GUIDEBOOK FOR CAPACITY BUILDING IN THE ENGINEERING ENVIRONMENT

by the

Committee on engineering capacity building committee of the World Federation of Engineering Organizations

First edition - 2010

"The building of human, institutional, and infrastructure capacity to help societies develop secure, stable, and sustainable economies, governments, and other institutions through mentoring, training, education, physical projects, the infusion of financial and other resources, and, most importantly, the motivation and inspiration of people to improve their lives."

WORLD FEDERATION OF ENGINEERING ORGANIZATIONS

Committee on Engineering Capacity Building
World Federation of Engineering Organizations

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Appreciation is given to the CECB team of WFEO, other individuals who made this publication possible and the various organizations, societies and institutions that contibuted generously in terms of capacity and resources

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Financial assistance with distribution - Kuwait Society of Engineers

Printer

Ultra Litho, Johannesburg

ISBN 978 - 0 - 620 - 48606 - 8

Preamble

The World Federation of Engineering Organizations - WFEO was founded in 1968 under the auspices of the United Nations Educational, Scientific and Cultural Organization - UNESCO.

As a non-governmental international institution WFEO brings together national engineering institutions from over 90 nations, representing approximately eight million engineers from around the world. WFEO co-operates with national and other international professional institutions in developing and applying engineering to the benefit of humanity. One means of accomplishing this goal is the formulating of advice and collation of experience, prepared independently of any commercial bias, which would be of assistance to others, such as governments and international agencies.

The United Nations Educational, Scientific and Cultural Organization founded in 1945, is an idea generator and a standard-setter in the fields of education, science, culture and communication. UNESCO has one hundred and ninety Member States and six Associate Members. UNESCO is actively pursuing the Millennium Development Goals, especially those aiming to:

- halve between 1990 and 2015 the proportion of people living in extreme poverty;
- achieve universal primary education in all nations by 2015;
- eliminate gender disparity in primary and secondary education by 2005; and
- half by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation.

WFEO as well as UNESCO are of the view that given the strong relation between, on the one hand, creation of a critical mass of educated and skilled engineering and science graduates and, on the other, economic and social development, stronger efforts should be made to develop and build these capacities in developing nations. However they are also of the view that the decline in recognition of the role of engineering in many developed nations necessitates that a similar approach should be followed in all nations.

At the World Summit for Sustainable Development in Johannesburg in 2002, WFEO hosted an event at which challenges around capacity building were discussed. At this event, the Africa Engineers Protocol concept of sustainable engineering as a prerequisite for sustainability, and the elements that are the foundation of sustainability, were introduced to WFEO. Subsequently, at the WFEO General Assembly in Tunis in 2003, and with the support of UNESCO, WFEO created a Standing Committee on Engineering Capacity Building - CECB[1].

The Committee on Engineering Capacity Building first met in Washington DC in 2004 and over the next few years proceeded to develop an understanding of the challenges and complexities that faced the engineering community regarding capacity and sustainability issues. At the CECB meeting in New Delhi in 2007, it was concluded that the time had come to deliver concrete results and contribute positively to the needs that

1 Initially known as the "Committee on Capacity Building". "Engineering" was added in 2009.

had become evident. At that meeting the idea to identify, assemble, share and if feasible promote the production of material that could facilitate and assist with capacity building was first mooted.

The CECB also recognized the integration of effort that is required to undertake successful capacity building. In December 2008, the CECB met in Brasilia and began work on the framework for a "guidebook for capacity building in the engineering environment" and an associated compendium of programmes and initiatives.

This guidebook has subsequently been produced by a team assembled by the CECB. The first edition will be launched at the WFEO World Engineers' Week in Argentina in October 2010.

The principles and ideas proposed in the guidebook are not position papers or policies of neither WFEO nor UNESCO, but represent a collection of philosophies, programmes, initiatives and good practice examples collated from the experiences of a range of engineering institutions and engineering professionals.

The guidebook sets out suggested approaches to the building of human resources and capability, an essential component of achieving national development objectives and the millennium development goals.

It is envisaged that the guidebook will be utilised as a source of reference to assist the creation of common understanding, the improvement of decision making, the promotion of integrated and multidisciplinary modes of development, and the improved planning and implementation of development programmes and initiatives.

UNESCO and WFEO gratefully acknowledge the contributions of a small team of engineering professionals, their colleagues, contributors and reviewers who gave generously of their time, expertise and experience. They also acknowledge the cooperation of the professional institutions that made the services of these individuals available.

Executive summary

Background

The World Federation of Engineering Organizations (WFEO) was founded in 1968 under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the agency of the United Nations Organisation that is the generator of ideas and setter of standards in the fields of education, science, culture and communication. WFEO, a non-governmental international institution, brings together national engineering institutions from over 90 nations, representing 8 million engineers from around the world. WFEO co-operates with national and other international professional institutions in developing and applying engineering to the benefit of humanity. One means of accomplishing this goal is the formulating of advice and collation of experience, prepared independently of any commercial bias, which would be of assistance to many entities and individuals, including governments and international agencies.

Collaboration with UNESCO on capacity building has been ongoing for quite a while and a number of initiatives have been aimed at integrating effort and aligning philosophy.

Both UNESCO and WFEO are of the view that given the strong relation between, on the one hand, creation of a critical mass of educated and skilled engineering and science graduates and, on the other hand, economic and social development, stronger efforts should be made to develop and build both engineering and science capacity, as well as informed decision-making capacity in developing nations. However they are also of the view that the decline in recognition of the role of engineering in many developed nations necessitates that a similar approach should be followed in all nations.

At the World Summit for Sustainable Development in Johannesburg in 2002, WFEO hosted an event at which challenges around capacity building were discussed. At this event, the Africa Engineers Protocol concept of sustainable engineering as a prerequisite for sustainability, and the elements that constitute the foundation of sustainability, were introduced to WFEO. At the WFEO General Assembly in Tunis in 2003, and with the support of UNESCO, WFEO created a Standing Committee on Engineering Capacity Building (CECB) facilitated by the American Society of Civil Engineers[2].

Since that time, the CECB's understanding of the challenges and complexities that face the engineering community regarding capacity and sustainability issues has grown substantially. The CECB recognizes the need to identify, assemble, share and where appropriate, possible and feasible promote the production of material that could facilitate and assist with capacity building. In addition the CECB recognizes the integration of effort that is required to undertake successful capacity building. It was decided that the most suitable way to do this would be through the production of a "Guidebook for capacity building in the engineering environment" and an associated compendium of programmes and initiatives.

The first edition of this guidebook was developed to be launched at the WFEO World Engineers' Week in Buenos Aires, Argentina in October 2010.

Introduction

The guidebook sets out suggested approaches to the building of human resources and capability within nations that will assist the sustainable achievement of national development objectives and the millennium development goals. This capability would not only be in respect of engineering – although the guidebook's emphasis is on engineering.

The principles and ideas proposed in the guidebook are not position papers or policies of either UNESCO or WFEO, but represent a collection of philosophies, programmes, initiatives and good practices collated from the experiences of a number of engineering institutions and engineering professionals.

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2 Initially known as the "Committee on Capacity Building". The word "Engineering" was added in 2009

It is envisaged that the guidebook will be utilized as a source of reference to assist the creation of common understanding, enhancing informed decision making, the promotion of integrated and multidisciplinary modes of development, and improved planning and implementation of development programmes and initiatives related to engineering infrastructure and services.

The nature and role of capacity building

A generic definition of capacity building is:

"The building of human, institutional, and infrastructure capacity to help societies develop secure, stable, and sustainable economies, governments, and other institutions through mentoring, training, education, physical projects, the infusion of financial and other resources, and, most importantly, the motivation and inspiration of people to improve their lives." [3]

Engineering professionals could confine their role to being only the planners, designers, constructors, operators and maintainers of infrastructure and services. Being professionally responsible demands however that engineers take a wider role upon themselves. This wider role includes a recognition that engineers need to facilitate and enhance not only their own knowledge, but also the knowledge of others, in order that decisions taken will ensure that engineering infrastructure is sustainable and that it is fit for its purpose, which is to underpin quality of life and the economic well-being of communities and nations.

It is becoming increasingly evident that, in spite of well developed technical engineering expertise and solutions, the complexities to create and provide even basic infrastructure services are proving to be beyond the capacity of many governments, institutions and communities. There is ample evidence that in many nations – including developed nations – there is a steady loss of informed decision-making capacity where infrastructure and the built environment are concerned.

Across the world, there is insufficient understanding of the need for infrastructure and services, and of how to develop, deliver, operate and care for that infrastructure and services. This demands action from the engineering profession. However efforts to deliver what is right, feasible, appropriate and affordable are often not taken seriously enough, or may even be ignored. Capacity of a variety of institutions, communities and individuals, and in respect of this understanding needs to be developed and maintained.

This guidebook is therefore, as its title indicates, about capacity building in the engineering environment. It is therefore not specifically about capacity building of engineering professionals or of any other particular group of individuals, communities or institutions. Where it needs to, it also embraces development or enhancement of systems that would enable the building of the capacity of those individuals, communities and institutions.

Success in capacity building will only be achieved through a systematic approach, taking into account what were identified and presented by means of a variety of models. One of these models emanate from the Africa Engineers Forum Protocol and was defined as the "six pillars" of capacity building that were deemed to be necessary and more or less in balance for sustainability in engineering infrastructure and services.

These six pillars are:

- ***Individual*** – to ensure that the needs of the individual are met
- ***Institutional*** – to ensure that there are educational, professional, technical, governance and statutory institutions, systems and support structures in place. The institutions would be in both the public and private sectors, including stable, viable and responsible businesses, commercial

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3 General Henry Hatch, at a March 29, 2004 workshop sponsored by the Office of the Science and Technology Advisor to the U.S. Secretary of State.

enterprises and financial institutions that can support the provision, operation and maintaining of infrastructure and services

- ***Technical*** – to ensure that there are technical standards, codes of practice, technical literature and guidance material and so forth to underpin and support ethical and appropriate engineering, technological and procurement procedures and practices

- ***Decision-making*** – to ensure that decision makers have sufficient information and understanding as well as access to knowledge and skills to enable them to make informed, logical and rational decisions

- ***Funding*** – to ensure that adequate and affordable finance is available to enable sustainable solutions, and that financial practice is at all times responsible, including adequate revenue streams and where appropriate, even after external funders have withdrawn

- ***Resources, equipment, tools and supplies*** – to ensure that there is access to appropriate, affordable and suitable materials, equipment, tools and supplies for the designing, building, implementing, operating and maintaining of infrastructure and the provision of engineering services

One size certainly does not fit all, and in each instance where the building of capacity is deemed to be advisable and or necessary, the systematic approach introduced above needs also to ascertain to what extent, and in what manner, it is necessary to address the following three aspects:

- the level of the enabling environment,
- the institutional level,
- the individual level.

Each capacity building programme or initiative must:

- be preceded by:
  * identification of "stakeholders" including participants, interested and affected parties;
  * assessment of requirements and identification of priorities for capacity building with reference to priorities in terms of both what capacity to be built, and whose capacity was to be built;
  * identification and mobilisation of structures and agencies that will build the capacity, and mentor and sustain this capacity in the longer term;

- be followed by assessment of the results of capacity building: including results not just in terms of capacity built, but to what extent that capacity is leading to the required improvements in terms of outcomes[4] ; and feedback, leading to continuous improvement in capacity;

- be iterative in the sense that a first round of capacity building might be of a basic nature only, with each round successively raising the bar and/or addressing issues that have not been identified or covered previously.

It has to be emphasised that capacity building:

- must be focused on the purpose of improving capacity e.g. on those in whom capacity is being built using this to improve service delivery and not be about building capacity for its own sake, since it is all too often is the case that the need to apply the capacity is lost sight of.

- must address needs according to priority.

The efficacy of capacity building must be evaluated. Part of the evaluation must be an assessment of cost-effectiveness meaning that it must be ascertained whether the effort and cost of capacity

4 For example, not just that people have through the capacity building programme become more skilled, but that they apply those skills, and that this brings about better results in terms of achieving whatever it is they have been capacitated to do.

building was justified by the improvement in e.g. service delivery. If it was not, then maybe lack of capacity was not the bottleneck, and some other way to improve service delivery should rather have been undertaken. Alternatively, the capacity building needs might have been misunderstood, or the effort might have failed because of its content or inappropriateness, or even because of the way in which it was conducted and by whom.

Identification of the weak links in the service value chain should be part of that assessment prior to deciding where and what capacity must be built. If the objective is to improve service delivery, say, whether priority attention should go to some other link or links that is or are weaker, rather than to capacity building, should be thought through.

If capacity building is for the purpose of supporting a project or programme, e.g. as in an infrastructure delivery programme, then it is imperative that the capacity building must be integrated with the programme lifecycle.

In one case a government structure spent millions on giving technical training in water service delivery to a number of individuals who could not find jobs after they have been trained. The reason that came to light was that the authority concerned had not made any effort to find out what the demand was and did not subsequently establish the need tailored training to fit the need.

In another instance a statutory entity was giving bursaries to educate engineering students but did not look at what happened beyond graduation in terms of employment and mentorship in the candidate phase. In this particular instance there had been hundreds of vacancies in a local authority level but these authorities were not employing graduates since they lacked "experience" and were deemed unemployable. The lack of an integrated and informed process or pipeline is evident in many cases. The disconnect in this case however did not prevent the party that gave the bursaries to claim that they have reached their targets and fulfilled their mission.

The guidebook - a compilation of advice

The guidebook presents a compilation of advice[5] drawn from the experiences of the international engineering community, clustered under a set of headings which represent an idealised capacity building project:

- Researching needs: How to work with communities and institutions in order to establish their needs, that seldom equates to their expectations and or aspirations.
- Defining and influencing public policy: How to work with governments in participating nations to make the case for increasing resources for capacity building programmes, particularly emphasising the international evidence that indigenous or locally deployed technical capacity has been vital to alleviating poverty, improving quality of life and building prosperity in nations.
- Educating, training and developing skills: How to develop and implement qualifications, ethics and competence standards in participating nations, including building of skills of the educators themselves, and providing suitable teaching resources and facilities.
- Participating: How to attract and retain citizens towards education in engineering, in order to build and retain a demographically representative and local or indigenous technical skills base.
- Building networks and support systems: How to build transparent and equitable governance and representative structures and institutions to support all the above.
- Developing technical and business standards: How to develop a framework of standards, codes of practice and other supporting components, together with systems to enhance and ultimately improve adherence to these standards.

