Competences questionnaire including 579 Mechanical Engineering stakeholders, and a total of 3,812 respondents provided answers to the questionnaire on Subject-specific Competences, including 494 from the Mechanical Engineering subject group. Responses from Mechanical Engineering subject group represented about 13% out of all responses to the questionnaires.

4.2. Analysis of Consultation Results for the Generic Competences

The Mechanical Engineering SAG conducted analyses of the data resulting from the consultation, focusing on the perceived levels of importance, achievement and ranking of the competences. Table 4.1 indicates the responses of the Mechanical Engineering stakeholders with regard to the common eighteen generic competences. The competences are ordered top-down by ranking of importance. The corresponding medians of levels of achievement are recorded for each competence. The comparison between the two indicated the perceived size of the gap between importance and achievement. For the eighteen common Generic Competences, the top seven, the bottom seven and the middle four generic competences were identified.

4.2.1. *Explanation and Observation of the Results Generic Related Competences*

Table 4.1 indicates that the academics and students agreed on the rating for the top position "Ability to translate knowledge into practice" (No. 4) which is rated second by the employers and the graduates. The "Ability for conceptual thinking, analysis and synthesis" (No. 1) was rated at the top by the graduates, as the third most important by the academics and the sixth by the employers. "The Objective decision making and practical cost-effective problem solving" (No. 5) was rated at the top by employers, as the third by the graduates and the sixth by the students. "Professionalism, ethical values and commitment to UBUNTU (respect for the well-being and dignity of fellow human beings)" (No. 2) was rated as the fifth in importance by the academics and below the top seven by the other groups. "Self-confidence, entrepreneurial spirit and skills" (No. 17) was considered among the first seven competences by all stakeholders. The academics and the students agree on rating "Ability for creative and innovative thinking" (No. 10) as the second most important competence while it is rated seventh by employers and fifth by the graduates. The indicators of Table 4.1 are summarised in Table 4.2.

Table 4.1

Main Features of Mechanical Stakeholders Responses to Questionnaires of Generic Competences

	Data of all Areas Stakeholders' Responses to the Questionnaire on Generic Competences															
	Academics				Employers				Students				Graduates			
	Competences	Importance	Achievement	Gap	Competences	Importance	Achievement	Gap	Competences	Importance	Achievement	Gap	Competences	Importance	Achievement	Gap
Top Seven	4	3.81	2.85	0.96	5	3.74	2.47	1.27	4	3.76	2.60	1.16	1	3.75	2.84	0.91
	10	3.66	2.94	0.72	4	3.74	2.38	1.36	10	3.74	2.81	0.93	4	3.74	2.60	1.14
	1	3.63	2.77	0.86	12	3.70	2.51	1.19	11	3.69	2.94	0.75	5	3.64	2.81	0.83
	6	3.59	2.82	0.77	17	3.69	2.49	1.2	6	3.65	2.49	1.16	6	3.63	2.63	1.00
	2	3.58	2.61	0.97	11	3.69	2.64	1.05	17	3.63	2.53	1.10	10	3.63	2.61	1.02
	17	3.57	2.8	0.77	1	3.69	2.81	0.88	5	3.63	2.79	0.84	17	3.61	2.48	1.13
	11	3.53	2.84	0.69	10	3.67	2.53	1.14	9	3.60	2.73	0.87	11	3. 6	2.81	0.79
Middle Four	15	3.52	2.74	0.78	16	3.66	2.62	1.04	16	3.60	2.69	0.91	16	3.59	2.66	0.93
	16	3.49	2.76	0.73	6	3.66	2.66	1.00	12	3.52	2.87	0.65	12	3.56	2.67	0.89
	5	3.47	2.67	0.8	2	3.64	2.51	1.13	1	3.52	2.91	0.61	3	3.53	2.54	0.99
	7	3.45	2.7	0.75	9	3.62	2.70	0.92	3	3.48	2.75	0.73	2	3.51	2.52	0.99
Bottom Seven	9	3.43	2.73	0.7	8	3.56	2.75	0.81	7	3.47	2.9	0.57	15	3.48	2.75	0.73
	3	3.42	2.56	0.86	7	3.47	2.64	0.83	15	3.47	2.86	0.61	9	3.46	2.77	0.69
	12	3.37	2.66	0.71	15	3.47	2.67	0.8	2	3.45	2.55	0.91	7	3.46	2.76	0.7
	13	3.33	2.65	0.68	3	3.43	2.44	0.99	13	3.46	2.56	0.84	8	3.35	2.83	0.55
	8	3.27	2.77	0.5	14	3.41	2.48	0.93	8	3.38	2.76	0.62	14	3.38	2.4	0.95
	14	3.25	2.38	0.87	13	3.36	2.4	0.86	14	3.26	2.39	0.87	13	3.35	2.44	0.91
	18	3.18	2.32	0.86	18	3.05	2.4	0.65	18	3.22	2.25	0.97	18	3.2	2.1	1.1

Table 4.2
Indicators of the stakeholders´ responses to the Questionnaire on Generic Competences

	Academics	Employers	Students	Graduates
# Competences with importance level >= 3.5 out of 4	8	12	11	10
# Competences with achievement level <= low 2.8 out of 4	13	17	14	13
Competences with Highest Gap between Importance and Achievement Levels				
	#2 Professionalism and ethical values	#4 Ability to translate knowledge into practice	#4 Ability to translate knowledge into practice	#4 Ability to translate knowledge into practice
	#4 Ability to translate knowledge into practice	#5 Objective decision making and practical cost-effective problem solving	#17 Self-confidence, entrepreneurial spirit and skills	#17 Self-confidence, entrepreneurial spirit and skills
Rating of Importance Level				
Competences rated by all stakeholder groups in the top five	#4 Ability to translate knowledge into practice			
Competences rated by all stakeholder groups in the bottom five	#14 Ability to work in intra- and intercultural and/or international context #13 Environmental and economic consciousness #18 Commitment to preserve and to add value to African identity and cultural heritage			
Competence Ranking				
Competences ranked by all stakeholder groups in the top five	#4 Ability to translate knowledge into practice #1 Ability for conceptual thinking, analysis and synthesis			
Competences ranked by all stakeholder groups in the bottom five	#14 Ability to work in intra- and intercultural and/or international context #16 Ability to evaluate, review and enhance quality			

It can be also noticed that the highest gaps between importance and achievement levels were identified in competences related to "Translation of knowledge into practice", "Self-confidence and entrepreneurial skills", "Professionalism and ethical commitment", and "Objective decision-making". Competences related to environmental and economic consciousness, preservation of African cultural heritage, the ability to work in intra/inter-national contexts, and the ability to evaluate, review and enhance quality were rated lowest in importance and level of achievement.

Competence No.7 ("Ability to communicate effectively in national/official and local languages") was ranked very low by students, graduates and academics. This feature reflects the fact that local/national languages are not typically employed in technical communications and reports in the Mechanical Engineering discipline. Perhaps effective communication in local languages should be included in future curricula.

4.3. Analysis of the Consultation Results for Mechanical Engineering Subject-specific Competences

Table 4.3 provides the raw data of responses to the questionnaire about Mechanical Engineering subject-specific competences with regard to how the various categories of stakeholders rated the "importance" and the "achievement" of each competence in current curricula. They also ranked the nineteen subject-specific competences, choosing the five most important from their point of view. Similarly, on the basis of the average ratings by the stakeholder groups, the top-seven, bottom-seven and middle-five mechanical engineering competences were identified.

Based on the data of Table 4.3 shown below, the following observations can be made:

4.3.1. *Discussion of the Results of the Consultation on the Subject-specific Competences for Mechanical Engineering*

As has proved the case in Tuning projects worldwide, the levels of achievement were generally viewed as lower than levels of importance. The number of competences judged to have an importance level higher than 3.5 (out of 4) were, according to the various stakeholder groups from ten to sixteen competences out of nineteen. The number of competences rated less than 2.8 in achievement by the four stakeholder groups ranged from twelve to fifteen competences out of nineteen.

Academics, students and graduates all identified the capacity to employ Mechanical Engineering skills to transform local natural resources into products through value addition (competence #19), as the competence having largest gap between importance and achievement. Employers and students have also all identified the skills in safety and risk management in Mechanical Engineering systems (competence #14), as a competence showing a large gap between levels of importance and achievement. Capacities to conduct life-cycle assessment, to interact with multidisciplinary groups, and to create, innovate and contribute to technological development were identified by academics, employers and graduates as manifesting large gaps between levels of importance and achievement.

The most highly ranked competences were associated with abilities to apply knowledge of the basic and applied Mechanical Engineering sciences (competence #1), capacity to conceive, analyse, design and manufacture products and systems (competence #4), ability to identify, evaluate and implement appropriate technologies (competence #2), capacity to create, innovate and contribute to technological development (competence #3) and skills in planning and executing mechanical engineering projects (#5).

With regard to the results of the ranking exercise, students, employers and academics all placed competences as #1, #4 and #2 among the five highest. Competence #3 (creation and innovation) was ranked high by all stakeholders except employers. This ranking probably reflects employers' desire to use technology but not to "waste time" in R&D projects that would create technology. On the other hand, graduates rank design higher than application of knowledge, conceiving application of knowledge as a subcategory of design. In line with this reading of consultation results, it is worth noting that academics assigned a much higher level of importance to the "capacity to create, innovate, and contribute to technological development" than employers did.

Table 4.3
Mechanical Engineering Stakeholder Responses to Questionnaire on Subject-Specific Competences

	Data of all Stakeholders' Responses to the Questionnaire on Generic Competences															
	Academics				Employers				Students				Graduates			
	Competences	Importance	Achievement	Gap	Competences	Importance	Achievement	Gap	Competences	Importance	Achievement	Gap	Competences	Importance	Achievement	Gap
Top Seven	1	3.82	3.11	0.71	15	3.72	2.80	0.92	1	3.82	3.03	0.79	1	3.74	3.16	0.58
	4	3.69	2.90	0.79	14	3.71	2.30	1.41	15	3.78	2.72	1.06	5	3.67	2.85	0.82
	15	3.66	2.85	0.81	1	3.69	3.07	0.62	4	3.78	2.89	0.89	19	3.65	2.57	1.08
	3	3.65	2.83	0.82	6	3.67	2.94	0.73	3	3.74	2.50	1.24	4	3.64	2.82	0.82
	12	3.63	2.86	0.77	4	3.66	2.71	0.95	2	3.72	2.62	1.10	7	3.64	2.73	0.91
	2	3.62	2.69	0.93	12	3.64	2.75	0.89	9	3.71	2.62	1.09	2	3.63	2.65	0.98
	19	3.62	2.55	1.07	19	3.64	2.42	1.22	5	3.71	2.84	0.87	3	3.62	2.63	0.99
Middle Five	5	3.61	2.84	0.77	2	3.63	2.59	1.04	14	3.70	2.69	1.01	14	3.62	2.57	1.05
	6	3.53	2.83	0.70	5	3.60	2.73	0.87	12	3.69	3.06	0.63	6	3.61	2.83	0.78
	7	3.52	2.74	0.78	17	3.56	2,52	1.04	13	3,67	2.66	1.01	13	3.60	2.70	0.90
	13	3.48	2.64	0.84	7	3.56	2.56	1.00	6	3.67	2.70	0.97	15	3.59	2.81	0.78
	10	3.47	2.73	0.74	10	3.55	2.48	1.07	19	3.65	2.46	1.19	12	3.53	2.93	0.60
Bottom Seven	9	3.40	2.66	0.74	18	3.48	2.25	1.23	7	3.62	2.66	0.96	16	3.51	2.52	0.99
	17	3.40	2.67	0.73	16	3.44	2.18	1.26	10	3.62	2.54	1.08	9	3.49	2.67	0.82
	8	3.39	2.47	0.92	3	3.43	2.43	1.00	17	3.54	2.57	0.97	17	3.49	2.65	0.84
	14	3.37	2.40	0.97	13	3.43	2.41	1.02	11	3.51	2.52	0.99	11	3.45	2.42	1.03
	18	3.36	2.38	0.98	9	3.37	2.29	0.45	16	3.47	2.38	1.09	10	3.42	2.72	0.70
	16	3.34	2.39	0.95	11	3.30	2.15	1.15	18	3.44	2.41	1.03	18	3.40	2.47	0.93
	11	3.30	2.39	0.91	8	3.27	2.52	0.75	8	3.40	2.43	0.97	8	3.39	2.57	0.82

Table 4.4
Indicators of the Stakeholders Responses to the Subject-specific Competences

	Academics	Employers	Students	Graduates
# Competences with importance level >= 3.5 out of 4	10	12	16	13
# Competences with achievement level <= low 2.8 out of 4	12	15	15	13
Competences with Highest Gap between Importance and Achievement Levels				
	#19 Capacity to employ Mechanical Engineering skills to transform local national resources into products or services through value addition	#14 Skills in safety and risk management in Mechanical Engineering systems	#3 Capacity to create, innovate and contribute to technological development	#19 Capacity to employ mechanical engineering skills to transform local national resources into products or services through value addition
	#18 Capacity to conduct lifecycle assessment for products and systems	#16 Capacity to interact with multidisciplinary groups towards developing integrated solutions	#19 Capacity to employ Mechanical Engineering skills to transform local national resources into products or services through value addition	#14 Skills in safety and risk management in mechanical engineering systems
Rating of Importance Level				
Competences rated by all stakeholder groups in the top five	#1 Ability to apply knowledge of the basic and applied sciences of mechanical engineering #4 Capacity to conceive, analyse, design and manufacture mechanical products and systems			
Competences rated by all stakeholder groups in the bottom five	#8 Skills in evaluating the environmental and socio-economic impact of mechanical projects #11 Capacity to integrate legal, economic and financial aspects in decision-making in mechanical engineering projects			

Competence Ranking	
Competences ranked by all stakeholder groups in the top five	#1 Ability to apply knowledge of the basic and applied sciences of mechanical engineering #4 Capacity to conceive, analyse, design and manufacture mechanical products and systems #2 Ability to identify, evaluate and implement the most appropriate technologies for the context of the current project
Competences ranked by all stakeholder groups in the bottom five	#17 Skills in employing quality control techniques in managing materials, products, resources and services #18 Capacity to conduct life-cycle assessment for products and systems

Most of the stakeholders also identified a second grouping of related competences as being very important. These include competences that address "providing mechanical engineering solutions to societal problems for sustainable development" (competence #13) and "capacity to transform local resources into products" (competence #19). All stakeholders ranked competence #19 on the high side. However, students and graduates perceived a large gap between the importance of this competence and its achievement. This observation should receive attention when rectifying current curricula. Competences related to quality assurance (competence #17), lifecycle assessment (competence #18), safety and risk management (competence #14) were ranked very low by almost all stakeholders. This finding reflects the low level of technological development in the continent, with the result that issues related to quality culture are not given a high priority.

Employers estimated a small gap between importance and achievement levels for the competences related to application of knowledge in Mechanical Engineering field (competence #1) and the capacity to model and simulate mechanical engineering systems and processes (competence #9). This indicates that, in the eyes of employers, academics have performed their task properly. More indications are illustrated in Table 4.4.

The working group also defined specific learning outcomes for Mechanical Engineering first-cycle degrees. First-cycle degrees facilitate professionally qualifying studies in Mechanical Engineering with early professional careers (professional qualification) and qualify graduates for advanced scientific degree programmes or for additional degree programmes other than Mechanical Engineering.