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5 This advice represents what the authors of the guidebook regard as "good practice", rather than "best practice". If a current situation is much below good practice, the goal should be to raise it to good practice levels -- and not necessarily strive for best practice, which could require unwarranted effort and resources. Many nations, institutions and communities are too often so enthralled at the thought of achieving best practice that they devote disproportionate resources to a minority of projects and programmes, leaving inadequate resources for that which might be more mundane, but which is likely to be important to more citizens. As Voltaire wrote: "the best is the enemy of the good".

- Managing projects according to lifecycle principles: How to identify, and apply, factors key to taking projects from their initial conceptualisation right through to their successful completion, and subsequent successful operation, including maintenance, and ignoring ultimate decommissioning at the end of the useful life of the infrastructure.

- Obtaining and utilising external funding: How to apply for, and use, external funding.

The guidebook presents a number of illustrations of how capacity can be built in widely varying circumstances, such as island nations with small populations, war-torn nations which have rebuilding needs, or nations rich in natural resources but, other than directly related to the resource are poor in infrastructure development and in technical capacity.

Examples are presented in the guidebook of the capacity that may be needed by communities and institutions, particularly in respect of:

- Skills, including skills that are technical, financial, and people-oriented.

- Resources, including funding, training programmes and mentoring processes, and in particular public policies

- Decision-making mechanisms, including policies, prioritisation rules and mechanisms, risk analysis and related policies, incentives, ethics, standards, and mechanisms for trade-off between alternatives taking into account and recognizing:
  - that choices are never absolute, but are invariably between alternatives;
  - the importance of identifying that results depend on a chain of factors, and not on one factor -- and recognizing the importance of identifying weak links, and in particular identifying the weakest link and that, once that is addressed, the next weakest link becomes the new priority; and
  - the importance of the "80/20 rule" and of first getting the basics right, with the "nice-to-haves" to follow only if additional resources become available.

- Administration and systems: Including governance, laws and regulations, procurement, monitoring and evaluation, and feedback loops.

The institutions referred to could include[6] :

- Local or indigenous institutions meaning that these are from the nation where the capacity building is taking place, as opposed to foreign; or
- Informal institutions such as communities who are not formally organised, as opposed to formal institutions; or
- Public sector institutions, including government itself, parastatals, statutory entities and semi-government agencies and utilities, as opposed to community-based organisations and non-governmental organisations as in turn opposed to the private sector.

Not only would each developmental situation require capacity building specific to that situation, but each individual, community and institution significant to that situation would require capacity building appropriate to its, his or her own needs.

The compendium

A resource additional to the guidebook, and complementing it, a compendium of programmes, projects, and initiatives is being developed. The compendium is however intended to be more than just

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6 It is important that the parties involved in capacity building are not referred to as "contributing" or "receiving". For a number of reasons, not least that, in the authors' experience, all parties receive during a capacity building process, and all contribute. The increase in capacity is not a uni-directional phenomenon -- rather, all should be referred to as "participants".

a resource to be consulted. The intention also is that it will stimulate networking, and provide a library as well as a "marketplace" where ideas, initiatives and programmes can be shared and exchanged, and that these will be captured and added to the compendium. This exchange of ideas will also no doubt identify aspects that need to be covered, that in turn will hopefully stimulate the development of programmes and initiatives that could fill the gaps.

The compendium is therefore not intended to be a static document, but will need to be updated from time to time. Contributions will be promoted and encouraged. For this purpose, the compendium will be in the form of an electronic database, hosted on the WFEO website.

Utilization of the guidebook

The purpose of the guidebook is to provide a source of reference to institutions and communities and to those involved at any level in working to develop, build and maintain:

- engineering capacity;
- sustainability of nations at large where this concerns infrastructure, services and providing for basic needs.

The guidebook could inter alia, and depending on the situation needs, assist with:

- identification of capacity building needs;
- designing of capacity building programmes for specific circumstances, or in response to a region-wide need[7] where applicable and appropriate;
- resourcing, and then implementing, capacity building programmes;
- reducing risks of and enhancing trust and credibility with stakeholders, including funding and resource institutions.

The guidebook is in the first instance written for a professional readership of built environment planners, practitioners and implementers who have the broader understanding of the role that infrastructure and services issues play, and who have the passion, the empathy and compassion to contribute to a better life for all. These readers will most probably be in senior management positions, and include those with strategic responsibilities. They will be people who are able to make a difference, and who have the ability to influence others to do what is needed.
However the material in the guidebook and is also selected for its value to a range of possible participants in capacity building. The guidebook therefore addresses capacity building at many levels, also taking account of the broad pipeline of issues and items in infrastructure service delivery. As noted earlier, it is about capacity building in the engineering environment, and not specifically about capacity building of engineering professionals or of any other particular group of individuals, communities or institutions.

The compendium attempts to address an even wider audience than that for which the guidebook is intended. For example, the compendium material is categorised and arranged in sections each aimed at groups with different needs, including school learners, rural communities, and/or officials with little if any strategic influence in infrastructure-related institutions. The first version or example of the compendium is presented in this guideline as appendix ..... but the intention is it would ultimately become an electronic database that can be updated and developed as and where more ideas and programmes become available.

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7 For example, to serve as a generic template for a nation, that it can adapt for its specific needs from time to time.

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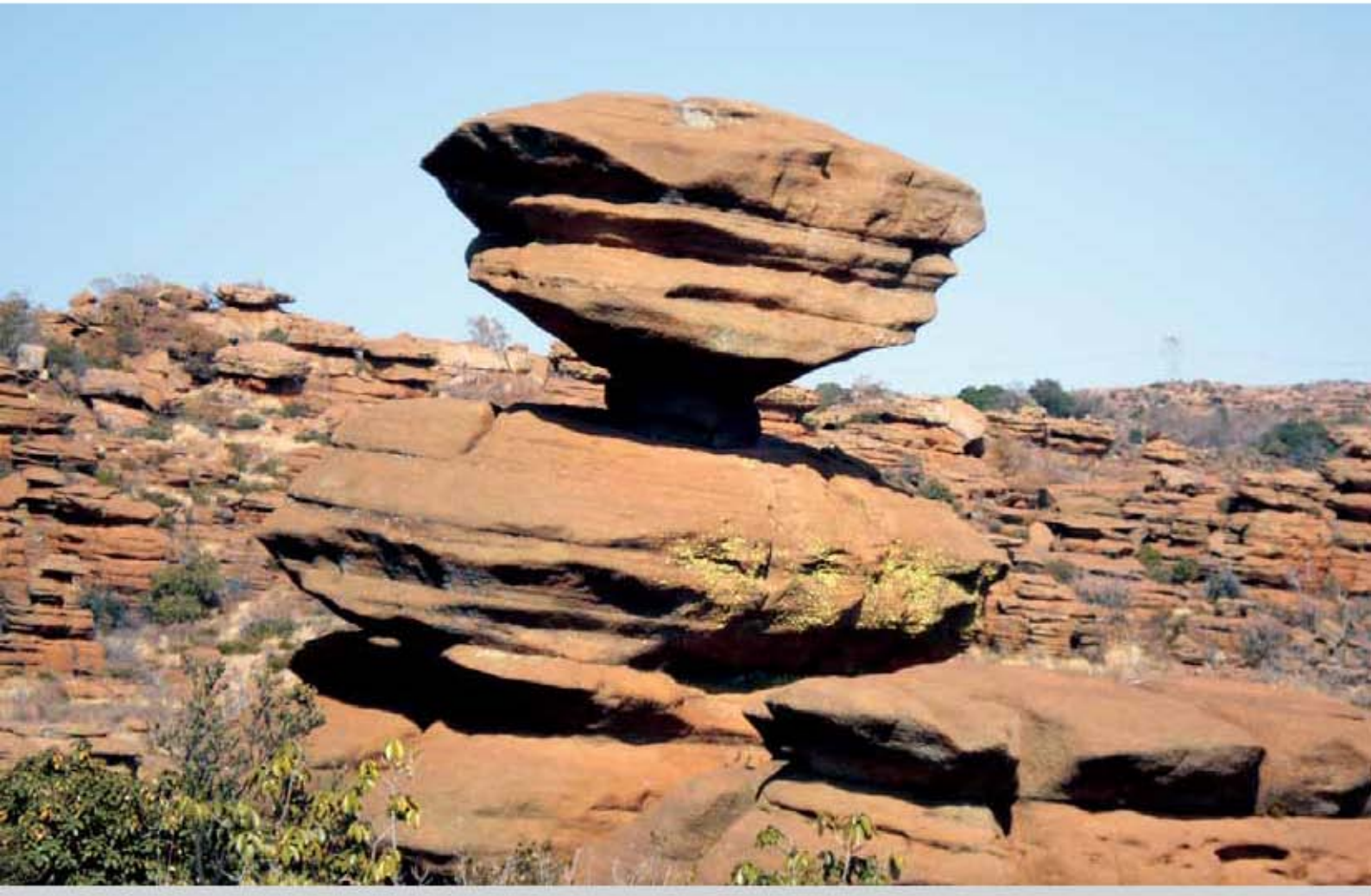


Engineering has to be rock solid in order to serve society

Acronyms used in the text include:

AAES	American Association of Engineering Societies
ASCE	American Society of Civil Engineers
CECB	Committee on Engineering Capacity Building
CSIR	Council for Scientific and Industrial Research (South Africa)
DFID	Department for International Development (UK)
EWB	Engineers Without Borders
GDP	Gross domestic product
GFCF	Gross fixed capital formation
ICE	Institution of Civil Engineers (UK)
IPENZ	Institution of Professional Engineers New Zealand
IT	Information technology
MoU	Memorandum of understanding
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
SAICE	South African Institution of Civil Engineering
SPEA	South Pacific Engineers Association
UNESCO	United Nations Educational, Scientific and Cultural Organization
WFEO	World Federation of Engineering Organizations

Foreword

"GUIDEBOOK FOR CAPACITY BUILDING IN ENGINEERING"

UNESCO Perspectives on Engineering Education and Capacity Building

The development and application of knowledge in engineering and technology underpins and drives sustainable social and economic development. Engineering and technology are vital in addressing poverty, sustainable development and the other Millennium Development Goals (MDGs), climate change mitigation and adaptation, bridging the "knowledge divide" and promoting international dialogue and cooperation. The role of engineering education and capacity building is absolutely vital in addressing these issues, and is one of the major challenges we face today and tomorrow.

Despite this, the role of engineering and technology in sustainable social and economic development is often overlooked by policy makers and the public. At the same time, there are serious challenges regarding attracting and retaining a cadre in terms of engineering professionals in terms of demographic representation. This will a major impact on our ability to address the challenges of sustainable social and economic development, poverty reduction and the other MDGs.

Building capacity in engineering

As discussed in the 2010 UNESCO Engineering Report many complex and complicated questions remain, including the numbers of each engineering discipline, the level of training and various related issues with reference to the different needs of each region, as well as and what organisations such as UNESCO and WFEO need to and could do about it. In addition there is no universal agreement on what the definition of an engineering professional. The issues obviously differ from country to country but a substantial of these issues tend be generic. Skewed or different approaches in terms of different policies in education and training furthermore complicates matters

Structural change

Despite this, structural as well as cyclical changes are taking place and at this stage government R&D funding in developed countries is declining in real terms, R&D facilities are downsizing, outsourcing and off-shoring to cheaper locations, as reflected in the declining publication of research papers. These changes may well have a discouraging effect on promoting engineering as a career of choice.

Many countries experience a so-called brain drain as mobility increases but on the other hand some countries experience an inflow of individuals. The engineering, science and technology capacity of many African countries has declined since their independence. Given the importance of engineering, science and technology in development, this background will have serious consequences for the future of these countries.

Green engineering

Engineering will be one of the most important areas of activity in the context of climate change mitigation and adaptation, and one of the major areas of need and growth for engineering is in the area of sustainable or green engineering. This will be one of the greatest demands and challenges that engineering has ever faced. One of the first challenges is to make sure that there are enough appropriately qualified and experienced engineers to meet this demand – this will require the development of new courses, training materials and systems of accreditation.

The demand for engineers will increase dramatically in order to deal with energy needs of the future. Urgent government action and investment is required right now to support course development and associated R&D and innovation.

Need for better data

The need for better statistics and indicators on engineering, especially at the international level is crucial, since the current data for engineering is collected and analysed at such an overall level as to be of limited usefulness. For example,while the origins of international trade in high-tech products in various fields of engineering should be more apparent, a clearer indication and attribution of this,

and the origins and destinations of exports and imports, would also be most useful in analysing issues related to the technological balance of payments.

These indicators are of limited use in analysing the need for, types and numbers of engineers required at national and international levels.

Considering the importance of engineering, science and technology in the knowledge society and economy, it is surprising that better data is not available on these most important drivers of social and economic development. In this guideline there is one reference to the ratio of engineers versus medical doctors and more needs to be done to examine and improve the health of nation's technology and infrastructure.

Promoting interest and understanding of engineering

Promoting interest in and understanding of the role of engineering in development, engineering education and capacity building and the application of engineering in these vital areas are multifaceted. There is a clear need to show that science and engineering are inherently interesting and to promote public understanding and perception, to make education and university courses more interesting as well as looking at all the contributing factors including remuneration and so forth and promoting engineering as a part of the solution, rather than part of the problem of sustainable development.

Issues like utilizing indigenous knowledge are important and the fact that relevance works, is demonstrated by the growth of Engineers Without Borders and similar groups around the world.

Transformation in engineering education and capacity building needs to respond to rapid change in knowledge production and application, emphasizing a cognitive, problem-solving approach, synthesis, awareness, ethics, social responsibility, experience and practice in national and global contexts. There is a need to learn how to learn and to emphasize the importance of lifelong and distance learning, continuous professional development, adaptability, flexibility, inter-disciplinary approaches and multiple career paths. Such transformation is essential if engineering is to catch and surf the "seventh wave" of technological change – relating to knowledge for sustainable development, climate change mitigation and adaptation, and new modes of learning.

The main challenges regarding the effective application of engineering and technology relate to the development, application and innovation to poverty reduction, sustainable development, climate change mitigation and adaptation. These challenges are linked to promoting the interest and enrolment of young people in engineering, as many young people, especially women, are keen to address international issues such as poverty reduction, sustainable development and climate change. Several success stories in terms of attracting younger generations are coming to the fore at this stage

In the context of the need to transform engineering education and capacity building to include sustainable development and wider social issues, the work of the WFEO Standing Committee on Capacity Building, and this guidebook could not be more timely and relevant. This is particularly relevant since in spite of various declarations, there is still a need to share information on what this means and effective capacity building in practice, and to share pedagogical approaches and curricula developed in this context.

The increasing emphasis on holistic, systems thinking is also timely, prompted, for example, by the renewed interest in biomimetics that links engineering and technology with natural systems. This reflects the interest in biomimetics of Leonardo da Vinci in the 15th/16th century, although recent interest has been facilitated by the development of computer science and technology and new materials – Leonardo would undoubtedly have taken a great interest in CAD/CAM and carbon fibre!

This publication from the WFEO Standing Committee on Capacity Building is an important to the ongoing discussion of engineering education and capacity building, and UNESCO looks forward to the development of this discussion and related initiatives that this guidebook will contribute to and stimulate. I would like to congratulate the team that produced this guidebook

This is a pioneering activity, and UNESCO looks forward to continued cooperation with WFEO on this area of increasing importance to engineering.

Tony Marjoram, UNESCO

Winds of change will have to blow for capacity building

1. Introduction to capacity building

1.1 Definitions of capacity building

It is increasingly evident that even where well-developed technical engineering expertise and solutions are at hand, the complexities to create and provide even basic infrastructure services are proving to be beyond the capacity of many governments, institutions and communities. In many nations or countries, including developed countries, there is ample evidence that there is a steady loss of informed decision-making capacity where it concerns infrastructure and the built environment.

Across the world, there is insufficient understanding of the need for infrastructure and services, and of how to develop, deliver, operate and care for that infrastructure and services. This demands action from the engineering profession. However efforts to deliver what is right, feasible, appropriate and affordable are often not taken seriously enough, or may even be ignored. Capacity of a variety of institutions and individuals, and in respect of this understanding needs to be built.[1]

A generic definition of capacity building, setting out its core principles, is:

"The building of human, institutional, and infrastructure capacity to help societies develop secure, stable, and sustainable economies, governments, and other institutions through mentoring, training, education, physical projects, the infusion of financial and other resources, and, most importantly, the motivation and inspiration of people to improve their lives." [2]

A less complex statement of unknown origin is that:
"Capacity building is the process of assisting people to develop the technical and decision making skills to address their own needs for improving the living standards and prosperity of their own people, and building an environmentally sustainable society."

Engineering professionals could confine their role to being only

1 It is important that the parties involved in capacity building are not referred to as "contributing" or "receiving". Experience has showed that for a number of reasons all parties receive during a capacity building process, and all contribute. The increase in capacity is not a unidirectional phenomenon -- rather, all should be referred to as "participants".

2 General Henry Hatch, at a March 29, 2004 workshop sponsored by the Office of the Science and Technology Advisor to the U.S. Secretary of State.

the planners, designers, constructors, operators and maintainers of infrastructure and services. Being professionally responsible demands however that engineers take a wider role upon themselves. This wider role includes a recognition that engineering professionals need to facilitate and enhance not only their own knowledge, but also the knowledge of others, to facilitate informed decision that will subsequently ensure that engineering infrastructure is sustainable, fit for its purpose and ultimately underpin quality of life and the economic well-being of communities and nations.

The reality of what the role of engineering and its contribution to the wellbeing of humankind is, prompted the philosophy that there is need for this "Guidebook for capacity building in the engineering environment".

1.2 Capacity building and sustainability

Sustainability and sustainable development can only be achieved if the principles of sustainable engineering or engineering for sustainability are adhered to. With reference to basic services, relating to health and safety, sustainable engineering is the planning, design, construction, operation and maintenance of appropriate, affordable and sustainable engineering services and infrastructure. The ultimate goal should be the creation of an acceptable quality of life for all facilitated and supported by:

- Good practice in engineering and technology.
- Informed and intelligent decision-making about built environment infrastructure and engineering products by all government and governance structures and private sector entities.

Success in sustainable engineering is only achieved by an integrated approach to the development and maintenance of indigenous scientific, technological skills and expertise as well as informed decision-making capacity supported and facilitated by the key stakeholders including government, private enterprise, academic and professional structures.

1.3 Components of capacity building

Success in capacity building will only be achieved through a systematic approach, taking into account what were identified albeit in different approaches of which the Africa Engineers Forum Protocol is but only one model one model. The various items as assembled in the protocol were grouped and labeled as six essential "pillars" of capacity or sustainability includes **Individual, Institutional, Technical, Decision-making, Funding or Finance and Resources, equipment, tools and supplies**

In Chapter 3 these pillars are described in more detail.

One size certainly does not fit all, and in each instance where the building of capacity is deemed to be advisable, the systematic approach introduced above needs also to ascertain to what extent, and in what manner, it is necessary to address three aspects:

- the level of the enabling environment,
- the institutional level,
- the individual level.

Each capacity building programme or initiative must:

- be preceded by:
- identification of stakeholders;
- assessment of requirements and identification of priorities for capacity building, that is, priorities in terms of both what capacity to be built, and whose capacity to be built;
- identification and mobilisation of agencies that will build the capacity, and mentor and sustain this in the longer term;
- be followed by assessment of the results of capacity building and not just results in terms of capacity built, but also to what extent that capacity is leading to the required improvements in terms of outcomes [3];

3 For example, not just that people have through the capacity building programme become more skilled, but that they apply those skills, and that this brings about better results in terms of achieving whatever it is they have been capacitated to do.

- be supported by feedback, leading to continuous improvement in capacity;
- be iterative in terms of which a first round of capacity building might be of a basic nature only, with each round successively raising the bar.

Capacity must therefore:

- be focused on the purpose of improving capacity, e.g. on improving service delivery by those in whom capacity is being built and not be about building capacity for its own sake, since it is all too often is the case that the need to apply the capacity is lost sight of;
- address needs according to priority.

The efficacy of capacity building must ultimately be evaluated as part of the process. The evaluation must include an assessment of cost-effectiveness in terms of establishing whether the effort and cost of capacity building was justified by the improvement in e.g. service delivery. If this was not the case it could maybe be that a lack of capacity was not the bottleneck, and some other way to improve service delivery should rather have been undertaken. Alternatively, the capacity building needs might have been misunderstood, or the effort might have failed because of its content or inappropriateness, or even because of the way in which it was conducted and by whom.

Part of that assessment prior to deciding where and what capacity must be built, should be identification of the weak links in the service value chain. If the objective is to improve service delivery, say, should priority attention go to some other link or links that is or are weaker, rather than to capacity building?

If capacity building is for the purpose of supporting a project or programme of some sort, e.g. an infrastructure delivery programme, it is imperative that the capacity building must be integrated with the programme lifecycle.

1.4 Capacity building in developing nations

Capacity challenges and tensions are not restricted to developing nations but may have more severe impact on these nations since their resilience to deal with the issues is usually lower. Examples of these challenges and tensions include:

- Local political and social instability
- Environmental challenges including natural disasters caused

by both natural phenomena and human interventions
- Large scale illiteracy and a lack of skills and technological expertise due to a lack of education and training
- Large scale illness due to poor infrastructure and pandemics including malaria and HIV AIDS
- Globalisation issues that often marginalise nations due to economic policies driven by the more developed nations of the world and consequential exploitation of resources and raw materials by the more developed nations
- Aid and donor programmes offered and facilitated by more developed nations, which do not necessarily take the principles of affordability, sustainability, appropriate technology, transfer of skills and local or indigenous capacity into account.

Contrast between modern technology and rural access needs

2. Structure and readership of the guidebook

2.1 The guidebook – a compilation of advice

The guidebook presents a compilation of advice drawn from the experiences of the international engineering community. The advice is clustered under a set of headings which represent issues that would generally need to be addressed during the course of an idealised capacity building project need or would need to be addressed in order to create or enhance an environment that is enabling of successful capacity building. Chapters where more detail is provided are given in the list below:

- **Chapter 3** - The necessity of a systems approach to service delivery, and describes how the role of capacity building in support of that ought to be understood. It also motivates the need for an integrated approach to capacity building
- **Chapter 4** - Establishing needs: How to work with communities and institutions in order to establish their needs
- **Chapter 5** - Informing and influencing public policy: How to work with governments in participating nations to make the case for increasing resources for capacity building programmes, particularly emphasising the international evidence that building technical capacity has been vital to alleviating poverty, improving quality of life and building prosperity in nations
- **Chapter 6** - Training and developing skills: How to develop and apply engineering skills in participating nations, including building of skills in the educators themselves, and providing suitable teaching resources
- **Chapter 7** - Participating: How to attract citizens towards education in engineering, in order to build a local skills base
- **Chapter 8** - Building professional networks and support systems: How to build structures and institutions to support all the above
- **Chapter 9** - Developing and implementing norms and standards: How to develop a framework of criteria/ parameters, norms and standards, together with systems to improve adherence to these
- **Chapter 10** - A detailed description of a capacity building process as part of a large capital works project

- **Chapter 11** - Further generic areas where capacity could be built that would be mutually supportive of the capacity building measures described in Chapters 5 through to Chapter 9

- **Chapter 12** - Conclusions, recommendations and thoughts on a way forward

Note that this advice represents what the authors of the guidebook regard as "good practice", rather than "best practice". If a current situation is much below good practice, the goal should be to raise it to good practice levels - and not to strive for best practice, which could require unwarranted effort and resources. Many nations, institutions and communities are too often so enthralled at the thought of achieving best practice that they devote disproportionate resources to a minority of projects and programmes, leaving inadequate resources for that which might be more mundane, but which is likely to be important to more citizens.

Voltaire wrote: *"The best is the enemy of the good".*

The guidebook presents a number of illustrations of how capacity can be built in widely varying circumstances - such as South Pacific island nations with small populations, war-torn nations which have rebuilding needs, or nations rich in natural resources but poor in infrastructure development.

Examples are presented in the guidebook of the capacity that may be needed by communities and institutions, particularly in respect of:

- Skills: Including skills that are technical, financial, and people-oriented.
- Resources: Including finance, training programmes and mentoring processes, and policies (particularly public policies).
- Decision-making mechanisms: Including policies, prioritisation rules and mechanisms, risk analysis and policies, incentives, ethics, standards, trade-off mechanisms but even more than these, recognizing:
  - that choices are never absolute, but are invariably between alternatives;
  - the importance of identifying that results depend on a chain of factors, and not on one factor and recognizing the importance of identifying weak links, and in particular identifying the weakest link and that, once that is addressed, the next weakest link becomes the new priority; and
  - the importance of the "80/20 rule" and of first getting the basics right, with the "nice-to-haves" to follow only if resources remain.
- Administration and systems: Including governance, laws and regulations, procurement, monitoring and evaluation, and feedback loops.

The institutions referred to could include:

- Local or indigenous institutions, meaning those in a country or the nation where the capacity building is taking place, as opposed to foreign; or
- Informal institutions, such as communities that are not formally organized, as opposed to formal; or
- Public sector institutions, including government itself, parastatals, and semi-government agencies and utilities, as opposed to community-based organisations and non-governmental organisations, as, in turn, opposed to the private sector.

Not only would each developmental situation require capacity building specific to that situation, but each individual, community and institution significant to that situation would require capacity building appropriate to its own needs.

The guidebook has five appendices that cover:

- special policy needs of developing nations (Appendix 1);
- capacity-building on a construction project in a developing nation rural area (Appendix 2);
- external funding and assistance sources (Appendix 3);
- a checklist for evaluating technical capacity building plans (Appendix 4); and
- a set of case studies and special issues (Appendix 5).
- a first edition of the compendium of capacity building programmes and initiatives

2.2 The compendium

A resource additional to and complementing the guidebook is be a compendium of programmes, projects, and initiatives.

See page xi of the Executive Summary for a more detailed description.

2.3 Utilization of the guidebook

The intended readers and users of the guidebook are deemed to include a number of individuals, organizations and other entities. The purpose of the guidebook is inter alia to provide a source of reference to institutions and communities and to those involved at any level in working to develop build and maintain:

- engineering capacity
- sustainability of nations at large where this concerns infrastructure, services and basic needs.

See the Executive Summary for a more detailed description.

Capacity building is a mountain to climb - step by step

3. Principles, components and appropriateness of capacity building

3.1 Inter-relationships of economic, social, environmental and developmental goals

In the pursuit of a more secure, stable and sustainable world, all nations have to constantly enhance their human, institutional and infrastructure capacity to deal with the evolving physical and natural environment. To do so they need a sufficient and appropriate base of technologically educated, trained and orientated individuals and groups to sustain and improve their economies and quality of life. Such a base will facilitate the infusion of funding and finance for development, operation and maintenance for engineering infrastructure and services and provide a basis for business partnerships and development by local entrepreneurs.

As nations become increasingly urbanised they become more dependent on increasingly complex systems to provide services and amenities, including technical, institutional, financial and other systems to produce, procure and provide food, water and other services, and to ultimately recycle waste products. That is, they become more dependent on an extensive service delivery chain of efforts and events.

Without technical innovation, expertise and order, largely brought about by the application of engineering and technology, urban environments cannot be stable and sustainable. As the world's population grows, and as the proportion living in urban areas increases beyond the 2010 figure of over 50% of all people, the world will become further dependent on engineering, and hence on the technical capability of its people.

Planned and orderly urbanisation has proven to be essential for people to live at a reasonable level of economic prosperity, to enjoy educational, health and social services that enable them to live their lives in dignity and without hardship, and to ensure that the negative impacts of human activity on the environment are acceptable, manageable and increasingly minimized. On the other hand there is the harsh reality of uncontrolled urbanisation that has led to serious degradation of the standard of living, unacceptable situations and a deteriorating environment in many places across the world.

In summary, as well as the reliance on engineering to stabilise urban life, there is also reliance in all nations on engineering innovation and advances to create, operate and maintain products and services that can be used, transferred or sold to others. Ensuring that a nation has sufficiently robust supplies of technical as well as decision making capacity is essential to any nation that wishes to prosper in the 21st century.

3.2 Service delivery, a systems approach and the role of capacity building

3.2.1 Service delivery

It was noted earlier that capacity building needs to be systematically approached before it can be expected to succeed. However, before moving on to further discussion of the principles and components of capacity building, the purpose and appropriateness of capacity building needs to be more thoroughly understood.

The *"capacity building in the engineering environment"* that is the subject of this guidebook is capacity building that has the purpose of enabling appropriate, effective, affordable and sustainable service delivery.