Table 4.5
Summary of Results Expected from Mechanical Engineering First Cycle Degree Holders in Four Areas

A	The ability to demonstrate knowledge and understanding of the basics of:	Basic and Engineering Sciences
	Mathematics including differential equation, integral calculus, linear algebra, vector algebra, numerical methods, probability and statistics	
	High-level programming	
	Solid and fluid mechanics; statics and dynamics	
	Material science and engineering, and strength of materials	
	Thermal science: thermodynamics and heat and mass transfer	
	Principles of turbo-machinery, reciprocating engines and machines, and material handling equipment, etc.	
	Electrical and electronic circuits, electrical machines and drives	
	Control systems	
B	The ability to analyse:	Engineering Analysis
	Mass, momentum and energy balances and efficiency of systems	
	Hydraulic and pneumatic systems	
	Machine elements and mechanical systems	
C	The ability to carry out design of machine elements and mechanical systems using both traditional means and computer-aided tools	Engineering Design
D	The ability to demonstrate the safe use of workshop and laboratory equipment	Engineering Practice
	The ability to operate and maintain mechanical equipment and systems	
	The ability to understand and apply safe systems, codes and standards at work	
	The ability to understand and apply safe systems, codes and	
	The ability to select and use control and production systems	

Table 4.5 summarises the abilities identified by the Mechanical Engineering SAG as expected outcomes of (A) basic engineering sciences, (B) engineering analysis, (C) engineering design and (D) engineering practice.

4.4. Conclusion

This chapter actually raises the question of the adequacy between training and employment. In fact, it advocates that constructive dialogue to develop a curriculum strongly involves companies and allows them as well as all other stakeholders to express their views on the competencies and the specific weight of each competency. Thus it is possible to identify the skills that constitute the core of the business and those that are in fact collateral (or complementary).

This consultation process ultimately leads to a ranking of competences and, ultimately, to a metaprofile determination specific to a given area. It is essential to understand that flexibility continues to exist and that, even with a detailed classification of competences, it is still possible for each university to go its own way in order to achieve the desired result of the companies: a graduate able to cope with the constraints imposed by his function in the company.

Chapter 5

Elaboration of Meta-profile

African universities are still marked by the stigmas of French, English, Spanish, Portuguese and Dutch historical legacies, which explain these stubborn prejudices and strong disparities that we still observe today in the African higher education landscape. For decades, these disparities have over time generated all sorts of specificities and exceptions that are now the barriers that the Tuning Africa Project must overcome by placing the student at the heart of its action and transforming the walls into bridges, so that the best available to each system becomes the base of the building common to all on the basis of a logic of dialogue, harmonisation and cooperation. The Tuning Africa Project is a logical extension of the major contemporary initiatives aimed at structuring an African higher education area. It is in full synergy with the Revised Addis Ababa Convention on the Recognition of Studies, Certificates, Diplomas, Degrees and other titles of Higher Education in the African States of 2014 on the Recognition of Studies, Certificates, Diplomas and other academic qualifications in African higher education.

The mutual recognition of diplomas and the creation of a common credit transfer framework constitute a major means of promoting mobility in the education systems of the African countries. But how do we make degrees comparable and what makes one degree globally equivalent to another? For example, what do we have to say that a Mechanical Engineering degree from one African country is equivalent to another degree obtained in another country? How can one come to the conviction that, finally, the competences conferred by these two degrees are globally the same?

More generally, what makes one degree close to another? It is clear that the issue of recognition is generic rather than that of comparability. In the context of setting up an African higher education area, the Convention also addresses the difficult problem of the recognition of diplomas on the labour market, which amounts to reducing the comparability of two degrees to the comparability of the competences conferred by these diplomas. Recognition is actually the dedication of a learning experience. In a simplistic way, it is measured by the potential for an academic qualification acquired in one country to be valid in another country, as an objective indicator that the graduate has acquired the skills required to enter the labour market or to undertake the continued studies in an equivalent university programme in another country.

Seen in this light, it can clearly be said that a quality diploma in the framework of an African Higher Education Area is a diploma with a proven social relevance in addition to the fact that it will be comparable to diplomas of similar nature while preserving an identity that will reflect the diversity of the courses within the space. It is not therefore identical course, but overall equivalent course.

The question of recognition is also generic to that of the internationalisation of higher education in the African space. As a result of internationalisation, the mobility of students and teachers is becoming more and more frequent and this trend is likely to accelerate. No African university alone can provide all the appropriate answers to the increasingly pressing demands of qualifications in a field as effervescent as Mechanical Engineering. The Tuning Africa Project is a formal methodology through which universities can emit audible signals by other universities, with all the flexibility it takes for each of these universities to keep their own personality. It is therefore through internationalisation that the partners can offer students courses of excellence and strengthen the quality of their training offer.

According to Tuning Africa, the recognition decision is dependent on the ability to prove that the learning process has resulted in the desired skills at the required level. This definition leaves ample room for affirming the identity of the training while allowing a wide variety of pathways and processes to achieve the goals. For example, Mechanical Engineering students in two different African countries will not have exactly the same path in terms of curricula. In one case, the first will follow a course that gives more weight to mechanical manufacturing while the other can benefit from a course that emphasises more materials. But, this really does not matter because what matters is ultimately that the achievements, seen as the ability of both graduates to comply with the expected performance of a Mechanical Engineering graduate are broadly the same. These outcomes should also be transparent in the methodologies and rigor in their research or in the language in which their conclusions are presented. They must also allow the academic debate to continue and deepen.

But this internationalisation approach carries great challenges that call for a new discourse and a methodology so that the signals emitted by each partner are understood by the others and make it possible to define bridges through which the internationalisation strategy takes shape. This discourse, commonly known as the harmonisation of programmes and curricula, challenges partnership on the imperative of legibility and comparability of courses and qualifications. Harmonisation of programmes and curricula between institutions requires transparency and builds on skills, credit, mobility, portability and recognition to facilitate building bridges between partner institutions.

5.1. The Development of Meta-profiles for the Domain

The Tuning Africa Methodology consists in setting benchmarks specific to each field of learning and declines these benchmarks into fundamental building blocks which are the characteristic competences of the diploma awarded at the end of the learning process. Regardless of the path offered to learners in a given country, academics come in according to the nature of the contributions they make to the learner's training.

Seen in this perspective, the following questions become legitimate:

- How should group of competences be constituted?
- Which is the group of skills that puts us at the heart of the job and who should therefore be in the courses independently of the country?
- Which are the skill groups that should be considered peripheral and likely to be highly flexible from one university to another?

According to the Tuning Africa Methodology, this process of classifying skills in groups follows a stakeholder consultation process that results in a ranking of skills. A process that follows reflection around a number of issues brings together experts around these cardinal landmarks. They analyse, from their particular context, how each group of academics defines its specific domain.

Here are the key questions around which reflections in a given area of learning will focus:

- Which are the skills that embody the core contributions of each of the specialties to the development and progress of society?

- What are the fundamental elements in a particular field of study or knowledge and, how could they be determined?

- Which are the skills that can be considered fundamental for those who achieve certification in this particular area and at each level?

- Which are the non-core skills that are most sought after in the region?

It is indeed essential to differentiate the fundamental elements of the specialised aspects introduced for different reasons in the different fields of study. The result of this work has been the elaboration of lists of skills specific to each area of learning and to every part of the world. This gives the participants a control over the understanding of each of the domains but also a certain property on the results. This has been a significant conclusion that has proved very useful in different parts of the world. The debates on the fundamental elements of each domain are one of the key processes of Tuning Africa.

The intelligent treatment of the results of these stakeholder consultations leads to this famous classification of skills into relevant groups. In a given region, this work aims to define the identity of the degree without removing the flexibility of each country, or even each university. Therefore, thematic groups agree on the component lists that have identified the core and the level of diversification, and they also go further: they classify the findings and create a structure that presents how they understand how the competences conferred by the learning process are interrelated and how they contribute to defining the identity of the degree. These structures are called Meta-profiles.

Thus, a Meta-profile is a structural representation of skill group that gives its identity to a given field of study. We can also say that a Meta-profile is a mental construct that categorises skills into recognised major components and illustrates their interrelationship.

The Meta-profile presents an understanding of the basic elements and their description, as well as of their identification and explanation in an intelligible language. They offer the location, importance and weight of the different factors that make up the overall picture. Meta-profiles provide the contours around which credentials can be identified and recognised because key elements are properly described.

The Meta-profile associated with a given field of learning is a particularly relevant tool for achieving an understanding of the identity of a field of study at the level of the individual region. This brings a number of benefits.

The first of these advantages is the ability to bring out a collective understanding by placing the level of debate around essential elements and secondary additions in the field of study such as Mechanical Engineering, Civil Engineering, Medicine, Economics, Agriculture, Teacher Education, Higher Education Management, and / or Applied Geology.

In addition, this collective understanding is important for achieving a common understanding of credentials as it focuses on the central role of reference points and their weight in a pedagogical programme. This representation also offers the opportunity to reflect and discuss in more detail about the combination of elements. This reflection and debate should normally lead to greater depth of understanding and quality.

The need to develop diplomas that could be recognised through the African Higher Education Area was one of the first aspirations of the Tuning experience. It is about collective understanding of a particular area as well as agreeing on what constitutes fundamentals in opposition to diverse or specialised skills.

However, in the last two years, a new stage has been developed. In addition to providing reference points, Tuning Project participants have undertaken an exercise that goes further: that of analysing the reference points, discussing their classification, their structure and their desired weight. How they might be grouped, or what the relationships and differences in importance might be, are examples of issues that led to the creation of Meta-profiles. The Tuning Thematic Groups (or Field Groups = SAG) are perfectly prepared to carry out this task at the regional level because, with highly experienced academics in their respective specialities, SAGs are real communities of practice (Eckert, 2006). In addition, Tuning communities are continuously open to parallel groups from other regions and other academic areas of practice and can therefore be fully considered as Communities or Learning Networks as will be explained below.

Meta-profiles offer an additional advantage around opportunities for recognition and joint degree development. Meta-profiles present the main constituent components of a learning process as well as their relative weighting in the identity of the diploma resulting from the training. As transnational diplomas become increasingly common, tools that promote common understanding become particularly useful. Meta-profiles open up a new and different path towards regionalisation (Knight, 2012) and, recently, even globalisation.

The specificity of the Tuning Methodology is precisely to work on the development of Meta-profiles at the regional level, Europe, Latin America, Africa, and Russia, that is, jointly developed, agreed as appropriate and then validated at regional level. There is normally a higher level of comparison with other regions of the world and possibly at the global level. However, this way of reaching the global level implies that we are again in the presence (as always in Tuning) of a bottom-up approach, that is, regions up; but in this case each region has its own process and could agree to compare or share with another only if and only if they choose to do so. In this way, the Tuning Methodology respects the original elements of local people who are at the heart of the process. This assumes a significant difference in terms of overall development indicators —from bottom to top rather than from top to bottom— and opens a new, improved path to achieving the global indicators.

In Africa, as it will be evident in the different results for each of the thematic groups, the development of Meta-profiles has opened up possibilities for a number of uses. Firstly, it allowed for tremendous intercultural dialogue around the understanding of how different skills were positioned within each degree. The experts, who come from different backgrounds in terms of country of origin, different linguistic and cultural traditions as well as different professional careers, have come to an understanding of the main elements to be taken into consideration. Secondly, they were also qualified to analyse how the different elements interconnected each other and the level of centrality they held.

Thirdly, regarding the recognition of diplomas, they found that it was very useful to be able to see the weight of the distinctive competences compared to the weight of those located more in the periphery. Fourth, each thematic group contrasted the Meta-profile with a number of universities in different countries to find out which elements were either absent or overrepresented and how to improve degrees in different contexts. Finally, and this is the heart of the subject, this Meta-profile will serve as a reference for the development of degree profiles in terms of the specificity of the region. Finally, it will be used to compare and contrast the regional perspective with Meta-profiles developed in other geographical areas, a way of reaching a bottom-up global perspective.

5.2. Elaboration of Meta-profiles in ME

The offer of training in Mechanical Engineering aims at the development of transversal skills in different fields of knowledge, know-how and skills as part of the training in general Mechanical Engineering. ME is a multidisciplinary Subject Area allowing graduates to adapt efficiently and quickly to varied and specific demands of the national and international job market.

- ME training enables graduates to acquire the skills necessary to practice trades related to the development, modelling and industrialisation of products and systems. Beyond these skills base, training also contributes to developing in graduates, on the one hand, the ability to adapt to the industrial and environmental context (management, sustainable development, innovation), and on the other hand, the capacity to produce actions and reactions adapted to the human, social and international environment (collective work, openness to the international dimension, communication).

- At the end of his/her multidisciplinary training, the graduate in Mechanical Engineering is called upon to intervene throughout the life cycle of industrial products during the different phases of a project. The acquisition skills allows to have an ability to apply the aquired knowledge in the scientific and technical fields and exercise abilities to design, analyse, model and industrialise products and systems while integrating ethical, economic and management aspects. The main activities that mechanical enginner graduate will practice are:

— product design

— modelling and simulation of the behavior of products and systems

— industrialisation and production

— production management

— research and development

These activities are mainly carried out in:

- Industrial sectors: automotive, aeronautics, agribusiness, etc.

- R & D and industrial innovation centers.

- Service sectors: design offices, advice and industrial assistance, etc.

5.3. Repository of Skills

The competence framework adopted includes, on the one hand, the Generic Competences recommended for all engineering training and, on the other hand, a set of Subject-specific Competences that further specify the knowledge, skills and abilities expected of a Mechanical Engineering graduate. In Tables 5.1 and 5.2, these competences are presented in clusters.

Table 5.1
Generic Competence Clusters

Scientific and Technical Skills: ACQUIRING SCIENTIFIC AND TECHNICAL KNOWLEDGE AND THE MASTERY OF ITS IMPLEMENTATION	
CG1	Knowledge and understanding of a basic science field and the ability to analyse and synthesize
CG2	Ability to mobilise the resources of a specific scientific and technical field
CG3	Mastery of methods and tools of the engineer
CG4	The ability to design, implement, test and validate solutions and methods
CG5	The ability to perform basic or applied research activities
CG6	The ability to collect, evaluate and exploit relevant information
Competences related to: ADAPTATION TO THE REQUIREMENTS OF BUSINESS AND SOCIETY	
CG7	Taking into account industrial, economic and professional issues
CG8	Respect for societal values
Organisational and human skills: TAKING INTO ACCOUNT THE ORGANISATIONAL, PERSONAL AND CULTURAL DIMENSION	
CG9	Ability to integrate, animate and evolve an organisation
CG10	Ability to undertake and innovate
CG11	Ability to work in an international context

Table 5.2
Subject-specific Competence Clusters

No.	Competences	Definition/explanation
Skills related to product development		
CS1	Analyse industrial needs and translate them into technical specifications.	Ability to recognise a need and evaluate it while integrating the simplest, most effective and most cost-effective technical solutions.
CS2	Design a product through a specification.	Ability to analyse the recommendations and the needed recommendations to design a product.
Skills related to product and system modelling		
CS3	Model, dimension and validate the behavior of a product.	Ability to evolve a product by optimising for example control parameters or by predicting its behavior regarding complex solicitations.
CS4	Design and model energy systems for industry taking into account environmental constraints.	Capacity to be at the origin of an innovative idea and to guarantee its adaptation by integrating the concept of sustainable products and systems.
Skills related to industrialisation		
CS5	Analyse the feasibility of manufacturing a product and design and implement useful tools for production.	Ability to identify the *inputs* and *outputs* during the realisation of a product while providing the necessary means and resources.
CS6	Manage production and implement a strategy to improve performance through the deployment of measurable indicators.	Ability to control products and systems by closely following their behaviours to make appropriate adjustments and ensure production performance.
CS7	Design, define, organise and implement the various procedures guaranteeing the quality of the product.	These are project management skills such as planning, organising and mobilising the logistics inherent in improving the qualification criteria of a product.

5.4. Development of the Meta-profile

To achieve the required competences, the training offer is built on three complementary and interconnected training clusters as shown in Figure 5.1. Each cluster relies on common and specialty courses that jointly contribute to building some of the expected competences.