The discussion in the preceding sections about economic, social, environmental and developmental goals made it clear that capacity building is a means to an end, and not an end in itself. The end, which represents the intended outcome is enhancement of quality of life, and the sound underpinning of economic development. These require, among other things, "service delivery" in its many forms. And one of the means to that would be appropriate development of engineering infrastructure, and the operation and maintenance of that infrastructure. Also, that infrastructure would need to be appropriate in time and place, in cost, and in the level of service and level of access that it provides, and to who, when, and at what cost it provides that.[4] Finally, the service delivery must be sustainable.

Capacity building must therefore be focused on

4 As long as capacity is inadequate and organisations are not geared up for service delivery, it is those with little or nothing who suffer most. Inadequate capacity in service delivery organisations will mean that millions will remain trapped in poverty with no means of escape. Access, education and good health as a result of clean water, safe removal of sanitation, shelter and warmth are critical to the development of a productive workforce." (Numbers and Needs Lawless 2007, page 347)

the purpose of improving capacity - e.g. on improving service delivery by those in whom capacity is being built. It must not be about building capacity for its own sake, something that is sadly a common phenomenon. The need to apply the capacity is lost sight of, and the building of capacity has become an end in itself. In the executive summary two examples are cited.

Service delivery that is appropriate, effective and sustainable requires a combination of management, financial, engineering, economics and social practices and techniques within a robust framework and management plan.

For successful service delivery, it is essential that a "systems approach" is adopted, taking into account the entire delivery chain. This "chain" nature of service delivery must be understood before the role of capacity building can be appreciated. The chain, in the case of infrastructure delivery, for example, is not the sequence between (say) project identification and commissioning of the infrastructure, but rather the much longer sequence, from the formulation by the owner of the infrastructure of its infrastructure policy, through identification of the elements of the service delivery programme, project design, procurement and then commissioning, and on through the lifetime operation and maintenance of the infrastructure and, eventually, its decommissioning and replacement.

In respect of the foregoing the following is therefore noteworthy:

- Delivery results from a **process** – which process has to be understood by and subscribed to by all those with significant influence on the process.
- The process can be viewed as a **chain of efforts and events** and this chain is at any moment in time only as strong as its weakest link at that time.
- For the chain to be strengthened, its weakest link must be identified, and then addressed; and
- as that weakest link is being improved, the next **weakest link** becomes apparent, and that must also then be addressed; whereas
- it is of no immediate value to allocate additional resources to other, stronger, links, until the weakest links have been addressed.

It is essential therefore that a service delivery strategy is related in context to a systems approach that has looked at the entire service delivery chain, has identified the weak links constituting constraints within the system as a whole -- and has then methodically addressed each of these. It would not be adequate to only address some of the constraints. *All* constraints along the entire delivery chain need to be dealt with, *starting with the most*

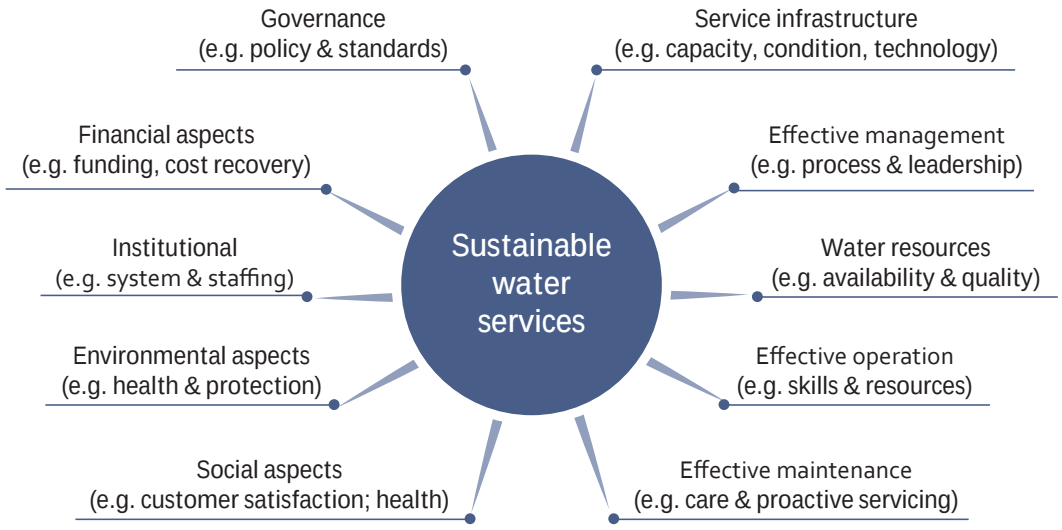


Figure 3.1 The elements key to ensuring sustainable water services

critical. As that is improved, the next most critical needs to be addressed – and so on.[5]

Weak links, or constraints, in respect of service delivery could be of many types. Capacity could be only one of them. As Figure 3.1 (which was drawn in order to depict the elements key to ensuring sustainable service delivery in respect of water services) suggests, other constraints could be:

- Governance – including policy and standards
- Revenue – raising the revenue needed
- Budgeting – allocating sufficient budget for appropriate purposes
- Prioritising – preferential treatment of strategic infrastructure and strategic expenditure
- Planning – of multi-year management in a programmatic way
- Skills – including recruitment and retention, especially of key staff
- Procuring resources
- Managing and exercising leadership in a universally accepted way
- Monitoring for achievement of results

Thus the constraints along the entire delivery chain need to be addressed on some basis of prioritisation.

The above list does not constitute a strategy for service delivery improvement, much less does it constitute a plan and programme of action. This strategy, and this plan and programme, require further consideration and consultation. Inter alia, provision must be made in the strategy and action plan for the prioritised addressing and improvement of each of the above, and for their coordination and integration into one system. It has to be recognized that "one size fits all" does certainly not apply, given the wide range of capacity, resources and the size of the problem, that is found from individual to individual, community to community, and institution to institution.

3.2.2 Role of capacity and capacity building

Given this context, the importance and role of capacity building must be evaluated. Part of the evaluation should be identification of the weak links in the service value chain prior to deciding where and what capacity must be built. If the objective is to improve service delivery, say, it could be that capacity building is not as important as addressing other link or links that is or are weaker. The question should be asked as to what priority should be given to addressing these other issues, rather than to capacity building?
In the same vein, capacity building initiatives need

5 As an analogy if one pours water through a series of funnels the flow will be restricted by each funnel in the chain. If some of the restrictions are unblocked in some of the funnels the overall flow of water is still impeded by the existing restrictions. Only by taking out all the restrictions along the line of funnels can the water flow freely.

to be assessed after the event. For cost-effectiveness, it could for example be questioned whether the improvement in for example service delivery justified the effort and cost in terms of capacity building. If it was not, then maybe lack of capacity was not the bottleneck, and some other way to improve service delivery should rather have been undertaken. Alternatively, the capacity building needs might have been misunderstood, or the effort might have failed because of its content or inappropriateness, or even because of the way in which it was conducted and by whom.

If capacity building is for the purpose of supporting a project or programme e.g. an infrastructure delivery programme, then it is imperative that the capacity building must be aligned and integrated with the programme lifecycle.

In each instance where the building of capacity is deemed to be advisable, the systematic approach introduced above needs also to ascertain to what extent, and in what manner, it is necessary to address all three levels:

- the level of the enabling environment,
- the institutional level, and
- the individual level.

As described in Chapter 1, each capacity building programme or initiative must:

- be preceded by:
    - identification of stakeholders;
    - assessment of requirements and identification of priorities for capacity building, that is, priorities in terms of both what capacity to be built, and whose capacity to be built must be established;
    - identification and mobilisation of agencies that will build the capacity, mentor and sustain this in the longer term;
    - be followed by assessment of the results of capacity building in terms of capacity built, but also including to what extent that capacity is leading to the required improvements in terms of outcomes [6]; and feedback, leading to continuous improvement in capacity;
    - be iterative in terms of which a first round of capacity building might be of a basic nature only, with each round successively raising the bar.

6 For example, not just that people have through the capacity building programme become more skilled, but that they apply those skills, and that this brings about better results in terms of achieving whatever it is they have been capacitated to do.

It needs also to be noted that the "capacity" that may need to be built in individuals, communities and institutions, could be of various types, particularly in respect of:

- Skills including skills that are technical, financial, and people-oriented.
- Resources, including finance, training programmes and mentoring processes, and in particular public policies.
- Decision-making mechanisms, including policies, prioritisation rules and mechanisms, risk analysis and policies, incentives, ethics, standards, and trade-off mechanisms and in addition recognizing:
    - that choices are never absolute, but are invariably between alternatives;
    - the importance of identifying that results depend on a chain of factors, and not on one factor - and recognizing the importance of identifying weak links, and in particular identifying the weakest link and that, once that is addressed, the next weakest link becomes the new priority; and
    - the importance of the "80/20 rule" and of first getting the basics right, with the "nice-to-haves" to follow only if resources remain
- Administration and systems including governance, laws and regulations, procurement, monitoring and evaluation, and feedback loops

The institutions referred to could include:

- Local or indigenous institutions that are from the nation where the capacity building is taking place, as opposed to foreign; or
- Informal institutions such as communities who are not formally organised, as opposed to formal institutions; or
- Public sector institutions, including government itself, semi-state organizations or parastatals, statutory entities and semi-government agencies and utilities, as opposed to community-based organisations and non-governmental organisations, as, in turn, opposed to the private sector.

Not only would each developmental situation require capacity building specific to that situation, but each individual, community and institution significant to that situation would require capacity building appropriate to its own needs.

Ultimately it is important that the parties involved in capacity building are not referred to as "contributing" or "receiving". For a number of reasons, not least that, in the authors' experience, all parties receive during a capacity building process, and all contribute. The increase in capacity is not a unidirectional phenomenon meaning that, all should be referred to as "participants".

3.2.3 Putting limits to building capacity

The point was made in Section 1.3 that the efficacy of capacity building must be evaluated. There needs to be assessment each time whether or not the effort and cost of capacity building was justified by the improvement in e.g. service delivery.

The point was then made that, if it was not, then maybe lack of capacity was not the bottleneck, and some other way to improve service delivery should rather have been undertaken. Alternatively, the capacity building needs might have been misunderstood, or the effort might have failed because of its content or inappropriateness, or even because of the way in which it was conducted and by whom.

Over and above this question, the issue of the appropriateness of capacity building in each instance that was noted, the question however remains whether was it correctly targeted and correctly designed. There is always another reason to call a limit to the building of capacity, and this reason, also, is based on cost-effectiveness, or *"effort-effectiveness".*

If the problem, e.g. the service delivery issue that has to be resolved is small, then anything more than a small effort to resolve capacity problems is probably not justified. However if the problem to be resolved is huge with reference to very large amounts of money at stake or if services delivery to many people were affected, then a huge capacity building effort might well be justified.

Section 3.4 below briefly describes situations of limited importance where limited impact is required and where it is sought to replicate these in large number and also where the interventions will remain one-offs. Section 3.4 also describes situations where a "top-down" seeks to put in place a capacity building policy which may be a national policy, followed by roll-out of programmes to implement those policies. In the latter type of situation, considerable effort, supported by a substantial budget, is clearly justified. In the former situations, clearly, far more limited effort, and with much smaller, maybe only shoestring or even no budget no budget at all, would be justifiable, but at the discretion of the responsible authorities.

"One size of capacity building effort does not fit all"

Chapter 10 - "Capacity building through capital projects", and especially the section "Capacity building process" in that chapter, describes a comprehensive process that is clearly appropriate only in circumstances where a huge effort, accompanied by a very large budget, is justified. In other circumstances, this process needs to be simplified and scaled down as appropriate to the needs and resources of each circumstance.

Last but not least, an additional limitation might be that of time. The importance for capacity building may be there, and the budget might also be made available if needed, but if time factors do not permit a comprehensive process, the capacity building process may have to be shortened or restricted.

3.2.4 Incentives, values and other factors

In terms of the general topic of service delivery it has to be mentioned that there are other significant related factors. A lack of understanding of service delivery, and of the role that capacity building can play to enhance service delivery, would not be complete without considering the factors mentioned in the sub heading. Considering these factors, experience has shown that in spite of the fact that all the requirements for service delivery were apparently satisfied in terms of resources, capacity, systems and so on, service delivery remained unsatisfactory. On investigation, the reason is commonly found among these other factors.
In situations such as these, building more and more capacity, accompanied with for example providing more and more finance the outcome may remain unsatisfactory.
A broad perspective is needed of the dynamics of service delivery, and how performance can be enhanced sustainably. A model, concerned with discovering, analysing and prioritising relationships, could assist.

This "delivery and reform space model" has been used both to evaluate how certain processes are progressing, and to better understand how the processes can be more effective.

Briefly, the model (Figure 3.2 below) describes the functionality environment in terms of three spheres, being:

- ability and resources;
- institutional and administrative arrangements; and,
- a third sphere of other factors, including inter alia vision, goals, values, incentives which are all inherently very important, but which are too frequently overlooked, political factors, acceptance by role-players of the goals and processes, ethics, and trust.

The first two of these are the usual areas of attention when "capacity" is built. See Section 3.2.2 for the "various types" of capacity that "may need to be built". Experience however shows that the factors mentioned in the "third sphere" are seldom even acknowledged, let alone is an attempt made to address the opportunities these item offer or the constraints these impose.

Whereas "ability and resources" is the usual suspect when delivery fails, this may be the wrong suspect, or at least represent an overemphasised co-conspirator of failure. It might well be that in many instances the prime cause of failure lies in one of the other two spheres.

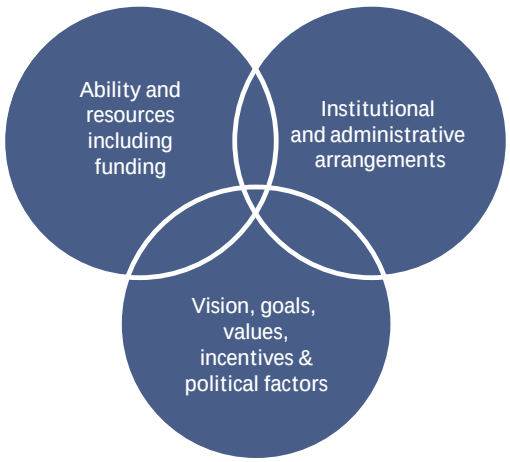


Figure 3.2 Delivery and reform space

Too often, whereas only the "ability and resources" sphere is identified as having failed, the "solution" is then invariably a combination of additional resources such as more grant funding or capacity-building to address the "ability" issue. Sometimes, however, institutional/administrative arrangements are addressed - for example improved billing system for services, or improved reporting structures. The third sphere is comparatively seldom addressed.