- The "Science and Technology" Pole: constitutes the scientific and technical base characterising training in Mechanical Engineering. It includes three training components:

  — "Development of products and systems" contributes to CG2, CG3, CG4, CG6, CS1 and CS2;

  — "Modelling of products and systems" contributes to CG1, CG2, CG3, CG4, CG5, CG6, CS3 and CS4;

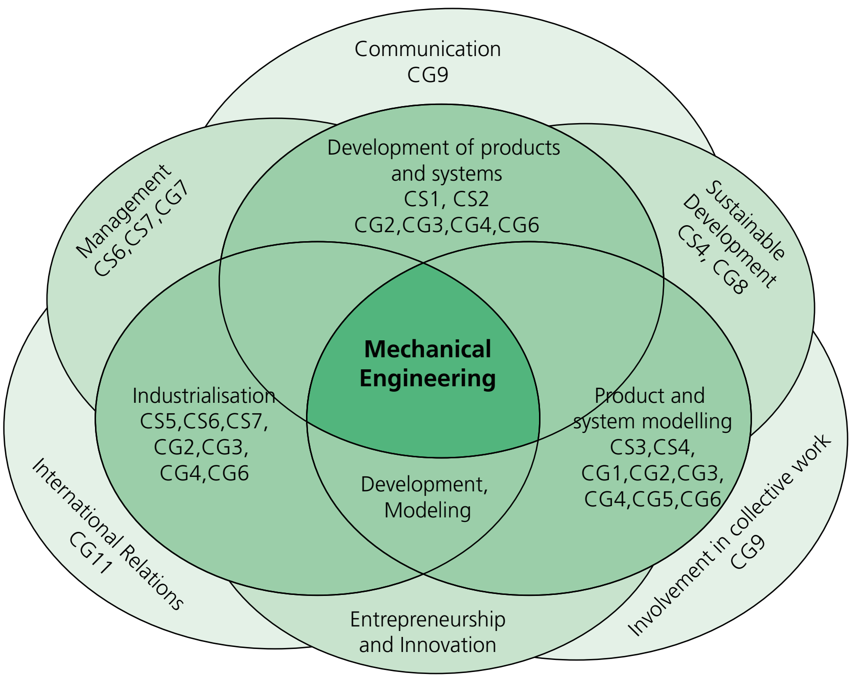


Figure 5.1
Meta-profile for Mechanical Engineering

— "Industrialisation" contributes to CG2, CG3, CG4, CG6, CS5, CS6 and CS7 skills.

- The "Adaptation Cluster" focuses on developing the capacity of a Mechanical Engineering graduate to adapt to the requirements of a company and to take part in management activities (CG7, CS6 and CS7), undertake and innovate (GC10) and take into consideration the environmental and sustainable development aspects (CG8 and CS4).

- The "Attitude Pole" aims to develop in the Mechanical Engineering graduate communication skills, commitment, involvement in collective work (CG9) and ability to work in an international context (CG11).

5.5. Conclusion

At the heart of the ongoing debate on learners' employability is the fundamental question of the skills acquired and the importance given to each predetermined skill by the stakeholders in the training process. It is through the consultation process that the training stakeholders express themselves and it is through a relevant treatment of the stakeholders' responses that it is possible to create clusters of skills that will be crucial in the process of the training process: curriculum development.

The metaprofile is the geometric expression of the skills desired by stakeholders according to a visualization that highlights the so-called essential skills that constitute the heart of the training in purely technical terms, and the complementary skills that bring to the learner additional elements more designed to ensure adaptability in a given work environment.

Chapter 6

Comparison of the Meta-profile at Regional Level

6.1. Comparing the Meta-profile with Real Profiles at the University Level

The Tuning Africa Project is a logical extension of the major contemporary initiatives aimed at structuring an African Higher Education Area, in synergy with the 2014 Addis Ababa Revised Convention on the Recognition of Studies and Certificates, Diplomas, degrees and other titles of higher education in the African States.

Developed in Europe, the Tuning and Harmonisation Africa (Tuning Africa) initiative has been adopted by the African Union in an approach to design instruments for materialising the intention shared by all member states to catalyse African integration through higher education and to promote intra-African academic mobility through an objective, transparent and reliable process of mutual recognition of academic qualifications.

Tuning Africa is a collaborative methodological approach that allows participating institutions to compare training profiles based on expected results and defined competencies in a given field of study.

In an Africa still marked by the stigmas of French, English, Spanish, Portuguese and Dutch historical legacies which explain the stubborn prejudices and the great disparities still observed today in the landscape of higher education, Tuning Africa is developing in an intelligible language objective concepts to highlight compatibilities and ensure comparability for mutual recognition of curricula, diplomas and qualifications. For decades, these disparities have over time generated all sorts of specificities and exceptions that have become so many barriers that Tuning Africa can overcome by transforming the walls into bridges, placing the student at the heart of its action, so that the best available to each partner becomes the base of the building common to all on the basis of a logic of dialogue, harmonisation and cooperation. The mutual recognition of diplomas and the creation of an African credit transfer system framework are a major means of promoting mobility in education systems in the Continent.

No African university alone can provide all appropriate responses to the increasingly pressing demands of qualifications in a field as diverse and effervescent as Mechanical Engineering. Pooling is inevitably necessary and Tuning Africa offers a conventional framework through which universities can work together by adopting the principle of complementarity to maximise, qualitatively and quantitatively, the scientific potential of the group by building on the individual skills of each of the groups´ members of the partnership. This pooling of skills is the very basis of this mobility process for teachers, administrative staff and teachers, which enables universities to work together to offer quality courses by organising structured and coherent bridges between partners. It is through internationalisation that partners can offer students courses of excellence and reinforce the quality of training courses.

But this internationalisation approach brings with it great challenges that call for transparency between the partners so that the signals emitted by each partner are understood by the others and make it possible to define bridges through which the internationalisation strategy takes shape. This discourse, commonly known as the harmonisation of programmes and curricula, challenges partnership on the imperative of legibility and comparability of courses and qualifications. Harmonisation of curricula and curricula between institutions requires transparency and builds on skills, credit, mobility, portability and recognition to facilitate building bridges between partners.

But harmonisation does not mean uniformity. According to the Tuning Africa approach, differences between curricula also reflect sensitivities in the way of sticking priorities to desired skills in a given environment. The metaprofile gives a visual representation of the structure of a curriculum and the perception of the articulations of the curriculum in relation to the generic competences and the specific competences decided for the training. Although in the case of Mechanical Engineering the wide range of generic skills and specific skills adequately reflect the aspirations of institutions and companies in terms of human resources development, it is indisputable that in the end, the priorities will not necessarily become identical from one institution to another, from one country to another or from one region to another. That said, it is natural to ask the question of how the same training can be perceived from one region to another, from one country to another or from one university to another. The working group's follow-up task is to compare it against existing regional profiles, the objective being to establish differences and coincidences. At the same time, this process is being used by the respective regions / universities to reflect on their respective curricula and present changes accordingly. A very constructive approach in this exercise is to use the same jurisdiction in the meta-profiles to establish the regional profiles, establishing their relative difference and coincidences. This exercise required regions to examine their respective curricula currently offered against the general and specific competencies defined by the Tuning Africa Project.

The starting point here is the November 2012 meeting in Brussels where experts from Africa, Latin America and Russia met to compare approaches and results in applying the Tuning Methodology. On this occasion, the Africa group reported on its work in Mechanical Engineering and Construction Engineering. The groups Latin American and Russian respectively worked on Civil Engineering and Environmental Engineering. Since the Tuning Methodology was used by these different regional groups, the interest of this meeting was precisely to compare the results obtained in these very different contexts and to draw lessons from them.

The African Mechanical and Construction Tuning group had the opportunity to meet with other Tuning groups of engineering from Latin America and from Russia. Because these regional groups used the same tuning method, participants were expected to see the results and compare their meta-profiles.

The Russian team has refined the Tuning Methodology by creating the three skill groups that are: (a) general skills that are transversal to any engineer; (b) general skills specific to the field of Environmental Engineering and (c) specific skills in the field of Environmental Engineering. Quality occupies a prominent place in the Russian model and general skills specific to Environmental Engineering are developed in the fifth year of training. The final list of general includes the following:

1. Ability for abstract thinking, analysis and synthesis.
2. Ability to work in a team.
3. Capacity to generate new ideas (creativity).
4. Ability to identify, pose and resolve problems.
5. Ability to design and manage projects.
6. Ability to apply knowledge in practical situations.
7. Ability to communicate in a second language.
8. Skills in the use of ICT.
9. Capacity to learn and stay-up-to-date with learning.
10. Ability to communicate both orally and in written form in the native language.
11. Ability to work autonomously.
12. Ability to make critical decisions.
13. Ability for critical thinking.
14. Appreciation of and respect for diversity and multiculturality.
15. Ability to act with social responsibility and civic awareness.
16. Ability to act on the basis of ethical reasoning.
17. Commitment to the conservation of the environment.
18. Ability to communicate with non-experts of one’s field.

19. Ability to plan and manage time.

20. Ability to evaluate and maintain the quality of work produced.

21. Ability to be critical and self-critical.

22. Ability to search for, process and analyst information from variety of sources.

23. Commitment to safety.

24. Interpersonal and interactional skills.

25. Ability to undertake research at and appropriate level.

26. Knowledge and understanding of the subject area and understanding of the profession.

27. Ability to resolve conflicts and negotiate.

28. Ability to focus on quality.

29. Ability to focus on results.

30. Ability to innovate.

In addition to this list of skills, Russian experts presented a list of general skills specific to Environmental Engineering:

1. Ability to work in a team.
2. Capacity to generate new ideas (creativity).
3. Ability to apply knowledge in practical situations.
4. Skills in the use of ICT.
5. Ability to work autonomously.
6. Ability to plan and manage time.
7. Ability to evaluate and maintain the quality of work produced.

8. Knowledge and understanding of the subject area and understanding of the profession.

9. Ability to resolve conflicts and negotiate.

The case of Latin America only concerns Civil Engineering. The presentation made by the Latin American experts revealed that in this region, the experts decided to group the competences into the following four groups: social, cognitive, technological and ethical. Experts identified a list of 27 generic skills:

1. Capacity for abstraction, analysis and synthesis.
2. Ability to apply knowledge in practice.
3. Ability to organise and plan time.
4. Knowledge regarding the area of study and related professions.
5. Social responsibility and commitment citizenship.
6. Capacity for oral and written communication.
7. Ability to communicate in a second language.
8. Ability to use information and communication technology.
9. Capacity for investigation.
10. Ability to learn and update learning.
11. Ability to search for, process, and analyse information from a variety of sources.
12. Critical and self-critical abilities.
13. Ability to react to new situations.
14. Create skills.
15. Ability to identify, pose, and solve problems.

16. Ability to make decisions.
17. Ability to work as part of a team.
18. Interpersonal skills.
19. Ability to motivate and work towards common goals.
20. Commitment to look after the environment.
21. Commitment to socio-cultural environment.
22. Value and respect for diversity and multiculturality.
23. Ability to work in international in international contexts.
24. Ability to work autonomously.
25. Ability to formulate and manage projects.
26. Ethical commitment.
27. Commitment to quality.

Latin American experts, following the example of Russian experts, have identified a list of the most relevant skills for Civil Engineering:

1. Capacity for abstraction, analysis and synthesis.
2. Ability to apply knowledge in practice.
3. Knowledge regarding the area of study and related professions.
4. Ability to identify, pose, and solve problems.
5. Ability to use information and communication technology.
6. Ability to make decisions.
7. Ability to work as part of a team.
8. Ability to formulate and manage projects.

9. Ethical commitment.

10. Commitment to quality.

African experts who have worked in the field of Civil Engineering have previously identified 37 skills needed for this discipline. A more detailed analysis of these skills has reduced this number to the twenty skills listed below:

1. Ability to coordinate, manage, supervise and control Construction Management.

2. Ability to translate and interpret for data and/or drawings into actual.

3. Ability to design, quantify and calculate parameters and capacity to model and simulate systems, structures, projects and processes.

4. Ability to analyse, reconfigure and apply relevant drawings, data and technology and ability to transmit project requirements into sketches and explaining it to clients.

5. Knowledge to reconstruct, maintain, rehabilitate, renovate and knowledge of maintenance of infrastructure.

6. Skills in cost, quality and time optimisation and quality control techniques Leadership.

7. Skills in handling data or information (survey data, soil information…) Analysis.

8. Ability to identify the need for construction of any type and structure and ability to identify different options.

9. Knowledge of basic construction management principles and to programme Management.

10. Commitment to health and safety and capacity to introduce safety measures in construction and materials.

11. Capacity to test the quality of materials Quality Management.

12. Quality management and skills to address defects and quality issues Quality.

13. Ability to analyse (mathematical abstract background as basis for decision making).

14. Knowledge about national and international construction standards Regulations.

15. Ability to develop effective and professional interaction with other professions and to come to integrate solutions.

16. Skills in developing new, appropriate and sustainable construction technologies and materials.

17. Skills to finalise financial implications and identify legal responsibilities and frameworks.

18. Knowledge of plant and equipment.

19. Basic understanding of contractual and financial management as well as of insurance and guarantee aspects.

20. Skills in environmental and social impact assessment, knowledge about the context and the challenges of development.

The list of specific skills indicated does not reflect any prioritisation and therefore it is only at the level of later processing processes that will appear those skills that constitute the node of training in Civil Engineering and those who are peripheral.

At the end of the day, the group identified 18 generic competences that are crucial for a Civil Engineering graduate. These 18 generic competences were then clustered. The clusters were for the following areas: Critical Thinking, Professionalism, Creativity, Communication, Leadership, and Regulation. African experts categorised these competences into three clusters: Design and Analysis, Construction and Project Management.

6.2. Analysis

As a prelude to any comparison between the regions, the experts all agreed that the titles of competences, even when identical, must be understood in a way that takes into account the specific needs of the region. Thus, although Africa and Latin America have all worked on Civil Engineering, the academics in Latin America have many links to "construction" while in Africa the need concerns "design". In the meantime, the level of achievement of each of the jurisdictions described another difficulty. The academics agreed that when drafting descriptions of skills, it is critical to understanding and achieving the required level of compliance.

The comparison should take into account: (1) the local environment and the need of societies, (2) the local working conditions, (3) the possibility (or not) of individual's mobility and (4) ethical values. Academics from all regions (Africa, Latin America, and Russia concluded that the similarities between regions are probably close to achieving 80 per cent of the desired harmonisation. Academics use common language and share universal ideas but the concepts of activities are different. In order to compare the programmes equitably, flexibility is a prerequisite.

The comparative analysis of the methodologies of the three African, Latin American and Russian groups highlighted similarities in the Latin American and Russian approaches to the identification of so-called general skills and, a short list of specific general skills extracted from them and which are characteristic of a given domain. As the two groups have not really worked on the same areas, it is not possible to draw any more edifying conclusion regarding the possible comparability of Meta-profiles.

With regard to comparability issues in general, all three groups nevertheless agreed on the need to provide a clear definition of the competencies mentioned, whether generic or specific. It is therefore very appropriate, for ease of comparison, that the Latin American group specify each time the skills that are found in each of the four groups defined by the experts: ***social, cognitive, technological and ethical***.

The African and Latin American groups worked on identical areas: Construction Engineering and Civil Engineering. It appears that, depending on the context, the concentration centers of Civil Engineering training are not identical, even if we admit that, in the end, the skills acquired are comparable. In Latin America, risk management is seen as an essential element of the Civil Engineering curriculum with focus on construction programmes. Latin American academic experiences are designed to provide a high level of practical experience in conjunction with classroom courses. In Africa, on the other hand, practical experience occurs mainly in the field of vocational training. One exception is the qualifying period currently used in Ethiopia.

The African Civil Engineering Group was extremely impressed and interested in the South American and European approach of working with skill level descriptors according to the number of years of study. Latin America has a precise cataloge of defined skills for engineering in a broad sense.

Another characteristic of skills in Latin America is that they have been systematised in advance in social, cognitive, technological and ethical categorisations, while the African group has conformed clusters after identifying generic and specific skills of the subjects.