Noting that nothing happens for only one reason, there is invariably a set of contributing factors, some supportive of the change, and some inhibitive, that contributes to the outcomes or results. Some of these will be related which for example means that the one contributor "fails" because it is dependent upon another that has underperformed.

First-hand experience of situations where capacity has been built however show that because of contrary incentives or other reasons, the recipients of this capacity building nonetheless do not do what the capacity building was designed to enable them to do.

3.3 The "six" pillars of capacity building

The preceding section motivates the necessity for a systems or systematic approach to service delivery, and describes how the role of capacity building in support of that ought to be understood. This section motivates the need for an integrated approach to capacity building itself.

Although the principles of capacity building appear to be simple, its components are complex, interrelated and inherently difficult to address simultaneously. Well-intended schemes, programmes and initiatives can seem to be successful in the initial stages but then fail to be sustained or to be sustainable. Unless there is an integrated and aligned approach and unless it is recognized that the various elements are by nature essentially interdependent, constituting a balance is difficult to achieve.

Success in capacity building will only be achieved through a systematic approach. It is suggested that

there are six essential "pillars" which must always be in place and in balance if a society is to have sufficient and stable technical and decision-making capacity for engineering infrastructure service delivery to be appropriate, effective and sustainable.

These pillars are:

- **Individual** – it is vital that the needs of the individual are met. In the case of the engineering practitioner, this would imply that his/her needs are fulfilled in terms of a career with sufficient status, standing and rewards and support for developing and maintaining professional competence.
- **Institutional** – there must be appropriate educational, professional, technical and statutory institutions in place at a variety of levels including:

  - professional bodies which support and develop the individual;
  - education providers up to and beyond tertiary level which provide education and training;
  - research and development providers which resolve technical issues; and
  - statutory bodies which develop, establish, provide, monitor and enforce professional, technical and industry standards.
  - institutions must be both public and private sector, including stable, viable and responsible businesses, commercial enterprises and financial institutions that can support the provision, operation and maintenance of infrastructure and other services.

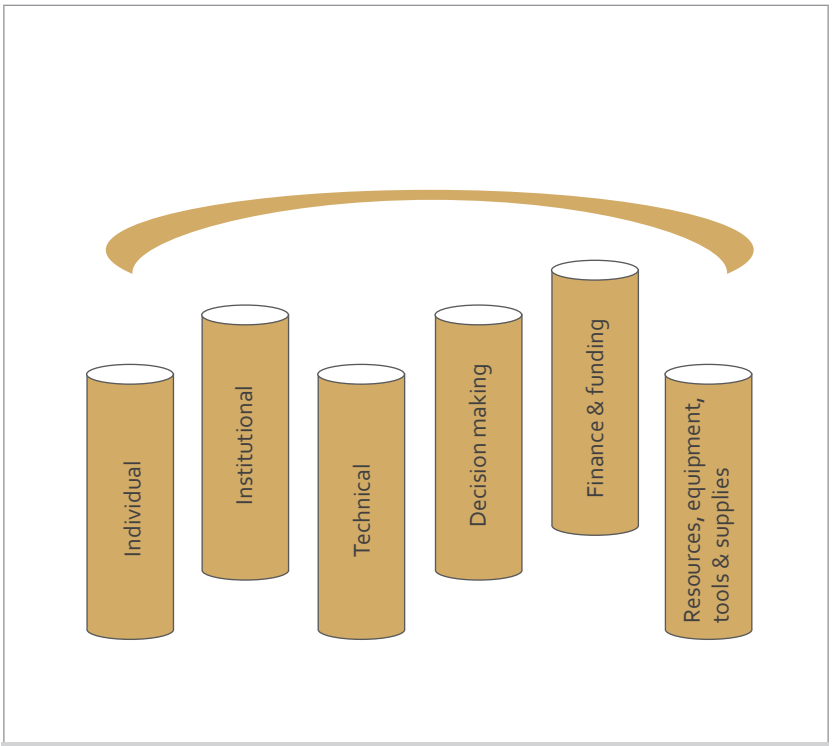


Figure 3. 3 The six pillars of capacity building in support of appropriate, effective and sustainable services delivery as modelled by the Africa Engineers Forum

- **Technical** – there must be an underpinning infrastructure including appropriate, relevant and up to date technical standards, codes of practice, procurement documents and procedures, regulations as well as a well developed statutory framework, including attention to safety and health issues, technical literature and guidance material and so forth to underpin and support ethical and appropriate engineering, technological and procurement practices.
- **Decision-making** – wherever technical and engineering related decisions are to be made, at all levels from individuals to communities to institutions, the decision makers need sufficient information and understanding as well as access to knowledge and skills to make logical and rational decisions.
- **Finance and funding** – it is important to ensure that adequate and affordable finance and funding are available to enable sustainable solutions (including adequate revenue streams after external funders, if any, have moved on), and that financial practice is at all times responsible. It is important also that capital and goods can be procured in a sound accounting and legal system and within a well organised and effective administrative and regulatory infrastructure.
- **Resources, equipment, tools and supplies** – there must also be access to appropriate, affordable and suitable materials, equipment, tools and supplies for the designing, building, implementing, operating and maintaining of infrastructure and the provision of engineering services.

To understand or interpret the context of this discussion is useful to clarify what is meant in this guidebook by *"sustainable"*, and by *"sustainable service delivery"*, *"sustainable development"* and *"sustainable infrastructure"*.

There are many different ways to measure or define sustainability. *"A universally accepted definition of sustainability is elusive because it is expected to achieve many things"* – Wikipedia.

The United Nations 2005 World Summit outcome document refers to the *"interdependent and mutually reinforcing pillars"* of sustainable development, economic development, social development, and environmental protection - Wikipedia.

Sustainable development *"involves the simultaneous pursuit of economic prosperity, environmental quality and social equity, famously known as the triple bottom line"* - Wikipedia.

In addition, many institutions use the following criteria to assess sustainable products, services, and other activities:

- Social criteria: socially desirable, culturally acceptable, psychologically nurturing.
- Financial criteria: economically sustainable, technologically feasible, operationally viable.
- Environmental criteria: environmentally robust, generationally sensitive, capable of continuous learning. *(Adapted from a review of Hawken et al)*

The authors of this guidebook subscribe to this list of criteria. Capacity building, as described in this guidebook, is therefore capacity building with *"sustainability"*, as described by these criteria, very much in mind.

To clarify what is meant by *"economically sustainable"* remains a vexing question. A common area of debate is whether the service delivery can be sustained by the revenue stream generated by the service, or whether it wholly or partially requires sub-venting or a subsidy that is sourced outside the service and/or from individuals, communities or institutions other than those that receive the service.

It is difficult to give a general response other than to suggest that, while each case must be treated on its merits, sub-venting or subsidising the costs of service delivery to the immediate recipients would appear, everything else being equal, to be justifiable if that service provides sufficient benefits even to those that are not the immediate recipients of the service. Another way of approaching the question is to ask whether sub-venting or subsidising is justified in the interests of *"the greater good"*.

3.4 Top-down versus bottom-up approaches

In practice, capacity building most frequently takes place in response to specific project or delivery needs, and can be formal or informal, or through on-the-job training, or simply through mentorship. This is not deemed to be a "bottom-up" approach as defined below, because there is no intention to expand the capacity building beyond immediate needs.

As shown below capacity building could however be intended to have a wider impact:

The initiative for a capacity building programme can commence at any level from national government down to an individual person or the other way round. Any person, a group of people, or an institution that has the commitment, passion and know how can make a difference.

The term *"top-down"* is used to describe an approach where appropriate public policies are first put in place, followed by roll-out of programmes to implement those policies. The implementation of these policies need however not necessarily be undertaken by or even driven by government. A policy might be implemented by supporting the programmes of other role-players including private sector or non-governmental organisations (NGOs), or by providing incentives to change behaviour and activity in the wider community.

A *"bottom-up"* approach is that initiated when a person, institution, or community senses a need and establishes a programme itself without necessarily considering public policy or the lack thereof, and with the intention of effecting wide impact. However, because the co-ordination of bottom-up approaches is difficult, this approach rarely leads to a completely systematic and integrated approach to capacity building. Nonetheless, bottom-up approaches can be highly cost effective and successful due to the higher levels of contribution of volunteer effort and buy-in than may occur during top-down initiatives.

It could be argued that irrespective of whether an initiative or activity commences as top-down or bottom-up, greatest long term benefits would arise if a top-down approach were developed which ensured that all programmes and activities were integrated and coordinated, and that buy-in is achieved. This is however far easier said than done. Top-down approaches to anything that depends on local level commitment and local identification of needs are notoriously difficult to get right. In addition the dangers of the top-down approach taking a one-size-fits-all view are ever present. Any top-down approach should and must nevertheless recognise and support the bottom-up activity that is aligned with the overall strategy to ensure that the all-important volunteer input is employed and maintained.

4. Establishing needs

In the following chapters of this guidebook, potential methods or templates for capacity building are discussed. These are presented in top-down format, but may also be applicable, with modifications, to bottom-up projects. For instance, the emphasis on obtaining governmental support and participation in such cases or approaches would be less, or absent altogether.
Step one in building capacity is invariably to establish the needs in respect of:

- The objective, bearing in mind that building capacity is only the means to an end that needs to be defined.
- The purpose of building that capacity, what capacity, then, needs to be built. An essential part of understanding of this is in turn to understand what capacity is already existing or present in the affected institutions and communities, and in the individual, and what potential there is for increasing that effectively and sufficiently.

In the process of growing understanding of the needs, caution must be exercised not to confuse needs with desires, anticipations and expectations. There must be a clear distinction between what constitutes real needs and what constitutes desires or aspirations which may not necessarily be in the best interests of the individuals, communities or institutions, or which may not be in the interests of the greater society, however that might be defined.

The interests of the various participating and stakeholder groups may be very different. It must therefore be recognized that each is likely to have its own set of needs and aspirations. Each will therefore need its own capacity building programme.

In terms of diverging interests and needs, it is very likely that a capacity building programme may have to take into account conflicts of interest and need, and the importance of trade-offs between one group and another. It may even be necessary to have a mechanism for resolving these trade-offs.

It will also have to be established what the real constraints are to achieving the desired end, as well as the potential of and limits to capacity building to assist in resolving these constraints. In order to establish the perceived constraints, as opposed to those that are more likely to be the real ones, perceived constraints also have to be dealt with.

In order to ensure maximum possible credibility from the research into needs it is vital that scientifically collected and maintained data, research methods and investigations are applied. Resources of all participants can then be used most effectively. Whereas such research methods, as well as the research process itself, may not be well understood by participating communities, and may be treated with suspicion by them, two key success factors are likely to be:

- Applying credible research methods, and managing the research process effectively.
- Establishing credibility and trust with the participating individuals, communities and institutions so that the research outcomes are agreed with and supported by them.

Limits to the building of capacity and to the effort put into establishing needs should be established and set, taking into account issues like cost-effectiveness and how to meet time deadlines by which the work has to be completed.

Important factors to be considered in researching, defining and prioritising needs and desires using illustrations that are drawn from capacity building of a variety of institutions, communities and individuals include:

- The importance of researchers understanding the community representation structure and decision-making methods employed in the community before trying to communicate with that community
- The community understanding, having faith in, trusting and ultimately respecting decisions and feeling comfortable and able to participate in the process
- The early involvement of affected, interested and communities and beneficiaries since sufficient time must be allowed for local peoples to consider issues and make decisions
- Possible involvement of groupings such as tribal leaders, business structures and religious groups
- The identification and respect of local customs. Offending locals culturally or socially may mean authentic information is unlikely to be provided. Getting to know locals and developing trust with key individuals and role players is important. Understanding local

perspectives and interpreting issues in the way the locals think will contribute to establishing confidence and enable easier handling of any problems and challenges that may occur. Where external role players are brought in they need sufficient time to interact with and learn the way the local community operates. In addition they need to be well briefed, including being made culturally aware of local customs

- The use of facilitated discussion using a neutral local individual to establish the views of local people will enhance discussions since this environment encourages open debate that may not be possible when "strangers" are around or in charge
- A gap analysis approach is often valuable, since external agents, groups and individuals who are not familiar with the local environment and circumstances generally tend to proceed too quickly to what to them seem to be the apparent solutions
- A key consideration is recognition that local players may not have been exposed to some of the range of potential solutions. For example, a community may not agree with or choose something that it is not familiar with or has not been exposed to. It might help if use is made of demonstration units and material, case studies from similar backgrounds and study tours to show participants a wider range of possibilities than they would otherwise be aware of. Sufficient time should be allowed for reflection and it should be recognized that the cultural fit of, for example, technologies new to a community, will often be more important than technical aspects
- Consultation on research findings should not be regarded as a once-off process. The consultation mechanism must be developed on the assumption that it will form the basis of a long term mentoring and guidance programme to define changing circumstances and even needs on an ongoing basis. Expecting of, and allowance for, a number of iterations or progressive steps may be necessary when things apparently seem to go "backwards". Under no circumstances should any cause of concern be ignored or left unaddressed
- Testing ideas with the local community is important and if the concepts are not accepted, a process to establish workable solutions that may have been suggested or preferred by them should be implemented and followed through
- Proceedings and outcomes must be recorded and documented properly and presented to the community in a format that is accessible and understandable. Report back and seeking feedback during the process and before finalising the reports and outcomes is essential components of ultimate acceptance and sustainability of solutions
- If the situation is one of an external agency acting as a supplier of assistance or funding wishing to build capacity in a community or institution or even in a nation, the possibilities of success will invariably be improved if the external agency as soon as possible identifies stakeholders that not only have vision and drive. In addition, they should have access to, credibility with and the trust of key decision-makers within the

targeted community, institution or nation, and of their peer groups

- The trust and co-operation of government structures will further enhance the chances of success. Those stakeholders can assist in many ways, not least in helping to define and prioritise the greatest needs and the means to achieve them.

The ultimate test will be whether those in whom capacity will have been built will at the end of the process have confidence and trust in and take ownership of the outcomes. Any project or initiative to address or achieve the outcomes has to be accepted and bought into. If this is not achieved it may be necessary to revisit the process.

The first two case studies that follow, illustrate two examples, very different in scope and in scale, of application of the above.