The Russian Tuning experience has not yet included the Civil Engineering. It concerned the Ecological Engineering. The Russian Tuning experts' approach distinguishes three categories of skills. It favours the term "general" skills to the detriment of "generic" skills. Russian academics who have worked on Environmental Engineering have classified the skills as follows:

a) Generic competences for Engineering (broad-based generic programmes).

b) General competences for Ecological Engineering.

c) Subject-specific competences for Ecological Engineering.

Russian experts do not distinguish between its regions in its programmes and its standards: the programmes were very largely homogeneous. The Russian Tuning Working Group for Environmental Engineering has identified "quality" as the central topic. But, it is good to mention that all groups have been aware of the need for quality insurance. However, quality universally poses questions of compromises that vary according to countries, priorities and problems to face.

The relationship between regions has become more complex because of the existence of clusters of competencies after identifying generic and subject-specific competences. It takes this step to approach the clustering of the expected outcome. The resulting discussion clarified the need for the definitions of the expected meaning. The Latin American skills, for instance, might need to define "cognitive" as "the ability to apply theory in practice" while employed by a company. Thus, in Latin America, academics consider this ability as a cognitive competence.

The Russian academics give priority to some skills (such as "ability to learn") because they are "integrated into their regional culture". Also one of the other places in Tuning Russia is the "ability to work".

Russian, Latin American, and African groups agreed to consider that although such a graduate would receive a "bachelor's degree," it does not correspond to a bachelor degree in a classical way. It is like an "honours degree" or a "graduate degree". If some universities award a title after three years of study, all regions have agreed to the qualification at a level as a "technician". Then in carrying out higher education reforms, a specific study should be done at the three-year stage.

6.3. Analysing the Weights of the Different Dominant Elements

Across the participating institutions profiled, a high degree of synergy has been encountered with respect to the core competences-particularly those related to Mechanical Engineering sciences, quality and innovation and creativity - and, to a lesser degree, quality. These include modelling and simulation. It may be the case that the weighting on Mechanical Engineering sciences (including subjects covering basic sciences, mechanics, thermodynamics, etc.) receives greater emphasis at the expense of neglected competences related to sustainability, which is fast emerging as a core competence globally. This competence includes the ability to analyse the product life-cycle (Ryan, P.,"Editor", 2014).

While competences related "entrepreneurial skills", "community engagement" and "professionalism and ethics" are relatively underweighted, it is evident that curriculum modernisation is necessary to adequately cover these competence clusters. On the other hand, a good correlation in general seems to prevail regarding community engagement (Akatieva, L. *et al.*, 2014).

6.4. Conclusion

Tuning Africa has allowed representatives of different universities in the continent to be able to define in a concerted manner, in the field of Mechanical Engineering, the skills needed for a learner to be able to respond effectively expressed by the companies. The consultation process that followed led to a visualization called a metaprofile that groups skills according to their importance in the training process.

This chapter has addressed a larger issue: the metaprofile developed by African academics reflects the African perception of mechanical engineering education. But in an open world with more and more people moving around, the question that arises is the comparability of curricula not within the African region, but wider, between the African region and the other regions.

The work of comparative analysis between the works of Africans and those of Latin Americans and Russians in the fields of engineering ultimately shows minor differences in the definition of skills. It should be noted, however, that the classification of said skills is not necessarily the same, which results in substantially different metaprofiles.

The conclusion of this whole chapter is finally that the listing of skills from one region to another is finally the same. What makes the difference is the importance that stakeholders attach to each of the listed competences. Differences in the formation process from one region to another are essentially the result of the perception of the importance attached to each competency to define in a concerted way, in the field of Mechanical Engineering, the skills necessary for a learner to learn.

Chapter 7

Some Examples of Revised / New Programmes

7.1. New Undergraduate Programme in "Mechatronics" in E-JUST

E-JUST, Egypt-Japan University of Science and Technology, has been able to participate in the Mechanical Engineering group of Tuning Africa Phase II. In the general meeting, the group discussed the subject that should be chosen as an exercise to discuss the Joint Master Degree programme. Members of the Mechanical Engineering Subject Area Group selected the subject of "Mechatronics". Then the group discussed establishing the hypothetical Joint Master Degree programme in "Mechatronics" during the Cairo and Addis Ababa meetings. At that time, E-JUST took into account the importance of such an interdisciplinary programme as Mechatronics for undergraduate education and has prepared the undergraduate programme "Mechatronics". Thus, E-JUST has now completed the preparation of the undergraduate programme "Mechatronics".

7.1.1. *Preparation of New Undergraduate Programme*

Since Mechatronics is an interdisciplinary field at the crossroads of Mechanical Engineering and Electronics, it should not appear as an incoherent mixture of Mechanical Engineering and Electrical Engineering, especially for undergraduate education. In order to avoid this and to create a valid programme, the competence-based learning and outcomes-based learning, which we studied in the Tuning Africa programme proved very useful for the faculty members involved in designing the new programme. All faculty members participated in the on-line course offered by Tuning Africa Project.

Social Needs

The increasing demand for industrial automation calls for new engineering skills which are combination of Mechanical, Electrical, Electronics, Control Engineering and Computer Science. This is the motivation for the development of the Mechatronics programme for undergraduate engineering which produces an innovative engineer ready to design and solve problems related to electromechanical and control.

A Mechatronics engineer can serve in the automotive industry, in home automation, aerospace, consumable products and appliances. He/she can work in all fields involving robotics for manufacturing, assembly and services as well as medical devices and micro-systems. He/she can also serve in industrial sectors which require programmable logic control and supervisory control.

Description of the Meta-profile of the New Programme

Mechatronics Engineering is the synergistic integration of precision machinery, electronics and information technology to design innovative components and systems to create functional and smart products. The research priorities of the programme are in the areas of Bio-mechatronics, autonomous robots, intelligent control systems, smart sensors/actuators, and Micro/Nano Electro Mechanical Systems (MEMS/NEMS) for industrial, automotive, and bio-medical applications.

In order to prepare engineers in these fields, we must first define the Meta-profile for this engineering field, identifying the competences and outcomes of our programme. Basically, Mechatronics Engineering is the interdisciplinary field comprising Mechanical Engineering and Electronics and it involves technologies concerned with mechanical systems, electronic systems, control systems and computers as shown below in Figure 7.1. *[See below, the note with the Figure.]*

Definition of the Competences

The competences which students should obtain in this programme were extracted from the Meta-profile as mentioned above. The competences are of two categories: Subject-specific competences and Generic or General competences. Generic competences include basic and intermediate levels; Subject-specific competences include specialisation**.** The competences are listed in the following sections.

Generic Competences

G1. Competences to be able to communicate with engineers, partners and communities, including the international community.

G2. Competences to report properly and to present findings to audiences.

G3. Competences to have a leadership and manage a team.

G4. Liberal arts and common sense.

G5. Competence in engineering ethics.

G6. Ability to critical evaluation and self-awareness.

G7. Commitment to lifelong learning.

G8. Flexibility and adaptability.

Subject-specific Competences

S1. Competences to understand the scientific background of the bases of Mechanical Engineering and apply them to Mechatronics Engineering.

S2. Competences to understand the scientific background of control and computer systems and apply them to Mechatronics Engineering.

S3. Competences to define specific problems and to solve them.

S4. Competences to design new Mechatronics systems.

S5. Capacity to create, innovate and contribute to technological development.

S6. Skills in designing and building Mechatronics systems.

S7. Capacity to integrate electrical, mechanical and software modules to design Mechatronics systems.

S8. Ability to provide Mechatronics Engineering solutions to social problems.

Description of Intended Learning Outcomes (ILOs)[1]

As a next step, the ILOs were defined according to the competences presented in the above section.

ILOs related to Generic Competences

The graduate will be able to:

a) Apply knowledge of mathematics, science and engineering concepts to the solution of engineering problems.

b) Design and conduct experiments as well as analyse and interpret data.

c) Design a system component and process to meet the required needs within realistic constraints.

d) Work effectively in multi-disciplinary teams.

e) Identify, formulate and solve fundamental engineering problems.

f) Display professional and ethical responsibilities; and contextual understanding.

[1] http://tll.mit.edu/help/intended-learning-outcomes

g) Communicate effectively.

h) Consider the impacts of engineering solutions on society and environment.

i) Engage in self- and life-long learning.

j) Demonstrate knowledge of contemporary engineering issues.

k) Use the techniques, skills and modern engineering tools, necessary for engineering practice.

ILOs related to Subject-specific Competences

l) Demonstrate knowledge and understanding of basic science and engineering fundamentals in mechanics, electronics and software and their interfacing.

m) Demonstrate knowledge and understanding of fundamentals of problem identification, formulation and solution in the inter-disciplinary fields of Mechatronics.

n) Demonstrate knowledge and understanding of the principles of sustainable design and development.

o) Identify at an appropriate level the design, production, interfacing and software needs of different parts of Mechatronics systems.

p) Create solutions to Mechatronics systems especially for manufacturing, maintenance and interfacing problems in a creative way, taking account of industrial and commercial constraints.

q) Compete, in-depth, in at least one engineering discipline, namely mechanics, electronics or interfacing and software.

r) Manage field problem, identification, formulation and solution.

s) Utilise practical systems approach to design and performance evaluation.

t) Apply the principles of sustainable design and development.

Checking the Consistency of the Programme ILOs with the Competences

Table 7.1 shows the results of checking the consistency of the programme ILOs (a~t) and the (G1~G8, S1~S8). From this result, it is found that the ILOs comprise all the competences.

Table 7.1

Checking the Consistency of the Programme ILOs with the competences

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t
G1	x			x																
G2	x			x					x											
G3	x	x		x																
G4				x						x	x									
G5				x							x									
G6				x						x										
G7											x									
G8										x										
S1	x	x										x							x	
S2	x	x											x							x
S3	x	x											x		x	x				
S4	x	x	x										x	x						
S5	x	x		x																
S6	x	x			x	x														
S7	x	x				x									x	x	x	x		
S8				x						x	x									

7.1.2. *Course Description of Programme*

Finally, we specified the units/courses/modules of the programme. The Mechatronics Engineering programme consists of the courses listed in Table 7.2. Also, the learning strategies for achieving the competences, such as lectures, tutorials and labs, are indicated.

Table 7.2
Course Description and Work Load

Level	Course Code	Course Name	Credits	Lecture	Tutorial	Lab	Contact Hrs.	SWL
1	EMG 111	Safety and Risk Management	2	2	—	0	2	90
	CRC 114	Technical Report Writing	2	2	—	0	2	90
	MTH 111	Mathematics (1)	3	2	2	0	4	135
	CHM 111	Chemistry (1)	3	2	2	0	4	135
	MSE 111	Fundamentals of Materials Science (Prop. + Test)	3	2	2	0	4	135
	MCE 111	Mechanics (Statics + Dynamics)	3	2	2	0	4	135
	CHM 112	Basic Sciences Lab-2 (Chemistry + Material)	2	—	—	4	4	90
	IME111	Engineering Drawing	3	2	1	1	4	135
2	CRC 121	Japanese Language (1)	0	2	—	0	2	0
	CRC 122	Communications, Presentations, and Soft Skills	2	2	—	0	2	90
	PHY 121	Physics (1)	3	2	2	0	4	135
	CSE 121	Computer Programming	3	2	—	2	4	135
	PHY122	Basic Sciences Lab-1 (Physics 1)	2	—	—	4	4	90
	IME 121	Introduction to Manufacturing Processes	3	2	1	1	4	135
	CPE 121	Introduction to Energy, Environmental, and Chemical Engg.	3	3	—	0	3	135
	CPE 122	Basic Engineering Lab-1 (Chemical + Energy + Env. Engg.)	3	—	—	6	6	135
3	CRC 231	Japanese Language (2)	0	2	—	0	2	0
	MTH 211	Mathematics (2)	3	2	2	0	4	135
	EPE 211	Electrical Engineering (Circuits + Machines)	3	2	2	0	4	135
	EPE 212	Measurements and Instrumentations	3	2	2	0	4	135
	EPE 213	Basic Engineering Lab-2 (Electrical + Instrument)	3	—	—	6	6	135
	CSE 211	Computing and Networking	2	2	—	0	2	90
	ERE 211	Thermo-Fluids	3	2	1	1	4	135

Level	Course Code	Course Name	Credits	Lecture	Tutorial	Lab	Contact Hrs.	SWL
4	EMG 222	Engineering Economy	2	2	—	0	2	90
	MTH 221	Probability and Statistics	3	2	2	0	4	135
	ECE 221	Introduction to Electronics Engineering	3	2	1	1	4	135
	MTE 221	Theory of Machines	3	2	1	1	4	135
	MTE 222	Strength of Materials	3	2	2	0	4	135
	MTE 223	Mechanical Vibrations	3	2	2	0	4	135
	MTE 224	Numerical Analysis	3	—	—	6	6	135
5		Humanities Elective 1	2	2	—	0	2	90
	MTE 311	Seminar on MTE	2	—	—	4	4	90
	MTE 312	Mechanical Design (1)	3	2	—	2	4	135
	ECE 312	Electronic Circuits	3	2	1	1	4	135
	MTE 315	Embedded Systems	3	2	2	0	4	135
	MTE 313	Automatic Control (1)	3	2	1	1	4	135
	MTE 314	Introduction to Mechatronics	3	2	1	1	4	135
6	EMG 323	Project Management	2	2	—	0	2	90
		Humanities Elective 2	2	2	—	0	2	90
	MTE 321	Pneumatics and Hydraulic Systems	3	2	1	1	4	135
	MTE 322	Project Based Learning in MTE	2	2	—	0	2	90
	MTE 323	Mechatronics Systems Design	3	2	2	0	4	135
	MTE 324	Mechanical Design (2)	3	2	1	1	4	135
	MTE 325	Robotics	3	2	1	1	4	135
7	MGT 111	Introduction to Business	2	2	—	0	2	90
	CRC 481	Ethics and Values	2	2	—	0	2	90
	MTE 4xx	MTE Elective 1	3	2		0	4	135
	MTE 4xx	MTE Elective 2	3	2		2	4	135
	MTE 4xx	MTE Elective 3	3	2		2	4	135
	MTE 410	Senior Project (1)	4 + 2	0	—	18	18	270
8	ENT 241	Introduction to Entrepreneurship	2	2	—	0	2	90
	MTE 4xx	MTE Elective 4	3	2		2	4	135
	MTE 4xx	MTE Elective 5	3	2		2	4	135
	MTE 420	Senior Project (2)	4 + 2	0	—	18	18	270
Industrial Training (2 modules)			3					
Total			**152**					

* SWL = 3 (Credit Hours x Weeks/semester).

We found that the entire process of integration and alignment (competences-ILOs-Learning, Teaching and Assessment) is:

1. *holistic* since it considers the whole systems involved in proposed the Undergraduate Programme;
2. *integrative* since it considers relevant stakeholders involved in the education process;
3. *systematic* since we proceeded from competences towards an integrative alignment, in gradual steps;
4. *progressive* since basic knowledge of the building blocks for the formulation of ILOs is essential to formulate a student-centred educational programme;
5. *hierarchical* since the alignment process is top-down, from graduate competences, to programme, to course unit 'output oriented';
6. *cyclic* in that it will be subject to continuous evaluation and refinement.

7.1.3. *Summary*

The new undergraduate programme in "Mechatronics" has been prepared successfully in E-JUST, which opened its undergraduate school in September 2017. We prepared this programme basing it on the experience of education in the graduate school, and on the knowledge obtained in the Tuning Africa meeting, according to the following items:

1. The meta-profile of the new Mechatronics programme.
2. Definition of the competences: Subject-specific and Generic or General.
3. Relationships between the competences and the meta-profile.
4. Description of the expected outcomes related to the competences.
5. Structure and curriculum of the Mechatronics Engineering courses.

We have found this methodology useful to complete the new programme.

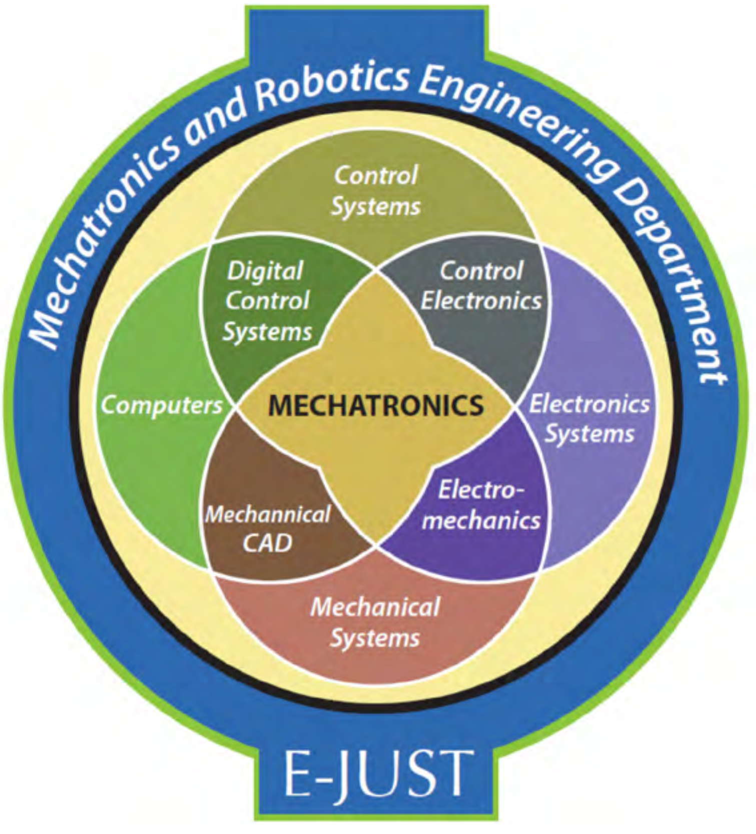


Figure 7.1
Meta-Profile of Programme in "Mechatronics"

7.2. Revised Master Programme at Jimma University, Ethiopia

7.2.1. *Name of the New or Revised Programme*

Name of the Programme (Revised)	Sustainable Energy Engineering
Degree Level	M.Sc
School	Mechanical Engineering
Year of Activation	2010-2011; Revised version 2016-2017 onwards
Official length of the programme	2 years
Official language	English
Website of the school	ju.edu.et/Institute of Technology/School of Mechanical Engineering
Website of the degree programme	ju.edu.et/Institute of Technology/School of Mechanical Engineering
Reference office	Director, Post Graduate Studies, research and Publication
Address and email of the school	School of Mechanical Engineering, Jimma Institute of Technology, KitoFurdisa Campus, P.O. Box;378, Jimma, Ethiopia

7.2.2. *Justification of the New Programme or Rationale for the Revision of the Existing Programme*

The Mechanical Engineering SAG has developed a new M.Sc programme in Renewable Energy and Jimma University in Ethiopia has revised, in line with the Tuning Methodology, the existing M.Sc programme in Sustainable Energy Engineering currently under implementation. The revision also covers the need for dynamic curriculum revision in the current context of design for sustainability and the emerging trends pertaining to techno-economics of renewable and transition pathways. This programme is also included as one of the mobility programmes through an INTRA AFRICA mobility project titled MOUNAF in which Jimma University is a partner. The rationale for the revision of the existing programme is as follows.

7.2.3. *Identify the Future Fields or Sectors of Employment of Graduates*

- Government and (inter/trans)national agencies.
- R&D in energy production and power generation companies.
- Entrepreneurship (local, global).
- Consultants in the field(s) of Energy and Sustainability.
- Education and academia, research institutions.
- NGO's working in the areas of Energy and Environment.
- Process industries.

7.2.4. *Describe the Length and Level of the Programme*

The two year Master programme with 120 ECTS, modularised, is developed with 70% core content and 30% elective subjects catering to three different tracks, namely "Renewable Energy Systems", "Energy Efficiency" and "Conservation"(apart from energy policy and economics).

One semester will be earmarked for thesis work by research apart from another course named Developmental Team Training Programme (DTTP), wherein students spend six weeks in assigned local communities affecting development in physical and verifiable real terms while working with stakeholders and pooling the required resources by themselves. This is intended to promote inter-sectoral collaboration and coordination among different development agencies, government agencies, etc.; while encouraging working in teams comprising professionals from different disciplines so as to inculcate interdisciplinary approach. An individual research-based thesis will follow after the DTTP. Innovation and creativity are to be emphasised in the broader domain of relevance, technical feasibility and economic viability. Interdisciplinary approaches and systems-based thinking would be highlighted while proposing sustainable solutions.

Further studies

Since the nature of the course as such is interdisciplinary, upon graduation, the student can pursue further study leading to a Doctoral degree in different speciality areas such as:

- Renewable Energy.
- Energy Systems Engineering.
- Thermofluids Engineering.
- Computational Fluid Dynamics.
- CDM.
- Climate Change.
- Environmental Engineering.
- Industrial Ecology.
- Energy Management.

7.2.5. *Definition of the Competences*

The stated competences, both Generic and Subject-specific, are self-explanatory for the Master level programme. Their broader range and scope can also be ascertained from the diagram with the associated linkages. Various expected learning outcomes associated with design, optimisation, installation and efficient operation of renewable energy systems are essentially embedded with the concept of sustainability as a common thread.

7.2.6. *Description of the Degree Profile of the Revised Programme in terms of Generic and/or Subject-specific Competences and Levels*

Table 7.3
Generic competences and their levels

GC	Name of the Generic Competence	Level
G1	Analyse, synthesise and evaluate interdisciplinary knowledge to solve complex problems in the field of Sustainable Energy.	2
G2	Appreciate the social and environmental requirements for the sustainable generation, distribution and utilisation of energy in a rapidly growing economy, and of the current and emerging technologies that can be applied to meet these requirements.	3
G3	Knowledge and critical understanding of the core skills in energy resources, converters and systems applications for a more sustainable future.	3
G4	Critically review existing practices and develop original and creative solutions to problems within the domain.	2
G5	Promote endogenous knowledge production and management.	2
G6	Facilitate the development of dialogue, networks, cooperation, collaboration, and partnerships with the relevant stakeholders.	3
G7	Utilise innovative technologies for solving complex problems in the field of Sustainable Energy Engineering.	2
G8	Communicate and work effectively with peers and academic staff in a variety of tasks, demonstrating appropriate levels of autonomy and responsibility.	3
G9	Appreciate multi-cultural differences with partners within a team/group.	2
G10	Utilise entrepreneurial skills to convert sustainable Energy ideas into realistic business models.	2

Table 7.4
Subject-specific Competences and their Levels

SSC	Name of the Subject-specific Competence	Level
S1	Make feasibility studies of energy resources.	2
S2	Plan, design, analyse and develop energy conversion systems and devices.	2
S3	Assess environmental, social and economic impacts of energy systems.	2
S4	Make investigations to optimise operating costs of energy systems.	2
S5	Install, operate and maintain renewable energy systems.	2
S6	Analysing and developing test setups for testing energy systems and devices to assess the quality, safety and reliability of performance of the systems.	1
S7	Making energy auditing and suggesting energy efficiency improvement measures.	3
S8	Implementing and evaluating energy conservation measures.	3
S9	Renewable Energy Resources assessment and study.	1
S10	Research and development for innovation in Renewable Energy Technologies.	2
S11	Energy policy formulation and strategic plan development.	1
S12	Renewable Energy project appraisal and management.	2
S13	Energy efficiency improvement and optimisation.	3
S14	Renewable Energy conversion technology dissemination.	1
S15	Effecting Rural electrification for improving energy access in off-grid areas.	2
S16	Plan and execute a significant project of research, investigation or development in a specialist area within the renewable energy arena, demonstrating extensive, detailed and critical understanding of that specialty.	3

7.2.7. *Describe the Expected Learning Outcomes related to the Competences*

a) Demonstrate capacity to produce effective design of Sustainable Energy products and systems.

b) Carry out Techno-economic feasibility studies for evaluation of energy resource utilisation.

c) Plan, design, analyse and develop sustainable energy conversion systems and devices.

d) Assess environmental, social and economic impacts.

e) Perform optimisation of operating costs of energy systems.

f) Install, operate and maintain sustainable energy systems.

g) Analyse and develop test set-ups for energy systems and devices.

h) Conduct energy audits and suggesting energy efficiency measures.

i) Implement and evaluate energy conservation measures.

j) Formulate strategies to realise UN goals for Sustainable Develop.

k) Network with developmental agencies, NGOs and other stakeholders.

7.2.8. *Meta-profile*

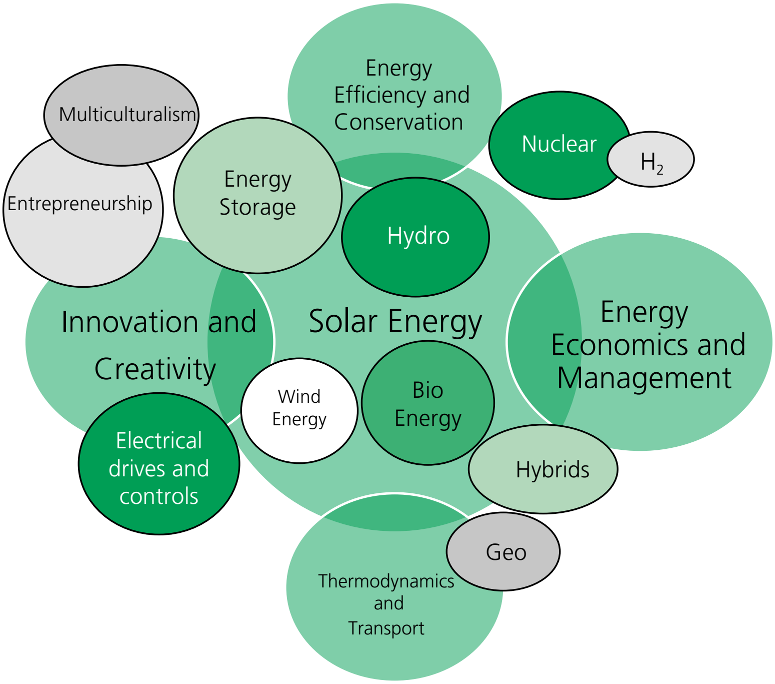


Figure 7.2
Metaprofile of the Programme Sustainable Energy Engineering

This metaprofile clearly shows that the formation of solar energy is built on three concentric circles in which all the modules are found. The first circle consists of central modules for such training: hydroelectricity, bio-energies, wind energy. The second circle that engulfs the first consists of complementary modules such as energy storage, energy saving, hybrid energies, thermodynamics and energy transport, electrical drives and control, innovation and creativity. The third circle is constituted more transversal such as entrepreneurship, multiculturalism, nuclear energetics and geothermal energies.

The visualisation of the elements by the metaprofile also makes it possible to discuss the relevance of this curriculum given the fact that modules such as geothermal, electrical drives and control are found outside the circle that constitutes the heart of the training.

7.2.9. *Check the link between the Competences and the Agreed-upon or Developed Meta-profile*

As can be seen from the table 7.5 given below, the programme profile has been designed to realise various domain elements of the Meta-profile

Table 7.5
Link between Competences and Meta-profile

Sl. No	Domain	Courses units linked to domains in the Meta-profile
1	Solar Energy	Solar Thermal Engineering
		Solar Photovoltaic Engineering
2	Bio energy	Bioenergy systems
		Bioenergy Systems
3	Geo	Geothermal Energy
4	Hydro	Hydro power Engineering
5	Wind	Wind Energy Engineering
6	Thermodynamics and Transport	Advanced Transport Phenomena
		Advanced Transport Phenomena Lab.
		Thermodynamics for Energy Conversion
7	Energy Efficiency and Conservation	Energy Auditing
		Energy Efficiency and Conservation
		Waste Heat Recovery and Cogeneration
		Energy Efficiency and Demand side Management
		Energy System Modelling and Simulation
8	Energy Storage	Distributed Generation Systems and Storage
9	Energy Economics and Management	Energy and Environment
		Energy Economics, Finance and Management
		Energy Management and Economics

Sl. No	Domain	Courses units linked to domains in the Meta-profile
10	Electrical Machines and Controls	Instrumentation and Controls for Energy Systems
		Electrical Machines and Drives
11	Hydrogen and Nuclear	Introduction to Sustainable Energy Systems
11	Innovation and Creativity	Computational Techniques for Energy Systems
		Computational Lab.
		Renewable Energy Lab.
		Integrated Energy Planning
		Systems Engineering /Systems Analysis
		Integrated Sustainable Energy System Design
		Networking (including stakeholder involvement and partnership)
		Energy Policy Frameworks and Climate Change
		Renewable Energy Policy and Planning
		Thesis
		Scientific Research Methods
12	Entrepreneurship	Project Management and Entrepreneurship
13	Multiculturalism	Developmental Team Training Programme
		Seminar

7.2.10. *Specify the Units/Courses/Modules of the Programme*

Modules

Module No.	Module Name	List of Courses	Cr.hr.	Course No
01	Sustainable Energy Systems	Introduction to Sustainable Energy Systems	2	SEE 6011
		Thermodynamics for Energy Conversion	3	SEE 6012
02	Energy Management	Energy and Environment	2	SEE 6021
		Project Management and Entrepreneurship	2	SEE 7022
		Energy Management and Economics	2	SEE 7021
03	Computational Techniques for Energy Systems	Advanced Flow and Transport Phenomena	3	SEE 6031
		Advanced Flow and Transport Phenomena Lab.	1	SEE 6033
		Computational Methods in Energy Systems	3	SEE 6032
		Computational Methods in Energy Systems Lab.	1	SEE 6034
04	Instrumentation and Controls for Energy Systems	Instrumentation and Controls for Energy Systems	3	ECE 6041
		Electrical Machines and Drives	3	ECE 6042
05	**Elective** Renewable Energy stream	Solar Thermal Engineering Solar Photovoltaic Engineering Integrated Sustainable Energy System Design Project Bioenergy Systems I; Thermochemical Bioenergy Systems II; Biochemical Geothermal Energy Engineering	3	SRE 6051 SRE 6052 SRE 6053 SRE 6054 SRE 6055 SRE 6056
06	**Elective** Energy efficiency and conservation stream	Energy Efficiency and Conservation Energy Auditing Waste Heat Recovery and Cogeneration Systems engineering/Systems Analysis Energy System Modelling and Simulation Integrated Sustainable Energy System Design Project	3	SEC 7061 SEC 7062 SEC 7063 SEC 7064 SEC 7065 SRE 6053

Module No.	Module Name	List of Courses	Cr.hr.	Course No
07	**Elective** Energy policy and economics stream	Integrated Energy Planning Networking (including stakeholder involvement and partnership) Energy Policy Frameworks and Climate Change Renewable Energy Policy and Planning Energy Efficiency and Demand side Management Energy Economics, Finance and Management	3	SEP 7071 SEP 7072 SEP 7073 SEP 7074 SEP 7075 SEP 7076
08	Wind Energy	Wind Energy Engineering	3	SEE 6082
09	Hydropower	Hydropower Engineering	3	SEE 7091
10	Renewable Energy Practice	Renewable Energy Lab.	1	SEE 7101
11	Energy storage	Distributed Energy Systems and Storage	3	SEE 6111
12	Seminar and Research Methods	Scientific Research Methods	3	ROIT 7119
		Seminar	1	SEE 7133
13	Community Based Education	Developmental Team Training Programme	3	DTTP 7002
14	Research	Thesis	12	SEE 7152