The third and last case study suggests means of general guidance.

Case study: Water chlorination in Honduras

The World Bank's report Science, Technology, and Innovation - Capacity Building for Sustainable Growth and Poverty Reduction cites the following story of a water chlorination project in Honduras. A system for chlorinating drinking water was designed for Honduras. The system involved placing a small tank with a chlorine solution on top of the existing water tank. A flow regulator automatically released small quantities of chlorine into the water tank.

Initially, the regulator did not work properly. As a result the local plumber who was maintaining the system was criticized for not doing his work properly.

Following consultation with the plumber, a new regulator was designed and made from locally available materials.

Over time, the plumber made several improvements to the design of the system. Also, in subsequent years, the plumber trained other people in his village and other villages to make the regulator device.

This shows that through co-creation the plumber become an expert and was able to create a profitable business in water chlorination.

Source: Page 81 of http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099079975330/DID_STI_Capacity_Building.pdf

Case study: South Pacific Engineers Association

In 2008 the Institution of Professional Engineers New Zealand (IPENZ) perceived a general need for capacity building of the engineering communities in the South Pacific region. Following extensive consultations with representatives of the engineering communities in six nations (Papua New Guinea, Samoa, Tonga, Cook Islands, Fiji and Vanuatu), the outcome is a self-governing South Pacific Engineers Association, and associated competence registers. The goal is to support the improvement of engineering standards in the region.

The structure recognises the particular nature of the nations – with very low populations that are insufficiently large for national systems to be viable. Further South Pacific nations will be added as the Association builds up strength. The Association will be largely self-governing, but underpinned from New Zealand.

(For more information, see Appendix A5.1.)

Case study: A handbook for practitioners

"Democratic Dialogue – A Handbook for Practitioners" The Canadian International Development Agency, International IDEA, the Organisation of American States and the United Nations Development Programme have produced the document Democratic Dialogue – A Handbook for Practitioners.

This handbook provides guidance for those engaging in dialogue. The handbook presents the principles of dialogue, including conflict resolution. The handbook also presents summaries of how dialogue has been undertaken in specific nations.

The handbook is available at http://www.undp.org/publications/Democratic_Dialogue_Handbook_28Feb07.pdf

5. Relationship of capacity to prosperity and quality of life, with reference to the need for informed policy

5.1 Introduction

It is self-evident that individuals, communities and institutions with greater "capacity" [7] are more likely to enjoy higher quality of life, including greater economic prosperity, than those with less capacity, everything else being equal. This assumption is supported by substantial evidence internationally that the quality of its human capital and its technological capacity is proportionate and highly significant to a nation's ability to alleviate poverty, improve quality of life and build prosperity. The lesson is clear indicating that there is a need to build capacity in general, and in engineering in particular in countries with a lesser advanced technical base. There is also a need to inform national and regional policy of the link between capacity and prosperity/quality-of-life, and to develop and strengthen this link. Equally, it is vital that policies support the building of capacity. Therefore it may be necessary to influence changes in policy, so that it supports the building of capacity.

A good example of the contribution of sound engineering services to health and safety can be found in nations where engineering plays a relatively larger role. In these nations there is a marked and proven reduction for the extent of essential and in particular basic health services especially, but not exclusively, where these needs relate to water related illnesses.

This is due to the fact that many of the illnesses that the medical profession has to deal with, are directly caused by:

- a lack of clean drinking water
- poor sanitation
- poor storm water drainage that may lead to standing water which promotes mosquito breeding and increasing the possibility of malaria
- cooking and lighting with fossil fuels in confined areas that may lead to respiratory illnesses
- lack of safe transport and for example dust amelioration that could lead to unhealthy situations
- poor supply of water for irrigating of crops that lead to malnutrition
- overcrowding and its associated illnesses including tuberculosis
- pest and plague related illnesses related to poor rubbish and waste handling

The relationship is illustrated in the table below, showing the ratios relating to numbers of medical doctors and registered engineers in a selection of countries. It shows that in more developed countries there are higher numbers of citizens per doctor and lower numbers of citizens per engineer, which translates into the notion that better engineering services imply "a healthier population"

5.2 Stages of economic development

The most commonly used indicator of prosperity is Gross Domestic Product (GDP). The World Development Report 2005 demonstrated that the level of capacity development, particularly as manifested in the type of economy and the types of jobs available, has a high correlation with prosperity, indexed as GDP per capita.

Four conceptual stages of economic development.

- The poorest nations operate primary production-based and subsistence type economies. This is the first stage of economic development.
- The second stage involves low quality low-paid jobs and often using outdated equipment that is uneconomic to operate and too polluting for more advanced economies to continue using it. This stage can also involve the lowest standards of occupational health and safety. Some of the largest nations in terms of population in the world are in this second

7 As defined in Section 3.2.2 in terms of the types of capacity that may need to be built. This definition is more or less consistently used throughout this Guidebook.

Country	Population	No of registered engineers	Population per engineer	Population per doctor
Norway	4 600 246	37 685	122	308
China *	1 300 000 000	10 000 000	130	593
Finland	5 357 934	39 537	136	304
India *	1 020 000 000	6 500 000	157	2 320
Greece	15 000 000	87 337	172	199
Denmark	5 520 295	30 926	179	273
Canada	30 337 000	169 512	179	475
Sweden	9 254 613	44 352	209	291
Germany	82 443 000	380 000	217	291
Brazil	184 203 744	811 483	227	379
Iceland	270 603	1 019	266	283
France	60 656 178	220 000	276	297
Ireland	3 917 203	14 000	280	362
Japan	121 000 000	400 000	303	476
UK	58 821 000	189 406	311	492
USA	296 771 226	762 000	389	361
Argentina	36 260 130	80 000	453	354
Australia	20 372 452	44 767	455	414
Hong Kong	5 000 000	10 798	463	617
Malaysia	25 500 000	47 000	543	1 436
Chile	14 973 843	22 000	681	2 025
Poland *	40 265 683	53 796	748	408
Singapore	4 240 000	3 161	1 341	318
Korea	45 985 289	21 534	2 135	585
Hungary	10 661 747	4 815	2 214	437
Romania	23 434 194	8 056	2 909	523
South Africa	46 888 200	14 806	3 166	1 493
Sri Lanka	18 732 255	3 348	5 595	-
Tanzania	36 766 356	6 200	5 930	-
Namibia	2 030 692	320	6 346	4 545
Zimbabwe	12 746 990	2 000	6 373	7 092
Swaziland	979 000	80	12 238	9 100
Zambia	11 261 795	881	12 783	11 100
Ghana	21 029 853	1 644	12 792	2 500

Figure 5.1 Source Allyson Lawless - Numbers and needs: Addressing imbalances in the civil engineering profession 2005

stage of development of which China, India and possibly Brazil are current examples. Nations in this stage have rapidly increasing demand for resources, experience rapid urbanization, and thus also experience extensive and substantial environmental problems. This is a major concern for those nations as well as for the global community. A key question for developing nations is how they can accelerate their development, and avoid or minimize the time period during which their people suffer the worst effects of the second stage of economic development. Appropriate and serious attention to workforce capacity building will facilitate the development process.

- In the third stage, capital for better equipment and better training of workers is deployed, and the remuneration of workers increases. Both the second and third stages are characteristic of the development of an industrial economy.
- The fourth stage of economic development is the transition to a knowledge-based service economy. In this stage remuneration rates are high, the most advanced technology is deployed, environmental impacts start to lessen and better social services can be afforded. Manufacturing still exists but is highly automated; there is efficient use of resources and lower-than-before environmental impact.

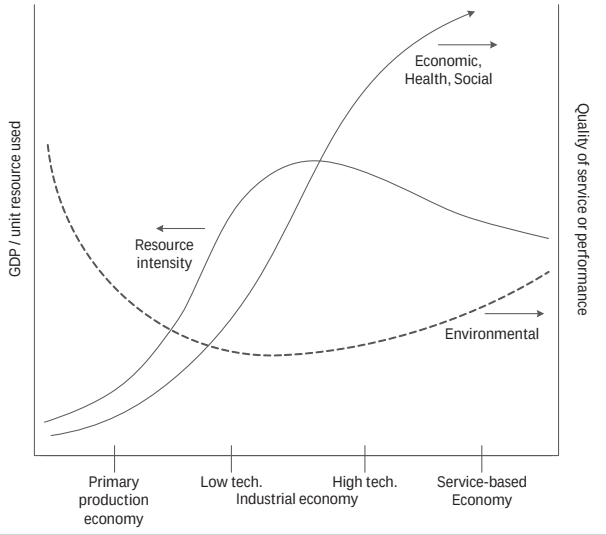


Figure 5.3 Illustration to show changes in economic, social, health, environmental and resource intensity performance of economies during the transitions from primary-based to industrial-based and then to service-based.

5.3 Capacity building imperatives apply to all nations

The need to build capacity does not decrease as a nation develops. This is especially so in respect of engineering capacity at all levels. Demands for informed decision-making may even increase as levels of technology and development advance. In addition the challenges to maintain the infrastructure investments made increase as the built environment demands escalate.

In stark contrast, the understanding of as well as the credibility and respect for, the role of engineering and technology has either declined or not keep pace with development. Somewhere it has been said that *"modern society has a love affair with technology but disregards the engineering behind it and what and who it is that brings technology to them."*

A lack of attention to the ongoing renewal of technical capacity can lead even advanced economies to failure if they do not retain and develop sufficient and appropriate skills to be able to support themselves. Loss of infrastructure resilience and the potential for highly damaging and cascading failure of infrastructural systems, in terms of which failure of one component leads to failure of another, is a real risk throughout much of the developed world.

Irrespective of its living standards or its size, a nation must therefore pay attention to development and renewal of its decision-making and technical capacity if it is to prosper, sustain and support its people.

In addition the apparent reliability of services and long lifecycle design principles as well as the *"invisibility"* of infrastructure create a false sense of security. In a number of nations, failures are now occurring as infrastructure that has been created after World War II has reached the end of its design life. In other cases, infrastructure is failing due to neglect and has prematurely reached the end of its life. Sadly, it has sometimes taken failures and disasters to get the public and decision-makers to realise the loss of technical capacity, and to acknowledge it through remedial action of one sort or another.

Developing nations have for historical reasons always been the worst off with respect to most components of technical capacity. This is despite that some of them have been successful in terms of the numbers of and quality of indigenous technical capacity that has been trained. Unfortunately, many of these individuals have subsequently been lost to the developed and high growth nations, which have sought to recruit engineering professionals, attracting them with higher remuneration packages and better living conditions than they were getting in their countries of origin. When technical capacity shortfalls do occur in developed nations, the economic strengths of those nations enable them to offer remuneration which will attract skilled people from less developed nations. This worsens the problems experienced in the developing nations. Extensive capacity building should therefore be seen as an ethical as well as a practical issue especially in terms of which a local basic engineering workforce is imperative and crucial where it concerns providing of day to day basic engineering services. The international financial crisis of 2008-2010 may in the long term have both a positive as well as a negative impact on developing nations. In the first place many professionals may return to their nations of origin and boost the numbers available in those nations. At the same time a number of developed as well as developing nations have embarked on extensive investment in infrastructure programmes to counter the economic downturn, which means that professionals may migrate once more.

5.4 Evidence of correlations with reference to capacity, infrastructure, prosperity and quality of life

There is substantial evidence internationally that the quality of human capital and the technological capacity of a nation is highly significant to its ability to alleviate poverty, improve quality of life and build prosperity. The extent, penetration and coverage and quality of infrastructure evidently contribute to the wellbeing of a nation.

Figure 5.4 shows the relationship, for a selection of developed and developing nations, between economic growth and gross fixed capital formation (GFCF) (Investec 2005). As an enabler

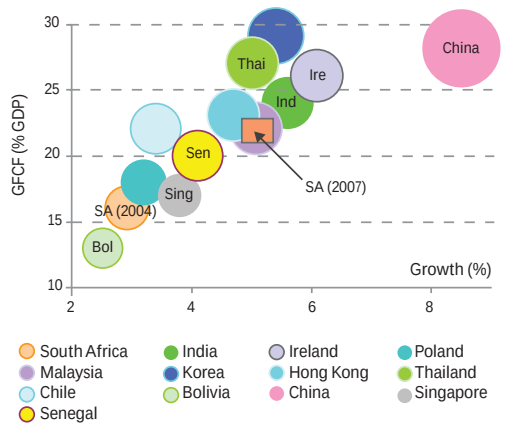


Figure 5.4 Relationship between GFCF and growth (Investec 2005)

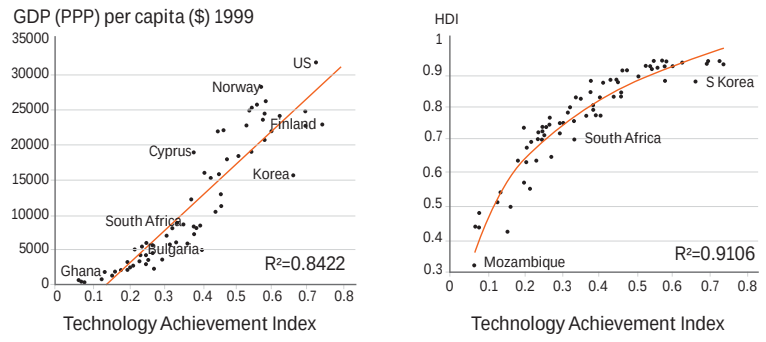


Figure 5.5 The dependence of wealth and living standards on technology (after United Nations: reported in Roux, 2007)

of economic growth, the construction industry stimulates growth by increasing the productive capacity of the economy through the provision of infrastructure to both the public and private sectors alike. An established global benchmark is that GFCF should vary between 20% and 30% of GDP and that construction investment should represent between 20% and 30% of GFCF (4% to 9% of GDP), in order to generate a consistent economic growth rate of 5% and more (Murray & Roberts, 2008). Technological capacity has a high correlation with prosperity. The technology achievement index (TAI) correlates well with both GDP and the Human Development Index (HDI) – See Figure 5.4 (Roux 2007)[8].

Figure 5.5 shows data which suggests a very high correlation between, on the one hand, improvements in education as indexed by changes in number of years of education and, on the other, predicted GDP/capita growth rate for the period up to 2020.