Course offering schedule

Si. No.	Course Code	Course Title	Cr.Hr.	ECTS	Lect-Tut-Prac
Semester I					
1	SEE 6011	Introduction to Sustainable Energy Systems	2	4	2-0-0
2	SEE 6031	Advanced Flow and Transport Phenomena	3	6	2-3-0
3	SEE 6021	Energy and Environment	2	4	2-0-0
4	ECE 6041	Instrumentation and Controls for Energy Systems	3	6	2-2-1
5	SEE 7091	Hydropower Energy Engineering	3	6	2-3-0
6	SEE 6033	Advanced Flow and Transport Phenomena Lab.	1	2	0-0-3
Total			**14**	**28**	**10-8-7**
Semester II					
1	SEE 6032	Computational Techniques for Energy Systems	3	6	2-3-0
2	SEE 6012	Thermodynamics and Energy Conversion	3	6	2-3-0
3	SEE 6111	Distributed Energy Systems and Storage	3	6	2-3-0
4	Elective	Elective I	3	6	2-3-0
5	SEE 6082	Wind Energy Engineering	3	6	2-3-0
6	SEE 6034	Computational Lab.	1	2	0-0-3
Total			**16**	**32**	**10-15-3**
Semester III					
1	SEE 7021	Energy Management and Economics	2	4	2-2-0
2	Elective	Elective II:	3	6	2-3-0
3	Elective	Elective III:	3	6	2-3-0
4	SEE 7022	Project Management and Entrepreneurship	2	4	2-2-0
5	SEE 7133	Seminar	1	2	0-0-3
6	ROIT7119	Scientific Research Methods	3	6	2-3-0
7	SEE 7101	Renewable Energy Lab.	1	2	0-0-3
Total			**15**	**30**	**10-13-06**
Semester IV					
1	DTTP 7002	Developmental Team training programme	3	5	0-0-5
2	SEE 7152	Thesis	12	25	0-0-30
Total			**15**	**30**	**0-0-35**

List of Electives: Renewable Energy stream

Si. No.	Course Code	Course Title	Cr.Hr.	ECTS	Lect-Tut-Prac
Elective					
1	SRE 6051	Solar Thermal Engineering	3	6	2-3-0
2	SRE 6052	Solar Photovoltaic Engineering	3	6	2-3-0
3	SRE 6053	Integrated Sustainable Energy System Design Project	3	6	2-3-0
4	SRE 6054	Bioenergy Systems I; Thermochemical	3	6	2-3-0
5	SRE 6055	Bioenergy Systems II; Biochemical	3	6	2-3-0
6	SRE 6056	Geothermal Energy Engineering	3	6	2-3-0

List of Electives: Energy Efficiency and Conservation stream

Si. No.	Course Code	Course Title	Cr.Hr.	ECTS	Lect-Tut-Prac
Elective					
1	SEC 7061	Energy Efficiency and Conservation	3	6	2-3-0
2	SEC 7062	Energy Auditing	3	6	2-3-0
3	SEC 7063	Waste Heat Recovery and Cogeneration	3	6	2-3-0
4	SEC 7064	Systems Engineering/Systems Analysis	3	6	2-3-0
5	SEC 7065	Energy System Modelling and Simulation	3	6	2-3-0
6	SRE 6053	Integrated Sustainable Energy System Design Project	3	6	2-3-0

List of Electives - Energy Policy and Economics Stream

Si. No.	Course Code	Course Title	Cr.Hr.	ECTS	Lect-Tut-Prac
Elective I					
1	SEP 7071	Integrated Energy Planning	3	6	2-3-0
2	SEP 7072	Networking (including stakeholder involvement and partnership)	3	6	2-3-0
3	SEP 7073	Energy Policy Frameworks and Climate Change	3	6	2-3-0
4	SEP 7074	Renewable Energy Policy and Planning	3	6	2-3-0
5	SEP 7075	Energy Efficiency and Demand side Management	3	6	2-3-0
6	SEP 7076	Energy Economics, Finance and Management	3	6	2-3-0

7.2.11. *Consistency between Competences and Intended[2] Learning Outcomes (ILOs)*

Table 7.7
Checking the Consistency of the Programme ILOs with the competences

	a	b	c	d	e	f	g	h	i	j	k
G1	x	x	x								
G2				x	x					x	x
G3		x				x		x	x	x	
G4	x	x									
G5	x									x	
G6				x						x	x
G7		x	x					x	x		
G8											x
G9				x						x	x
G10								x	x		
S1		x								x	
S2	x		x				x			x	
S3		x		x						x	x
S4					x			x	x		
S5						x	x			x	
S6			x			x	x	x	x		x
S7					x			x	x	x	
S8		x	x		x		x	x	x	x	
S9				x	x		x	x			x
S10	x				x		x			x	x
S11										x	x
S12				x	x					x	x
S13			x		x		x	x	x		
S14										x	x
S15						x				x	x
S16	x	x	x	x	x		x	x	x	x	x

[2] http://tll.mit.edu/help/intended-learning-outcomes

7.2.12. *Eligibility and Admission Requirements*

Admission

- Students holding a Bachelor degree in Mechanical, Electrical, Energy, Environmental, Chemical and Process Engineering.

- Students holding a Bachelor Degree in Chemistry or Applied Physics, together with a work experience related to RE can be considered after passing an entrance examination.

- Bachelor degree courses such as Power Plant Engineering, Electrical Machines and Drives, etc. can be taken as a tool to bridge gaps and harmonise applicant's background with admission requirements.

- The applicants must appear and qualify through an entrance examination.

- The student must possess a minimum CGPA of 2.75 out of 4.0.

7.3. Conclusion

A curriculum responds to a concern for the development of skills specific to a given environment. This concern is expressed through a list of Generic competences and Subject-specific competences that are considered essential and that a stakeholder consultation process makes it possible to prioritise. This prioritisation makes it possible to give a visualisation in the form of a Meta-profile. In this way, a Mechanical Engineer trained according to the African specifications will necessarily be different from the one trained in Latin America or Russia according to other requirements. What transpires is that, even if the competences are the same, the skills priorities are not likely to be identical from one country to another, from one region to another.

Chapter 8

Reflection on Staff Development Needs and Possibilities, SAG Level

8.1. Introduction

In a world where knowledge is competing in a new space characterised by excellence, competitiveness and attractiveness, HEIs are forced to network and partner at the national, regional, continental and international levels. This requires that they become international and facilitate the mobility of their Researchers, Teachers and Students in order to improve their ability to elaborate and transfer knowledge in a harmonised way.

The Tuning Africa initiative ultimate objective is to support the harmonisation of higher education programmes and ultimately the creation of a flexible, attractive and competitive African Higher Education Area, through an in-house collaboration. Tuning Africa proposes a methodology to address all issues related to the internationalisation of training within the framework of an African Higher Education Area. Today, 120 African universities are involved in Phase II.

Through this initiative, participating universities learn to develop new relevant curricula and more effective teaching methods. In the process, they learn to build formal frameworks for student exchanges in 8 fields of study.

Relevant questions, for which it was difficult to envisage an appropriate response, find their resolutions in the framework of Tuning Africa.

These include capacity building in the skills-based approach, the establishment of a comprehensive framework for student and staff mobility, or, more broadly, the creation of an African Higher Education Area as a major component of African integration.

The major question that emerges in this context is how to ensure the capacity building of a university to adopt the Tuning Africa Methodology; How to organise this capacity building. It is precisely in these terms that the question of staff development with its corollary in terms of assessing needs and possibilities in a given field arises.

8.2. Objectives

More broadly, Staff Development's activities are aimed at raising awareness about which markers to consider when developing joint training programmes in order to best achieve the desired learning outcomes. The themes related to staff development ultimately aim at a better understanding of the Tuning Africa approach with focus on topics such as the competency-based approach, the learner's workload, the learner-centred approach, teaching, learning and evaluation methods; quality assurance in the training and learning process.

With a view to staff development, tailor-made courses are designed to provide an appropriate response to a specific need expressed by a particular group of academics who wish to deepen their practical skills in a given field, for example: successful and distinctive comparable and compatible programmes, or a specific need, for example, to design joint degrees for the purpose of internationalising training.

The courses are in the form of seminars and internal workshops on various issues related to higher education and tailored to the needs expressed by target groups.

Staff development is based on the Tuning approach to the work in Subject Area Groups so participants can share ideas and best practices, as well as learn from colleagues and speakers. Activities are interactive and include the participation of expert(s) and presentation of recent case studies. They are provided in different forms, and supported by a wide range of modern technological approaches and techniques, including blended and distance learning, where appropriate.

The faculty development of Mechanical Engineering administrative staff and / or the community of Higher Education and Universities (ESU) are guided by a dual belief in:

i. development that involves strengthening the capabilities of the members of the scientific and academic body;

ii. specific programming ranging from individual support to support for the whole community.

Higher Education is the essential know-how industry, which provides quality education with an appropriate source of sustained research that can meet the immediate needs of the globalising society or the advancement of knowledge. The management of static human resources does not ensure the adequacy of training programmes for the job market. This creates a partnership between ESU institutions and companies through the exchange of experiences towards new directions to research innovation and development. The guarantee of the survival of teaching that meets the standards; in accordance with the realities and the prediction of a better future focuses on continuing education. This is not limited to student interns either, but has a new approach to translate excellence, in the valuation of results by consolidating workshops, laboratories or field work in companies, in order to follow an appropriate evolutionary logic that is based on harmonissed and complementary curricula.

- Support the development of trainers, professors and supervisors of doctoral and master theses by individual training in professions of teaching, research and professionalisation in advanced industries for avant-garde applications, rather than transfer technology and second-hand regional;

- Promote a South-South and South-North group dynamics of teaching and research to strengthen their skills, autonomy and competitiveness in an international, regional and national environment.

- Promote mobility not only of teachers but also of administrators in integration with the international environment.

8.3. Description of the Main Strengths and Weaknesses

8.3.1. *Strengths*

Every teacher always aims for excellence, which implies the concern to become a highly qualified and highly motivated staff member. This positive psychological state of teachers is a strength, not exploited because of lack of opportunities.

- The members of the scientific body pay for their studies themselves to reach a good level of improvement or to prepare their Masters dissertations or Doctoral theses.
- The realisation that development goes through the knowledge market is a quiet force.
- Numerous international organisations offer fellowships, research fellowships and opportunities for study around the world.
- Big sums of money (in terms of billions) are available to be used.

8.3.2. *Weaknesses*

- Lack of awareness of development by local supervisors.
- No collaboration between teachers themselves and between members of the academic and scientific bodies, and institutions among each other.
- The absence of a clear collaboration between training institutions such as manufacturers of research equipment, engineering didactics, laboratories and workshops, and even industries.
- The pride and spirit of exclusion of others by teachers is a weakness.
- The constraints and age restriction is a weakness for further development, as the average age of members of the scientific body is 50 years.

8.4. Main Needs in terms of Development

Currently, there is a profound change in educational needs:

i. the skill levels required in the labour market are higher;

ii. knowledge is multidisciplinary;

iii. knowledge becomes quickly obsolete;

iv. individuals must demonstrate mobility and capacity for lifelong learning;

v. training pathways become individualised;

vi. knowledge and skills must be recognised internationally;

vii. teaching is multilingual;

viii. teaching and research use ICT.

In Africa the need for continually updated technical and engineering education is a central issue, which is why renewing or strengthening the capacity of faculty resources is a priority.

Engineering courses require continuous improvement of teachers, in order to mitigate the inadequacy of knowledge with respect to practise in the face of the needs of companies related to the satisfaction of the well-being of all.

8.5. Proposals

8.5.1. *Governance Improvement*

- Build capacity on good governance mechanisms.

- Strengthen capacity to revive the system through continued organisational audits and sustainability of public and private higher education institutions.

- Strengthen the information system for results-based management planning in Africa.

8.5.2. *Continuous Quality Improvement*

- Promote quality assurance through continuing education.
- Ensure the adequacy of training programmes and their relevance for the job market through seminars and continuing professional development.
- Continuous development of scientific and technological research streams. Integrate the educational system into the global movement through advanced courses.
- Initiate workshops to implement ICTs and open up HEIs digitally.
- Reduce gender disparities in science and technology.
- Eliminate the disparities between the provinces and fight against the antivalues in the university circles by sensitisation.

In Mechanical Engineering, some themes have a global dimension (the energy challenge and global warming with the exhaust gases of thermal engines required to switch over thirty years to electric traction motors, etc., as an example); teaching and research are never done alone, but rather in partnership with fellow teachers, in order to mobilise broad and varied skills and to bring together the critical mass needed to advance knowledge and bring more people into vital sectors of industry, such as manufacturing vehicles, boats, aircrafts, etc., bringing about an improvement not only of teachers, but also of administrative staff, not to mention mobility of students. Perfecting one's knowledge in a different environment encourages questioning what one normally carries out by routine, and promotes knowledge of cutting edge industrial processes in an international competitive context. Mobility will result in co-supervision of theses, co-publications, and joint projects which will guarantee the quality assurance we advocate.

8.6. Assessment of Staff Development Needs

Staff development needs were collected from the participating universities and a summary of the needs expressed by the respondent universities are presented in Table 8.1.

Table 8.1
Staff training needs identified by respondent partner universities

HEI	**Needs reported** *[What areas of curriculum development, teaching learning and assessment do you think you and Your colleagues would like to have a workshop on?]*	Needs identified
Université Akli Mohand Oulhadj de Bouira	• Programming workshops for new teachers. • Popularisation of new approaches to teaching based on skills. • Continue to deepen the Tuning methodology. • Establish facilitator colleagues to integrate these new approaches into Higher Education. • Establish joint programmes between universities within the country and within the African continent. • Set up an African credit system. • Develop internal mobility. • Improvement of the quality of education in higher education. • Translate all acquired theories into practice. • Reduce wastage in higher education.	• Development of competences: general – of TLA. • Induction of new university teachers. • Competence-based approach: how to implement. • TLA: improvement. • Curriculum development: joint degrees. • Credits (and student workload).
École Nationale Supérieure Polytechnique, Université de Yaoundé I	Capacity building needs focus on mastering new methods. Pedagogics mainly focused on the use of digital educational tools and the implementation of the skills approach according to the Tuning Africa Methodology. Since then, the main themes for capacity building workshops to be the following: 1. The competency-based approach. 2. Tools and methods of digital education. 3. Evaluation methods for large groups. 4. Problems of Quality Assurance in the Training of Engineers.	• Competence-based approach: How to implement. • T&L: use of ICT. • Large classes (assessment). • Quality assurance (Engineering degrees).
Institut Supérieur de Techniques Appliquées (ISTA/Kinshasa, RD Congo)	How to achieve the objectives during a teaching session skills or Meta-profiles. • In Engineering on the know-how, what methodology to bring the students practice the theoretical lessons? • The race exemptions can they be the subject of open questions in improving the quality of teaching and research? • Need for academic specialty staff. • Bring back the Assistants and Heads of Works to the levels of Doctors specialised in engineering.	• TLA: Less on level (with relation to programme competences and the Meta-profile). • Development of competences: Translating knowledge into practice.