India ("IN" in the Figure), China (CN), Thailand (TH) and Spain (ES), the three highest on the right-hand side of the graph, are expected to be four of the strongest performing nations. The economies in India, China and Thailand have grown very rapidly over the last ten years, transitioning quickly up the first three stages of development. Spain is progressing towards a service economy. Other high performing nations include Malaysia (MY), Turkey (TR) and Korea (KR).

Common to all these economies is a commitment to engineering. In 2002 the OECD stated that on average 13.3% of graduates at higher level qualifications (typically degree level) were graduates in engineering. Over the same period 16.3% of graduates in lower level qualifications (sub-degree level) were graduates in engineering.

Rapidly developing nations such as Korea and China have much higher proportions of graduates in engineering – around one-third of graduates are in engineering. In Spain, 14.3% of graduates were in engineering, and, of lower level tertiary qualifications, 33.7% were in engineering. In Turkey, 11.8% of graduates and 33.7% of lower level tertiary qualification holders were in engineering. The lesson is clear. There is a need to build capacity generally - engineering capacity in particular - also to inform national and regional policy of the link between capacity and prosperity/quality-of-life. Equally, it is vital that policies support the building of capacity. Therefore it may be necessary to influence changes in policy, so that policies do support the building of capacity.

Appendix 1 describes some special policy needs in developing nations.

5.5 Supportive policies

Policies supportive of the building of capacity generally, and engineering capacity in particular, are needed.

A number of issues must be considered including:

- To recognize the need for and taking action to orientate, inform, assist and educate the public at large, elected representatives at all levels of government and government agencies as well as business and commerce decision makers about the essential and crucial role of and the contribution of engineering and technology to establish and maintain infrastructure services.
- To co-operate and interact with government and governance structures, employees as well as politicians, to assist with and facilitate informed decision-making in all areas of engineering and infrastructure services.
- To recognize the long term benefits and value of advocacy to government and outreach to the general public or to communities to orientate, inform and educate them about issues concerning engineering matters. To recognize that appropriate ways and means have to be used in various circumstances to achieve the goal of achieving informed decision making at all levels of society[9].
- To utilise private sector, non-governmental and community institutions, including professional bodies, as a vehicle both to influence public policy and to implement it.

8 Ironically the construction industry itself is notorious for low levels of innovation (Rust et al, 2009), with consequent low TAI in this sector.

9 Not forgetting that in a democracy it is individuals and communities that choose their representatives, and it is these representatives that are responsible for the public policy that plays such a major role in the delivery of services. Elected or appointed decision-makers ought to be merely the custodians for the needs and aspirations of those who they represent.

- To build and utilise networks between professional and occupational groups such as medical doctors, engineers, architects, scientists, lawyers and accountants, in order to develop and maintain unified rather than competing opinions about issues of common interest including for example:

  - the need for mathematics and science education;
  - the need to integrate, agree and apply budgets and funding allocated to ensure public health and safety in terms of providing adequate potable water and sanitation which effectively would reduce the need for extended health care, whereas health care often only treats the results, not the causes, of poor water and sanitation services.

- To recognise the need to orientate, inform and educate public officials about the need for underpinning systems such as upholding and application of technical standards and independent measurement systems in support of sustainability since these issues may not be automatically be seen as contributing to welfare and growth.

5.6 Key factors influencing engineering capacity building

In practical terms, the following are key factors important to the success of building engineering capacity:

Policy factors:

- Commitment to sustainable development practices to ensure sustainable practices
- Public and private sector participation in engineering practice, professional and related matters
- Development of a pool of knowledgeable and informed decision-makers, clients and users of engineering infrastructure and services, including the general public
- Platforms and mechanisms for engineering professionals who can influence best policy practices at all levels of decision making in government and private sector
- Public awareness programmes in order to enhance the visibility and recognition of the role of the engineering profession in civil society
- Appropriate science and technology policy including the extension of research and development initiatives by government
- Good practice policies relating to both local and foreign involvement in nations

Educational factors:

- Appropriate curricula at schools to prepare and enable learners to enter into the field of engineering with specific reference to

mathematics, science and technology
- Outreach and career guidance programmes for all school learners
- Acceptable and appropriate international frameworks to accredit and recognise educational qualifications and professional standards to facilitate reciprocity and equity
- Promotion of appropriate education and training for engineering professionals dealing with the challenges of rural and developmental engineering
- Networking frameworks amongst tertiary educational institutions involved in engineering related education
- Promotion and facilitation of entry to and equality for all demographic and gender groups in the engineering profession

Factors relating to ongoing professional development of engineering practitioners:

- Effective communication channels and facilities for all engineering professionals
- Alliance and integration models for interaction and networking among engineering and other built environment institutions
- Internationally accepted norms in terms of conduct, integrity, ethics, engineering standards and care for people and the natural environment
- Continuous learning and professional development opportunities for engineering professional
- Professional and technical networking opportunities and events
- An events database features annual programmes of events, including those relating to continuous professional development, for the purpose of forward planning and co-ordination
- A database of mentors and coaches who can be mobilised for assisting young graduates and even students
- Guideline documents to assist graduates with their candidate phase and to ensure that all the necessary aspects are attended to

Technical support factors:

- Access to technical information and data for all engineering professionals
- Harmonisation of standards, documentation, methods and procedures
- Access to good practice examples as well as case studies regarding engineering practice in terms of desirable and appropriate local and internationally recognized engineering standards, processes, procedures, methods or systems in relation to the delivery processes and the life cycle of products and assets
- Dissemination of and access to relevant published technical papers, articles, editorials, technical journals and magazines for reference purposes
- Utilising procurement as an instrument for development and capacity building

Other factors that can raise the chances of failure include:

- Inappropriate selection of solutions
- Diversion of available funding into complex administration structures or into fees for external consultants, rather than empowerment of the local people
- Lack of continuous and consistent funding that lead to stop-start behaviour, seriously harming progress and even impacting on credibility
- Financial failures and mothballed projects that render the capital used in the development either as wasted or sterile
- Corruption that is not addressed
- Financial stability

5.7 Education as a key factor in national policy

Overall, there must be national-level recognition of the need for long term investment in a stable and sustained education and research and development sector and in relevant education for local needs.

In the boxes below are examples that show the importance some nations attach to building capacity generally, and to engineering capacity specifically.

Case study: India

India has made a long-term effort to increase the numbers of engineering graduates and the quality of their education.

In the past, many engineering graduates sought employment outside the nation. However, many are now returning. In addition, more recent graduates are staying on to work in India in the software and design industries and finding well-paying careers.

The growing number of technically proficient and well-educated specialists has also enabled India to become a prime destination for the outsourcing technical support by the world's leading technology firms.

Case study: Ethiopia

The Ethiopian Government, with support from World Bank donors, has a programme called the Public Sector Capacity Building Program Support Project (PSCAP) which aims to improve the efficiency and responsiveness of public service delivery, empower citizens to participate more effectively in government processes and promote good governance and accountability.

This project is expected to:

- increase the predictability and adequacy of financial resources flows
- provide greater inclusiveness and transparency of planning and prioritization processes
- enhance revenue performance and fiscal autonomy
- enhance the environment for public servants
- improve the quality and efficiency of operations; and improved transparency and accountability

Source: http://web.worldbank.org/WBSITE/EXTERNAL/NATIONS/AFRICAEXT/0,,contentMDK:21082643~menuPK:1804110~pagePK:146736~piPK:146830~theSitePK:258644~isCURL:Y,00.html

Case Study: China

In 2001 the proportion of first science and engineering degrees to all bachelors-equivalent degrees was 59% in China, as compared to about 33% in the United States. These results were reported in the National Science Board's report *"Science and Engineering Indicators 2004"*.

The *Science and Engineering Indicators 2004* opens with the statement:

"Excellence in (science and engineering) higher education helps a nation to be technologically innovative and economically competitive."
This shows the importance placed on higher education and the acknowledgement that science and engineering education leads to a nation being more competitive.

Case study: Rwanda

Since 2006 the World Bank and the Government of Rwanda have been working together to build Rwanda's science, technology, and innovation capacity.

The objective of the programme has been to help Rwanda build its science, technology and innovation capacity to identify, design, and implement practical solutions to everyday practical economic and social development challenges.

The results indicate that:

- Capacity building should focus on finding practical solutions to practical problems.
- Science, technology and innovation capacity building is a cross-cutting issue with a direct impact on very diverse programmes.
- Capacity building requires coordinated action across a large number of organizations. Failure to coordinate and integrate actions and policies across these bureaucratic silos runs the risk that the capacity building programme will not achieve its objectives and that the money invested by other agencies and organizations will not produce the desired result or outputs and there will be a paucity of satisfactory outcomes.
- Science, technology and innovation capacity building involves all levels of technology and skills—ranging from sophisticated scientists to engineers and technical and vocational workers.
- Science, technology and innovation capacity building is not just about research and development - it is also about getting knowledge out of the laboratory and into the market. Knowledge diffusion is a critical component of the capacity-building process.
- Technical and research institutions perform poorly because of weak incentive structures. Fixing these incentives, boosting institutional performance and building an institutional culture of innovation are critical components of science, technology and innovation capacity.
- There is an advantage to being a latecomer. A nation does not have to invent everything it needs. It can achieve significant results and solve many problems by adapting and using off-the-shelf technology. Doing so still requires significant investments in capacity building.
- Science, technology and innovation capacity building is not about high technology only. Producing high-quality goods also requires significant scientific, engineering, and technical capacity.
- Science, technology and innovation capacity alone cannot solve all the problems of a sector. Finance, entrepreneurship, fiscal incentives, regulatory measures, government regulations, government support programmes, and public-private partnerships are critical elements that must function properly for capacity building to deliver concrete results.
- Innovation must be a way of life for everyone, not a sporadic activity of a few isolated scientists.

Source: http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099079975330/Building_STIcapacity_Rwanda.pdf

Case study: South Korea

At the 2004 meeting of the ASCE, the South Korean delegation presented the results of their nation's investment in the number and quality of engineering graduates over the past three decades.

Its presentation showed that:

- In 1970 South Korea had about 6,000 engineering graduates.
- In 1980 there were 14,000 engineering graduates.
- By 1990, there were 80,000 engineering graduates.

When plotted against South Korea's per capita GNP growth, the number of engineering graduates almost directly parallels the growth of the South Korean economy, offset by a few years. This shows the importance of engineering to the nation.

This data appears to show a direct cause and effect that demonstrates how investment in building a well qualified and sufficiently large pool of engineers leads to sustainable economic development.

Case study: South Africa

In spite of a huge effort to bring appropriate and effective education and training in reach of the population as a whole since 1994, school leavers with sufficient marks to succeed in tertiary education have not increased and in most cases quality has reduced. New and possibly inappropriate curricula, especially with reference to mathematics and science, have been "experimented" with and changed several times. Literacy and numeracy remains a vexing problem.

In spite of the poor preparation and conversely thanks to effective career guidance as well as policy to increase the numbers of engineering professionals, the latter part of the first decade of the new millennium statistics show that the applications to study engineering have soared and classes are over full. Staff and facilities are inadequate and all of this, starting with poor preparation at school level is resulting in poor throughput. Due to a lack of mentors graduates are also to struggle to prepare for professional graduation within reasonable periods of time.

Source N&N - Lawless 2005

6. Training and developing engineering skills

6.1 Education as a key factor in policy

Chapter 5 demonstrated the positive correlation between in particularly engineering capacity and prosperity and quality of life. The point was emphasized that programmes to achieve greater prosperity and improved quality of life must be underpinned by proficient, informed and anticipatory decision-making, which in turn depends heavily on a high level of technical education and training and the development of critical awareness and assessment programmes. The world is littered with examples of unsuitable or inappropriate technology and infrastructure due to a lack of "wise buyer" capability. The risk of poor decisions increases exponentially when governments do not recognize the need to employ skilled technical advisers.

Conversely, there is a compelling need for policies that will support the building of capacity. The most vital public policy is addressing the education and support of individuals and sector groups, including non-governmental institutions that train, mentor and support technically-educated individuals. In respect of the higher level engineering skills, adherence to international engineering standards is another crucial element in the quest for competency in order to ensure a level playing field and fair and equitable competition on the global stage.

This chapter addresses training and developing of engineering skills. It should be noted that at times reference is made to engineering professionals and in some cases to engineering practitioners and although these terms are sometimes interchangeable, it must read against the background that engineering practitioners is an inclusive term for those active in engineering, whereas not all practioners are necessarily professionally registered with a specific body or entity established for that purpose.

Achieving high levels of value creation per hour worked requires not only a technically literate workforce to implement and use modern technologies, but also needs to address issues like:

- technical capability to undertake investment projects;
- the ability to undertake relevant research and development;
- the technical skill and ability as well as competency of engineering professionals to spend capital in developing universally efficient and reliable infrastructure in the areas of water supply, transport, energy supply, waste treatment and other amenities and services that sustains and stabilises modern society.

The effective utilization of resources is a primary goal of the education of engineering professionals. Giving precedence to engineering education is therefore vital for nation building.

Necessary technical educational resources, capability and competency contain several elements and prerequisites:

- Technically literate government-employed engineering professionals and scientists, proficient in public policy matters, who can advise on key policies and create the policy conditions to attract investment that will be used responsibly. Areas where expertise is needed include, for example, operations and maintenance standards, and standards for environmentally and financially sustainable infrastructure investment
- Technically literate engineering professionals, technologists and scientists who are proficient in business and private sector matters, and are likely to be able to attract capital and use it wisely
- Engineering professionals with management skills and knowledge who can spend public capital effectively to deliver the most appropriate, affordable and sustainable infrastructure
- Engineering professionals with the skills to operate and maintain infrastructure assets and

production facilities to standards that ensure serviceability and reliable delivery

- A national commitment to wherever appropriate use internationally recognized engineering standards and codes of practice, and forms of contract for engineering services procurement
- A commitment to build, implement and maintain engineering education, professional registration or licensing systems and frameworks that comply with the standard of internationally recognized benchmarks including the Washington, Dublin and Sydney Accords for education, and quality or professional standards models such as the International Professional Engineer (IntPE) quality mark established in terms of the Engineers Mobility Forum [10]
- Supporting mechanisms including incubators and small business development financing to apply research and development results from local universities and companies for economic gain
- Tertiary education facilities, sufficient funding, sufficient numbers and suitably trained lecturing and coaching staff, research funding and facilities, bursaries
- Codes of conduct, codes of ethics and sound business principles that are already introduced at tertiary level

6.2 Generic engineering skills

Skills are usually acquired, sometimes by osmosis and sometimes actively learned from other human beings or from observing nature and by mimicking and exercising or repeating actions or procedures.