HEI	**Needs reported** *[What areas of curriculum development, teaching learning and assessment do you think you and Your colleagues would like to have a workshop on?]*	**Needs identified**
Cairo University	The workshops needed for enhancing the teaching and learning at the Faculty of Engineering - Cairo University are: 1. Student centred learning approach. 2. Innovative learning methods in engineering education. 3. Project–based learning approach in engineering education. 4. Resources Management.	• Student-centred learning approach. • T&L: learning in engineering education. • T&L: project-based learning (in engineering)
Egypt-Japan University of Science and Technology	The faculty development committee will plan the contents of our faculty development, which can give our staffs the practical skill implementation of student-centered competence-based approach. For this purpose, 8 staffs, members of faculty development committee, join in the on-line course 2 provided by Tuning Africa from the middle of December. These members will play roles of workshop core members. The subjects picked up in seminar, workshop and lectures will be discussed and implemented by this committee. The main part of workshop can be group discussions organised by committee members.	• Competence-based approach: How to implement.
Dilla University	1. Curriculum enhancement according to latest trends and developments. 2. Revision of curriculum for all years. 3. Promoting our local staff to M.sc level in order to improve our teaching and learning methodology. 4. Provide training by industry experts on different software technologies and latest trends and upgrade our staff skills. 5. Through industry link age upgrade our teaching and learning methodology by linking our department to industries and other foreign universities. Through staff exchange programming and M.sc and PhD Sponsorship programming enhance the staff teaching and learning.	• Curriculum development (based on competences and ILOs). • Curriculum development: revision. • T&L: use of ICT.
Jimma University	• Quality Assurance in Teaching-Learning. • Assessment for Competency based Education. • Use of Technology to enhance teaching-learning effectiveness. • Accreditation.	• Quality assurance in T&L. • Assessment: of competences. • T&L: use of ICT. • Accreditation.

HEI	**Needs reported** *[What areas of curriculum development, teaching learning and assessment do you think you and Your colleagues would like to have a workshop on?]*	**Needs identified**
Kwame Nkrumah University of Science and Technology (KNUST)	• Workshop on training in curriculum development. • Effective teaching skills and students assessment techniques. • Course design from competence to assessments.	• Curriculum development (based on competences and ILOs). • TLA: improvement. • Alignment: from competences to assessment. • Assessment: of competences.
University of Malawi-The Polytechnic	We need training workshops in areas of teaching, learning and assessment. We need training on how best to conduct and examine industrial attachment, so that the grades discriminate the best from the weak students	• TLA. • Assessment: internship periods/Work placements.
École Nationale d'Ingénieurs de Tunis	As part of our school's application for certification by the CTI (French Commission On Engineering Qualifications), we have needs in terms of development of skills of our teaching staff. We are therefore takers of all types of workshops with a preference for new pedagogical approaches and assessment strategies.	• TLA: new approaches. • Assessment: new approaches.

Subsequently, the participating universities developed proposals based on their needs assessment and all of the proposals submitted were reviewed in the Johannesburg meeting in April 2017. An outline of one such proposal entitled 'Enabling student ownership of learning through innovative assessment practices' has been jointly developed, involving Jimma University, Cape Peninsula University of Science and Technolgy and Stellenbosch University along with University of the Western Cape. In this regard, the full proposal developed by Jimma University is highlighted in Table 8.2.

Workshop title: ENABLING STUDENT OWNERSHIP OF LEARNING THROUGH INNOVATIVE ASSESSMENT PRACTICES

Prepared by: Prof. Dr. A. Venkata Ramayya (Jimma University)

Total duration *(e.g. 3h30)*: 4 hours.

Number of participants (please indicate both minimum and maximum): 20-30.

Participant profile, if any (e.g. new academics, all academics who teach XYZ programme, etc.). All academics who teach any Engineering related programme.

Aim (a clear and concise statement of what the participants will get out of the workshop):

Enabling academic staff to explore innovative assessment practices facilitating student ownership of learning, bringing about a paradigm shift.

Sub-aims:

- To make assessment more of a learning experience rather than means to measure attainment.
- To bring about a change in assessing gaps between where one is now and where one wants to be and needs to be.
- Tuning assessment towards knowledge application rather than the knowledge itself for honing of expected competencies.
- To enhance transparency about assessment processes and introducing student to ownership through transformative learning.
- To build trust between lecturers and students for greater accountability.

Table 8.2
Workshop framework

Timetable	Activity title (optional) and description (obligatory)	Type of activity	Feedback	Resources required	Tips for facilitators
3 days before	**Pre-workshop** The participants individually will go through background study material sent by facilitators prior to workshop. The participants will gain an insight on innovative assessment strategies.	Preparation	Discussion among all participants when initiated in subsequent sessions	Microphone	Moderating discussion
9.00-9.05 am	**Introduction and Briefing on workshop** by facilitator to the gathering of participants.	Explanation of workshop objectives/ILOs	—	Microphone	Focus on current setting and context
9.05-9.35 am	**Presentation by facilitator** on *"Pedagogy to Andragogy and Heutagogy-the paradigm shift in the context of assessment for competency based education"*	Input	—	LCD Projector, Flip chart, Marker, pens, Microphone	Focusing on relevance and contextualisation to the aim of the workshop
9.35-10.05	**Presentation by facilitator** on *"Framing Student assessment for ownership of learning"*	Input	—	LCD Projector, Flip chart, Marker, pens, Microphone	Focusing on relevance and contextualisation to the aim of the workshop

Timetable	Activity title (optional) and description (obligatory)	Type of activity	Feedback	Resources required	Tips for facilitators
10.05-10.35 am	**Redesigning assessment with innovation for student ownership of learning** *Step 1:* Under supervision, in groups of 4 to 5 determined by facilitator, participants to brainstorm on insight gained from pre workshop readings, feasibility and suitability of some of the innovations that can be introduced to enable student ownership of learning for prioritisation in the contextual setting and implementation.	Discussion for way forward Each group would prepare a poster inscribing the assessment they prepared for display in the next session	Facilitator will answer questions and moderate discussion among participants	Flip chart, Marker, pens, Microphone Chairs to be arranged like a round table	Grouping questions and discussion points for maintaining focus
10.45-10.55 am	Coffee/Tea break				
10.55-11.10 am	*Step 2:* Presentation of the group consensual work on new ideas/approaches for the benefit of others as coordinated by the facilitator. Participants will get exposure to innovations in assessment in the current context.	Discussion for trying things out	Oral feedback will be given by the facilitator as well as other groups to the presentation by a particular group; Groups will exchange each other's work	Flip chart, Marker, pens, Microphone	Passing on constructive suggestions for implementation

Timetable	Activity title (optional) and description (obligatory)	Type of activity	Feedback	Resources required	Tips for facilitators
11.10-11.30 am	**Customising and designing an innovative the assessment** *Step1*: In the same groups, participants are to design an assessment activity for a specific module in one course selected by the group. The activity must demonstrate learner-centredness apart from aligning the assessment with the Intended Learning Outcomes. Participants will acquire confidence in attempting and designing assessment activities which will lead to greater student ownership of learning.	Trying things out In groups Each group would prepare a poster inscribing the assessment they prepared for display in the next session	Feedback by the facilitators and comments by other participants	Flip chart, Marker, pens, Microphone Chairs to be arranged like a round table	Careful selection of the assessment topic or course / module so that all groups can work on the same topic for comparative assessment and zeroing on innovative strategies.
11.30-11.45 am	*Step 2*: Presentation by group representative. The participants will see the difference in approaches for innovative assessment.	Reflection and evaluation of different group's work	By facilitator	Microphone	To point out creative aspects of different groups work focusing on the workshop ILOs.
11,45-12.00noon	**TITLE:** **How else, it could have been done to promote student ownership** All participants will discuss together. Participants will get appraised of the mental blocks hindering innovative thinking.	Reflection and evaluation among participants on the innovative assessment drafted earlier	Each group on another	Microphone	To promote objective assessment of each group's work by other group.

Timetable	Activity title (optional) and description (obligatory)	Type of activity	Feedback	Resources required	Tips for facilitators
12.00-12.20 pm	**TITLE:** **Planning for the future** Each participant to indicate some 'take-away' aspects of the workshop for their assessment strategy and his plans towards implementation in the aftermath of the workshop. Awareness creation and realisation of changed perception on student ownership of learning.	Post-workshop activity	By all concerned As self-commitment for improvement	Microphone	To compile the individual strategies mentioned for implementation and follow up.
12.20-12.50 pm	**TITLE:** **Reflection and Evaluation** Collection of feedback from participants by the facilitator using feedback forms designed earlier. Even participants will be encouraged to speak up on positive aspects of the workshop as well as suggestions for improvement. The participants highlight the take away aspects of the workshop. Reflection on their own practice and experience sharing.	Reflection and evaluation	By all	Microphone	To prepare the feedback form so as to entail critical review and forwarding suggestions.

Timetable	Activity title (optional) and description (obligatory)	Type of activity	Feedback	Resources required	Tips for facilitators
12.50-1.00 pm	**TITLE:** **Summarising and closure** The facilitator would summarise the outcomes and highlight the innovations pointed out and way forward for realising student ownership of learning by pinpointing interventions that can be embraced by all.	Conclusion and way forward	Facilitator	LCD Projector/ Microphone	The facilitator must keep a tab on consensual and innovative ideas and make them ready for presentation at the end.

8.7. Conclusion

The active participation of many universities in the Tuning Africa project is a sign that perfectly demonstrates the importance these universities place on the understanding of the skills approach and its implications in terms of recognition of diplomas and courses and organisation of mobility between universities.

In this context, the main challenge becomes that of the dissemination of the methodology within the universities and its adoption by the countries. The process of dissemination within universities is delicate in that it involves both a sometimes radical change in the pedagogical process and the adoption of a new methodological approach by teachers. This chapter outlines the dissemination experiences that have been carried out and opens the way to Tuning Africa becoming the reference instrument for professionalising higher education in Africa.

Chapter 9

Student Workload Reflection

Introduction

There is a great debate in higher education circles about the notion of quality of the learning experience. Despite all the differences that this concept raises, a consensus emerges that the notion of quality must be linked to the student's ability to achieve the main objectives set at the end of the learning process.

The concept of quality here appears to be very controversial.

For some, this notion is rather subjective and its appreciation is based on factors such as: a) the relevance of evaluation criteria, allowing students to understand what is expected of them; b) quantity, the quality and speed of feedback on the work being evaluated; c) the quality of the learning environment; d) the level of use of information and communication technologies for learning; e) the institution's ability to take into account student feedback to continuously improve academic performance.

According to the Tuning Methodology, the quality of a programme is measured by its ability to incorporate an adequate estimate of the workload required for students to achieve the learning outcomes that are specified in the programme. In this sense, the adoption of credits to consider the total workload of students —not just the work associated with formal activities— is a process that actually innovates in teaching and learning processes and that induces the establishment of a student-centred programme in African universities.

That said, the notion of workload is problematic in Africa where the popular consciousness still sees the teacher as the only source of information and therefore admits that the quality of a training is closely linked to the number of hours of study and presence of the student in front of the teacher. There is no university credit system shared by all African countries. In addition, many higher education institutions in the region are still relatively unfamiliar with a credit system that purports to support programme change and drive change towards student-centred approach.

Scheduled learning and teaching activities typically feature alongside time in which students are expected to study independently. Independent study might include preparation for scheduled sessions, follow-up work, wider reading or practice, completion of assessment tasks, or revision.

There is an obvious complexity to take into account the personal work of the student in African universities. This complexity stems from the fact that traditionally in Africa, the student is not perceived as a partner in the learning process and that the achievement of learning objectives is a common challenge for the student and the teacher.

It is for this reason that at the Tuning Africa level, two lines of work have been clearly defined:

1. **Proposal on a Credit System for Africa:** This step will be the responsibility of the Tuning Africa Advisory Group (TAPAG). The main role of this group will be to support all the initiatives developed by the universities, notably to contribute to the definition of the basis of a credit system for Africa.

2. **Scientific Research on Student Workload in Africa:** This second step needs to be coordinated with TAPAG. However, this will be the sole responsibility of the universities. An extensive survey will be conducted around the estimation of student workload in Africa from the perspective of teachers and students. All 120 universities will have to consult a number of students and professors in some courses / units which represent a semester. The consultation process will provide a global picture of the total workload (in terms

of hours) that an African student needs to successfully complete the courses in the 8 fields of study covered by Tuning Africa II. The survey will be based on the perceptions of what teachers and students consider to be the time required, or dedicated, as well as on the acquisition of learning outcomes in the relevant courses during a particular semester in each field of studies.

9.1. Relevance of a Continental Credit System. Issues Affecting its Adoption that are Related to the SAG

The Mechanical Engineering SAG considered the relevance of a continental credit system. It was generally agreed that there was need to establish a common credit system for easy of transferability of credits. However, before this could be done, there was a need to examine in detail the current practices in the participating institutions. It was agreed that the following information would be obtained from each of the participating institutions.

1. Description of the institutional/national regulations regarding contact hours/ independent work hours.

2. Estimation of the “normal” workload/week and the “normal” workload/academic year for a student in each institution.

3. Comparison between all institutions in relation to the student workload.

4. Agreement in relation to a range of student workload hours.

The template given in the next page (Table 9.1) was used to collect this information.

Table 9.1
Template used for data collection

Unified Template for Calculation of Student Workload per Institution to be Filled by All Members of the Group		
1	Name of the Institution	
2	Name of the Programme	
3	Number of term/semesters per year	
4	Number of weeks per term/semester/semester	
5	Number of years per degree	
6	Average Number of course Units per year	
7	Credit System	
8	Number of credits per degree	
9	Number of contact hours per week	
10	Estimated number of student independent work load per week	
11	Number of contact hours per term/semester	
12	Estimated number of student independent work load per term/semester	
13	Number of contact hours per year	
14	Estimated number of student independent work load per year	
15	Number of contact hours per degree	
16	Estimated number of student independent work load per degree	
Notes	Account for exam time on student work load	
	Independent work = All activies outside class: work at home	
	Student Workload = Contact Hours +Hours of Independent Work	
Summary	Average estimated student work load per week	
	Average estimated student work load per year	
	Average estimated student work load per degree	

The SAG then developed descriptions of what activities are considered face-to-face and those that constitute independent student work. The Table 9.2 below gives a summary of activities comprised by these two categories of learning activities.

Realising that implementation and the status of the regulations may be largely dictated by national regulations, the SAG collected information on whether there were National or Institutional regulations, or both, that guided the policy on contact and/or independent student workload.

Table 9.2
Activities Spanning contact and independent work hours

Contact Hours (In Class)	Independent Work hours
Lecture Time	Out-of-Class Student Work
Guided Tutorials	Conducting Homework
All types of In-Class Work	Completing Assignments
Guided Laboratory Work	Writing Lab/Project Reports
	Revising Lectures
	Participating in Group Projects
	Conducting Desk or Field Research
Usually prescribed in program regulations as contact hours	Implementing Projects at Workshops

The Table 9.3 shown below is a depiction of the status of national / institutional regulations regarding student workload.

Table 9.3
Status of regulation in different participating countries

Status of National/ Institutional Regulations regarding Contact/ Independent Working Hours							
				Regulations		Institutional Regulations	
Number	Country	University	Degree	National	Institutional	Contact	Independent
1	Ethiopia	Jimma	B.Sc Eng	Yes	Yes	Yes	Yes
2	Zambia	Copperbelt	B.Sc Eng	Yes	Yes	Yes	No
3	Cameroon	Yaonde-1	M. Eng	Yes	Yes	Yes	No
4	Egypt	Cairo	B.Sc Eng	Yes	Yes	Yes	No
5	DR-Congo	Kinshasa-Ista	M. Eng	Yes	Yes	Yes	No
6	Rwanda	KIST	B.Sc Eng	Yes	Yes	Yes	No
7	South Africa	Stellenbosch	B.Sc Eng	Yes	Yes	Yes	Yes
8	Ghana	KNUST	B.Sc Eng	Yes	Yes	Yes	No
9	South Africa	CPUT	B.Tech	Yes	Yes	Yes	Yes
10	Malawi	Polytechnic	B.Sc Eng	Yes	Yes	Yes	Yes

It was established that all the nine countries under consideration had national and institutional regulations in place regarding student workload but only three out of the nine institutions considered independent work hours when computing the student workload, while the rest only considered face-to-face contact hours.

In trying to establish factors that guide or inform the duration of Engineering degree programmes in the institutions in the countries under discussion, the SAG decided to also get information on the average age and average number of schooling years before students enter University. This information is indicated in the Table 9.4 given below.

Table 9.4
Details of pre-university requirements

PRE-UNIVERSITY YEARS OF EDUCATION AND AVERAGE AGE AT ENROLMENT					
Number	Country	University	Degree	Previous years of Education	Average Student age at enrolment
1	Ethiopia	Jimma	B.Sc Eng	12	18
2	Zambia	Copperbelt	B.Sc Eng	12	18
3	Cameroon	Yaonde-1	M. Eng	13	17
4	Egypt	Cairo	B.Sc Eng	12	18
5	DR-Congo	ISTA-Kinshasa	M. Eng	12	17
6	Rwanda	KIST	B.Sc Eng	12	18
7	South Africa	Stellenbosch	B.Sc Eng	12	18
8	Ghana	KNUST	B.Sc Eng	12	18
9	South Africa	CPUT	B.Tech	12	18
10	Malawi	Polytechnic	B.Sc Eng	12	18

It was established that the average number of years for entry into university was 18 years and that students would normally have spent 12 years in school before entering university in all countries considered except for Cameroon where students spend 13 years in school before entering university. Having done the above, the Group then collected information on the average student workload (SWL) per week, then the student workload per year and finally the total student workload per entire degree programme. The duration of the degree programmes were also collected for comparison and the results are shown in the Table 9.5 shown below.

Table 9.5
Summary of student workload

ESTIMATION OF STUDENT WORK LOAD IN 10 MECHANICAL ENGINEERING PROGRAMS							
Number	Country	University	Degree	Number of years	SWL in hours/ week	SWL in hours/year	SWL in hours / degree
1	Ethiopia	Jimma	Bachelor of Science in Mechanical Engineering	5	51	1611	8082
2	Zambia	Copperbelt	Bachelor of Engineering Honours degree in Mechanical Engineering	5	50	1500	7500
3	Cameroon	Yaonde-1	Master of Engineering in Mechanical Engineering	5	54	1620	8100
4	Egypt	Cairo	Bachelor of Science in Mechanical Design Engineering	5	52	1836	9180
5	DR-Congo	ISTA-Kinshasa	Master of Engineering in Mechanical Engineering	6	54	1720	8400
6	Rwanda	KIST	Bachelor of Science in Mechanical Engineering	4	50	1400	5600
7	South Africa	Stellenbosch	Bachelor of Engineering in Mechanical Engineering	4	50	1500	6000
8	Ghana	KNUST	Bachelor of Science in Mechanical Engineering	4	50	1500	6000
9	South Africa	CPUT	Bachelor of Technology in Mechanical Engineering	4	54	1177	4707
10	Malawi	Malawi-The polytechnic	Bachelor of Engineering- mechanical Engineering (Honours)	5	60	1920	9450

It was noticed that the figures for the Bachelor of Technology at CPUT were quite different from the rest of the degree programems due to the nature of the degree which is tailored to technologists. As such, the figures from CPUT were not included in computing the average student workload. From the analysis the average student workload per week was found to range from 50 hours to 60 hours while the student workload per year was found to range from 1,500 hours to 1,920 hours.

9.2. Main Issues Arising from Workload Consultation

Around the globe, there is an increasing demand to provide some reference points concerning student workload. The European Credit Transfer and Accumulation System, abbreviated as ECTS, is one of the tools for promoting comparability and compatibility in European Higher Education [1]:

The ECTS credit system is also related to the issue of workload. Student workload in ECTS consists of the time required to complete all planned learning activities such as attending lectures, seminars, independent and private study, placements, preparation of projects, examinations, and so forth.

The general trend is that 60 credits measure the workload of a full-time student during one academic year. The student workload of a full-time study programme in Europe and Russia amounts in most cases to around 1,500-1,800 hours per year and, in those cases, one credit stands for around 25 to 30 working hours; whereas the workload is equivalent to 1,440 to 1,980 hours per year in Latin America.

9.2.1. *Reflections on an African Credit Transfer System*

Africa needs reliable means of measuring and transferring records of acquired knowledge in the realisation of the stated key policy imperatives and objectives. At present, there is no common approach to measuring and transferring of records of learning activities in African higher education institutions. The fact that there are different types of credit systems in Africa restricts mobility of staff and students. In order to foster the development of continental African credit transfer system for higher educational institutions, a survey had been conducted in various regions across Africa, such as North, South, and East, West and Central.

Nine countries have been covered by the study in the Mechanical Engineering Subject Area Group, which aimed to gather reflections from academics and students on student workload in relation to a particular unit/course/and module. The study was conducted looking at the workload with respect to total contact hours and independent work. Contact hours cover the amount of time spent on training in contact with the teacher or other staff of the university in the study of a particular unit/course/module. It includes lectures, seminars, clinical practices, lab, project work and fieldwork; whereas independent work is the time spent for learning activities that are not supervised. The latter includes reading texts or literature, fieldwork, laboratory work, preparation and execution/presentation of written work, working with internet sources, preparing for interim assessment, final exams and various other activities. The Mechanical Engineering Subject Area Group (MEng-SAG) that undertook the study includes twelve universities.

The total number of contact hours associated with a unit/course/module during a semester in Mechanical Engineering Subject Area Group was reported to be 313.72 by academics and 320.56 by students. These results showed that our data showed the best fit between academics' and students' estimates of contact hours among the various Tuning Africa Subject Area Groups. The mean contact hours in the Mechanical Engineering Subject Area Group was estimated separately across the regions. The results are shown in the Table 9.6 below.

Table 9.6
Total contact hour requirements from different regions and perspectives

Region	Country	Total contact hours estimated necessary for a unit/course/module during a semester	
		Academics	Students
North	Algeria, Egypt, Tunisia	302.24	316.36
West	Ghana	272.95	306.20
South	Malawi, South Africa	359.74	307.28
East	Ethiopia	286.58	304.21
Central	Cameroon, DR Congo	348.75	339.05

From the table, it appears that academics perceive the need for more total contact hours in south and central regions than others. However, students from the west region judged that they needed more contact hours than academics did. Overall, the estimates of academics and students with regard to the total contact hours needed to study a unit were more or less equivalent in all regions across Africa.

The other reflections obtained from the data collected on the time needed to complete self-work/study on a particular unit/course/module revealed that allocation of time to self-study is different based on the type and nature of the activities. However, academics and students predicted the total number of hours needed to complete an individual work is about 513.75 and 434.01 respectively. Students thought they needed less time to finish self-work than academics proposed. The summary of the results is shown in Table 9.7 below, along with pie charts highlighting the difference between the perceptions of the two groups of respondents (Figure 9.1).

Table 9.7
Summary of estimates of contact and independent work hours

	Contact hours	Independent work hours	Total per semester
Academics	313.72	513.75	827.47
Students	320.56	434.01	754.57

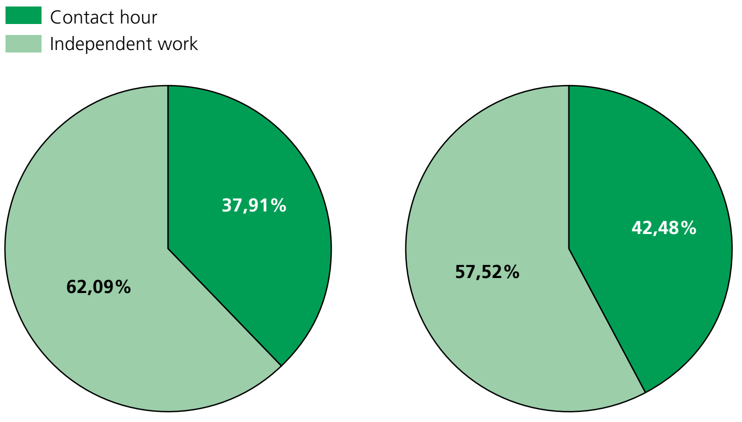


Figure 9.1
% Contact hours versus time necessary for independent work (Mechanical Engineering)

9.3. Conclusion

Student workload in 10 Mechanical Engineering Programmes in 9 countries have been analysed.

It was found that the range of student workload per week varied from 50 hours to 60 hours, while the average student workload was found to be 52 hours per week. This compares quite well with the average student workload of 51 hours for Civil Engineering degree programmes in Latin America. The student workload per year ranged from 1,500 hours to 1,840 hours. This compares quite well with student workload from Latin America which range from 1,440 to 1,980 and Russia and Europe which range from 1,500 to 1,800 hours per year.

The number of years required to complete a degree programme in Mechanical Engineering ranged from 4 to 6 years. It was further found that the duration of the degree programmes was not affected by the number of years of pre-university education or the average age before entry into university. The similarities of student workload among the institutions considered indicate that insofar as student workload is concerned, the introduction of a continental credit system would not be problematic. It will be necessary, however, to consult national regulatory bodies about the need for a continental credit system and address any challenges that may be envisaged in the adoption of such a system.

The various approaches to measuring and transferring student workload were surveyed in eight Mechanical Engineering programmes in nine countries in different regions of Africa. It was found that academics and students in all regions estimated very close to the same total number of contact hours required to study a unit/course/module. However, students judged that they needed less time to complete the necessary unsupervised study activities than academics did.

Generally, there is a similarity of time estimation for measuring and transferring knowledge between academics and students in all regions included in the survey. This suggests that there are excellent opportunities for implementing an African credit transfer system in all African higher education institutions.

Chapter 10

Conclusions

The Tuning Africa Methodology has been designed to make it easier to read curricula in terms of how they address relevant issues related to skills development and learners' employability. Starting from the generic competences or skills and the subject-specific competences or skills defined for a given field, it becomes easy to decide objectively on the comparability and on compatibility of the curricula, which in turn facilitates transparency, with, in the background, a view to the mobility of students between universities and the subsequent phenomena of course recognition.

From this point of view, it has been noted that, throughout the Continent, the Tuning Africa Methodology has been received with particular attention because it stems from a rigorous scientific approach that allows to pose in a more comprehensive way the nagging question of professionalisation. It takes into account lessons learned in order to reduce the unemployment of learners, all in a context of massive student enrollment in universities. This point, critical for all African countries, suddenly concerns all universities as they face the problem of relevance of training.

With regard to Mechanical Engineering, participants unanimously recognise the importance of this discipline for the industrialisation of the Continent while underlining major disparities in training approaches, which very often obstruct any attempt at comparability. The participants are all of the opinion that the analysis carried out comprehensively according to Tuning Africa Methodology emphasises similarities and therefore creates reference points between various curricula and various approaches to training in Mechanical Engineering. By putting a focus on skills or competences, understood in a broad sense, it allows everyone, without necessarily renouncing their own traditions, to position oneself to dialogue with others in a regional environment where there is more and more questions of student mobility, credit transferability, harmonisation of curricula and mutual recognition of pathways. Participants agreed that in reality, no Mechanical Engineering training system is better than others: all are comparable and all need to make an effort to be better understood by others.

Participants agree that the effectiveness of a training system is measured by the degree to which learners are given, at the rate of progress specific to each system, the skills that companies require from graduates to be effective in their employment and to create economic growth. In this respect, participants' conclusion is that the quality of a training system can be measured in terms of the degree of understanding with employers who, in the end, by their level of recruitment of learners after graduation, make it possible to judge the adequacy of training with respect to the needs of companies. However, employers speak more about skills, the ability to find solutions to problems, and the ability to take initiatives, than about the levels of knowledge in a given field or discipline, which are nonetheless necessary.

All of this poses an understandable imperative in developing curricula for constructive dialogue between universities, business and other stakeholders. Participants agree that the involvement in this dialogue of interlocutors others than academics brings a dose of pragmatism in the construction of curricula and softens the exchanges between academics who if left to themselves would, no doubt, indulge in sterile confrontations about the knowledge to be conferred and not about the skills to be acquired.

The various traditions in Mechanical Engineering education lead to quite different practices with regard to training methods. However, a point of convergence raised by members of the Mechanical Engineering Subject Area Group concerns the workload of the students. The members of the Mechanical Engineering SAG have unanimously concluded that student workload is often not taken into account in the planning of the educational process. The participants were fully aware of the need to change current practices by incorporating this parameter. But what will be the new learning process that will incorporate this parameter and, besides, how will it be integrated into present practice?

The international mobility of students and teachers in Africa has become a reality in full coherence with the 2007 Arusha Convention on the African Harmonization Strategy for Higher Education in order to ensure the recognition of studies, certificates, diplomas, and other academic qualifications in African higher education. It is a logical extension of major contemporary initiatives aimed at catalysing African integration through higher education through increased cooperation between academic institutions to promote intra-African academic mobility through objective, transparent mechanisms and reliable mutual recognition of academic qualifications.

According to the participants of the Mechanical Engineering Subject Area Group, Tuning Africa offers a collaborative methodological approach that allows participating institutions to compare training profiles according to the expected results and the skills acquired as defined in a given field of study. That said, participants all agree that the rational management of mobility and subsequent problems of recognition of studies in the broad sense requires some form of harmonisation of the organisation of the training process. If we agree that the lessons are almost everywhere structured in credits, then the question arises as to what a credit should be worth, and if it is possible to set up an ACTS (African Credit Transfer System). The Task Force has made bold and ambitious proposals in this regard, although the implementation of ACTS is still a concern today.

In the end, a lot of work has been done and as much remains to be done. But, no doubt, we are moving in a visible and credible way towards an African space of higher education, something unimaginable just a few years ago.

References

Akatieva, L. *et al.* Reference Points for the Design and Delivery of Degree Programmes in Tourism (2014) Deusto University http://tuningacademy.org/wp-content/uploads/2014/02/RefTourism_TuRu_EN.pdf

González, J. and Wagenaar, R., Student Workload teaching methods and learning outcomes: The Tuning Approach. http://www.unideusto.org/tuningeu/workload-a-ects/179-student-workload-teaching-methods-and-learning-outcomes-the-tuning-approach.html

Onana, C.A. *et al.,* 2014. The African Experience. University of Deusto, Bilbao, Spain. Retrieved at http://tuningacademy.org/wp-content/uploads/2014/05/Tuning-Africa-2014-English.pdf

Ryan, P., 2014. Policy and implementation: actions for curriculum reform. Tuning Journal for Higher Education, vol 2(1), http://www.tuningjournal.org/issue/view/6

Working towards a unified credit system for Africa together with students: The Tuning Africa initiative; http://www.africa-eu-partnership.org

Annex

Contributors to the Publication

Name	Phase	University	Country
Noureddine **ABDELBAKI**	II	Akli Mohand Oulhadj	Alger
Charles **AWONO ONANA**	I&II	Université de Yaounde I	Cameroon
Leonard Mukeba **KABEYA**	I&II	Institute Supérieur des Techniques Appliquées, ISTA/KINSHASA	Democratic Republic of Congo (ex Zaire)
Jean Paul Mbay **KATOND**	II	Université de Lubumbashi	Democratic Republic of Congo (ex Zaire)
Chahinaz A. Saleh S. **ABDELGHANY**	I&II	Cairo University	Egypt
Masaaki **SUZUKI**	II	Egypt-Japan University of Science and Technology	Egypt
Baye Molla **TIKUYE**	II	Dilla University	Ethiopia
Venkata Ramayya **ANCHA**	I&II	Jimma University	Ethiopia
Gabriel **TAKYI**	I&II	Kwame Nkrumah University of Science and Technology	Ghana
Moses Phenias Mngwapa **CHINYAMA**	I&II	University of Malawi - The Polytechnic	Malawi
Trollip Zwelethu **NGEWANA**	I&II	Cape Peninsula University of Technology	South Africa
André Eugene **MÜLLER**	I&II	Stellenbosch University	South Africa
Yamen **MAALEJ**	I&II	Université de Tunis El Manar, École Nationale d'Ingénieurs de Tunis	Tunisia
Shadrick **CHAMA**	I&II	Copperbelt University	Zambia

For more information about Tuning

International Tuning Academy
University of Deusto
Avda. de las Universidades, 24 (48007 Bilbao)
Tel. +34 944 13 90 95
Spain
dita@deusto.es

European Commission

AFRICAN UNION

Deusto
University of Deusto