Much of what are defined as engineering skills emanates from understanding and applying the scientific and basic laws of nature in creating a "world that never was" in order to provide for and serve the needs of human beings across a range of basic skills to sustain life right to high end sophistication.

Figure 6.1 illustrates the areas of skill along the project cycle that the engineering graduates have to acquire to ultimately qualify for professional status.

10 The various accords have been developed to provide a framework of equity in terms of which there would be measurable mechanisms in terms of the level and quality of engineering qualifications among nations. In essence the Washington Accord covers a four year degree programme for engineers, the Sydney Accord covers a three year programme for technologists and the Dublin Accord covers two year programme for technicians. At the professional reciprocity level the Engineers Mobility forum and the Technologist mobility forum could be cited as another example of frameworks that aim at comparable professional registration standards and competencies for engineering professionals. A list of signatories to these accords and more information can be obtained at www.ieagreements.net .

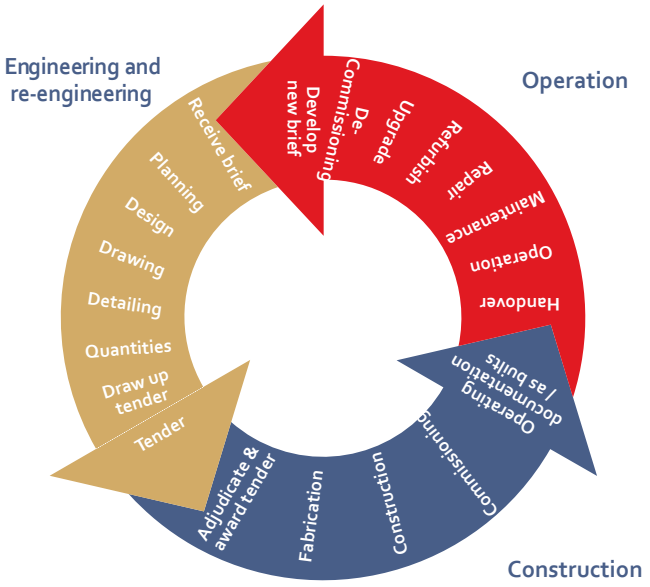


Figure 6.1 The project cycle showing the skills that need to be acquired Allyson Lawless - Number and Needs: Addressing imbalances in the civil engineering profession

The engineering skills required by challenges posed by the current environment and in particular in developing areas are daunting. Increasingly, the era of engineering solutions being imposed on "recipients" is over, and decision-making has to be more inclusive and participative. This in turn demands that non-engineering individuals, communities and institutions need some understanding of technical matters, at least as to how these affect them.

Engineering professionals have always been challenged to keep up to date, and to refresh their skills. The pressure to do so is constantly increasing, as knowledge becomes "obsolete" at a faster and faster pace. Continued professional development has become an imperative and life long learning a crucial element in the careers of all engineering practitioners.
There has always been a need for ongoing professional development programmes for engineering practitioners to assist them to engage with public policy and capital projects, operations and maintenance management in government and other governance structures. Exchange of staff and seconding programmes can assist with building understanding and skills in all sectors that would enhance decision making and sustainability.

Similarly, there has always been a need to enhance the status of engineering professionals, and to create an environment in which they can become and remain as committed as teachers, as public servants spending national capital. In addition they need to be valued as contributors, value adding role players, participate as forward thinkers and act to develop and enforce environmental standards as custodian of the environment at large.

Last but not least, the active and progressive transfer of skills and knowledge in a diminishing work force environment has become a crucial element to accelerate transforming and developing the younger generations scheduled to take over.

In many cases "retired" professionals are therefore becoming a valuable resource in skills development where there are insufficient numbers of actively employed individuals in the professions to deal with day to day mentorship needs of graduates.

In addition the engineering profession has taken stock of the range of skills that an engineering professional needs to practice in the complex environment of today. The conclusion was reached that this range would have to be extended at a rapid rate in order to cope with the changing and expanding environment. The American Society of Civil Engineers has for example listed 24 outcomes or areas of skill in terms of the body of knowledge (BOK) that they envisage that the professional engineer of 2025 will require. While many of these outcomes have been needed by engineers since time immemorial, a number of items like e.g. globalisation, communications and ethical responsibility are relatively recent additions.
The full list of skills required by this ASCE professional engineer of 2025 is:

Foundational Outcomes

Outcome 1: Mathematics
Outcome 2: Natural Sciences
Outcome 3: Humanities
Outcome 4: Social Sciences

Technical Outcomes

Outcome 5: Materials Science
Outcome 6: Mechanics

Outcome 7: Experiments
Outcome 8: Problem recognition and solving
Outcome 9: Design
Outcome 10: Sustainability
Outcome 11: Contemporary issues and historical perspectives
Outcome 12: Risk and uncertainty
Outcome 13: Project management
Outcome 14: Breadth in civil engineering areas
Outcome 15: Technical specialisation

Professional Outcomes:

Outcome 16: Communication
Outcome 17: Public policy
Outcome 18: Business and public administration
Outcome 19: Globalisation
Outcome 20: Leadership
Outcome 21: Teamwork
Outcome 22: Attitudes
Outcome 23: Lifelong learning
Outcome 24: Professional and ethical responsibility

The following list of skills or areas of importance possibly define the outcomes in a different way and in a number of areas it could be deemed to additional or complementary to the ASCE BOK list:

- *Research and application of research*
- *How to develop and apply technology*
- *Developing alternatives in an environment where resources are scarce*
- *Making an informed decision*
- *Assessing risks and designing for safety with safety factors*
- *Dealing with "customers" and "clients" as well as "owners" and "decision-makers"*
- *Understanding of and abiding with cultural and ethical issues*
- *Designing for sustainability*
- *Transferring skills and mentoring*
- *Knowing about finance and funding as well as economics*
- *The ability to speak, read and or understand a number of languages*
- *Understanding of global and local politics and governance systems*
- *Operating in multi-skilled teams*
- *Operating in gender, race, religious sensitive environments*
- *Developing skills in own field as well as creating skills for other people*
- *Creating an enabling environment for the engineering professional to do his or her work in*

- *Entrepreneurship*
- *Orientation in and awareness of multi-disciplinary environments*

6.3 Additional concerns appropriate to a developing environment

In addition to the issues mentioned in 6.2, there are additional challenges faced by primarily, but in many cases not exclusive to, the developing world environment. Skills that were until recently deemed to be present in all engineering graduates now seem to be poorly developed, and in many instances need additional attention. Poor preparation in terms of secondary school or pre-university education has led to serious challenges at tertiary levels which necessitates additional interventions. The areas for example include:

- numeracy
- literacy
- basic understanding of the sciences and laws of nature

6.4 Developing appropriate skills

Nations, institutions, communities and individuals need to decide where the real and ethical engineering challenges are and ensure that sufficient numbers of individuals among them have the skills appropriate to meeting those challenges.

Too often, however, the real challenges are, for one or another reason, not prioritised. For example "Quick fix" but unsustainable infrastructure is built, or "best practice" is aimed at where "good practice" would have sufficed, whereas it can be argued that the basic priority appropriate for that time and place ought to be the provision of basic sustainable services in challenging environments.

Developed nations and areas are usually "well-off" with respect to engineering professionals and support systems but this creates tensions between countries, since engineering professionals often tend to migrate towards the more developed parts of the world or to more developed parts of a country, leaving a technical skills vacuum behind them.

A different but also contentious point, is the tendency to refer to the skills appropriate to delivering affordable services for basic needs as "not really worthy of engineering status" or "low technology engineering". Many engineering professionals would rather deal with the "higher" end of engineering in its so-called "high technology" format. One of the reasons for this phenomenon may be that career guidance initiatives often focus on engineers building the large dam or the highway, or the high rise building that would excite the candidate and attract him or her into engineering. It is seldom that these initiative would feature the operation and maintenance of engineering facilities and services that also require engineering expertise. There is even less emphasis on issue like the provision of services for low income families that can really challenge the engineering professional to a great extent due to the adverse circumstances and lack of resources.

Unless all these issues are approached in an integrated manner, sustainability will not be achieved. The need to develop and maintain skills that are generic and "transportable" has become more important than ever as a globalisation accelerates and as the need for survival increases. As already mentioned, there is an unfortunate and unintended consequence in creating a universally acceptable, generic and comparative set of engineering competencies in the sense that it provides an easier route to migration of professionals from lesser developed areas to more developed areas. This has lead to a decimation of skills in less attractive environments, since more attractive remuneration and better living conditions in developed countries often present itself as an "escape".

The challenge for less developed nations is how to acquire and retain a basic engineering workforce that can at least deal with everyday issues and which is deployed right at the heart of communities, delivering local authority type basic services like potable water, sewage systems and transportation. For the more specialist issues, engineering professionals may from time to time have to be "imported" by these nations for specific tasks, as it

may not be viable to develop specialist skills in developing nations. Expectations should not be created that continuous employment of these specialists will be guaranteed in developing countries.

A mobile cadre of the highly specialized group of engineering professionals may even be the future for more developed nations as well, as it is clear that shortages of engineering professionals are increasing right across the globe.

It is important to know what is needed in terms of skills at all levels of government including national, regional and local levels. The South African "Numbers and Needs" studies in this regard revealed the complexities with reference to skills needed in all aspects of the engineering environment in terms of "what, where, how, who and how many" in terms of skills development. (Allyson Lawless - Numbers and Needs in local government: Addressing civil engineering - the critical profession for service delivery 2007)

All nations need human resource development policies and plans to ensure they have the necessary capacity and capabilities. These plans must include:

- Empowerment of decision makers not necessarily closely related to engineering has become integral part of engineering activities. These decision makers range from young children who have to learn to use scarce resources like water with responsibility and care, to the other end of the spectrum which are the rulers of nations who have to understand that funding for asset management or maintaining infrastructure is even more important than funding for the erection of a facility in the first place
- A commitment to provide physical and human resources and facilities for the education of engineering professionals and to educate and train an engineering corps of key personnel to internationally benchmarked standards
- A commitment to identifying and creating a supportive environment that is free of bias so that people from all racial, ethnic, gender and cultural groups within the nation are able to access and participate in the engineering profession
- Development of "lower level" tertiary education programmes which may be an initial access point for a broad selection of the population, together with plans to eventually move these qualifications to conform to the international benchmark standards
- Where there are no or insufficient local educational and training capacity, individuals should be assisted to be educated in other countries where facilities exist. The choice of an external host nation for education is vitally important to

ensure that the study fields that international students from developing nations embark on are aligned to needs and local environments of their nation of origin to ensure effective employment on return. In addition there is a major challenge in the sense that conditions in the home nation must be conducive to encourage that a graduate will in fact return to his or her home land

- Co-operation within regions can be beneficial and even essential where a nation does not have capacity to independently educate and train professionals. Exchange programmes and mutual approaches to regional requirements can facilitate development of the work force

Reducing waste and improving standards

Diversity, gender, wisdom and career guidance

7. Attracting citizens into engineering and technology education in order to build a local skills base

In order to build a local skills base there are a number of stumbling blocks to be overcome. The list of issues will vary from country to country and in some cases there will be very specific or unique matters to be dealt with. Each country or environment therefore needs to be examined and researched to enable the *"capacity builder"* to proceed with the right and the appropriate attitude and set of tools.

In many countries, including some well advanced developed nations, there are some crippling issues that affect and influence the ability to develop and maintain a local engineering related skills base. In a substantial number of cases teachers are generally under-skilled particularly in mathematics and science. There has also been a continuous *"experimenting"* with the primary as well as the secondary school curricula, trying out models that ultimately failed in northern hemisphere developed countries. Constant changes in the way that learners were supposed to be taught, poor access to resources and facilities, poor training and other factors have led to a demoralized teachers or educators corps and this has in turn contributed to *"don't care"* attitudes, teacher absenteeism and other negative factors.

In addition the developing world faces factors that affect learning outcomes related to the physical environment and socio economic issues at large and include:

- Malnutrition
- Long distances and inadequate transport facilities for learners to get to schools
- Many schools do not have libraries and furthermore teachers are not trained to help the learners on how to use the libraries;
- Many schools do not have science laboratories;
- Many schools do not have electricity;
- Teaching staff and learners have to cope with dilapidated school buildings or even no school building at all and having to resort to teaching in the open air or under trees;
- At many schools there is not clean water for the learners to drink;
- At many schools the sanitation is totally inadequate

There are a number of ways in which the decision making capacity of citizens of all ages can be improved to enable them to make informed decisions about careers and vocations. It is important to realise that such a choice is not that of the individual young person only, but that his or her support and contact network in terms of care givers like parents, relatives, teachers, future employers,

governments, the media and society at large all play a contributing role in forming an opinion and ultimately coming to a decision.

Ultimately the physical framework and opportunities in terms of access to primary and secondary education, culture, funding, facilities and many other environmental factors play a role in whether a individual joins the engineering profession or not.

It should furthermore be recognised that attracting, growing and retaining engineering professionals is a long process and to get to professional registration and maturity can easily take up to 25 to 35 years from date of birth. During this process various interventions may be necessary, especially in cases where there is an underdeveloped culture and understanding of science and engineering and technology. It must be emphasised that such a culture is not necessarily present in developed nations nor is it per se absent in under-developed nations.

To ensure a pragmatic approach and successful interventions there should be an integrated and continuous process as illustrated in figure 7.1 .

In various stages of the development of a professional there are specific focus areas and components for which capacity building exercises may have to be considered. Some of these components are illustrated in Figure 7.2

A collection of issues that should be taken into account are listed below. Since there are vast differences from one environment or situation to another, with reference to for example the stage of development, or the cultural and social circumstances in communities for which capacity building is intended, this list is not exhaustive, but serves to stimulate thought and promote understanding. Any attempt to plan interventions and provide capacity building should therefore be carefully researched and planned together with communities who are interested in participating.

Of principal importance is that every environment has its own set of challenges which has to be identified before embarking on capacity building. Although the following list is not scientifically structured and not meant to be a check list in any way, it does give an indication of the complexities that face anybody or anyone who has to decide on capacity building:

- Importance of contact with individuals and groups of practitioners in engineering as a means of inspiring prospective students
- How to de-mystify and make science and maths fun
- Making a direct connection of how maths and science is used in everyday life
- The role of and crucial importance of the inspiring teacher
- Address health and safety concerns that cannot easily be demonstrated by means of exciting science experiments

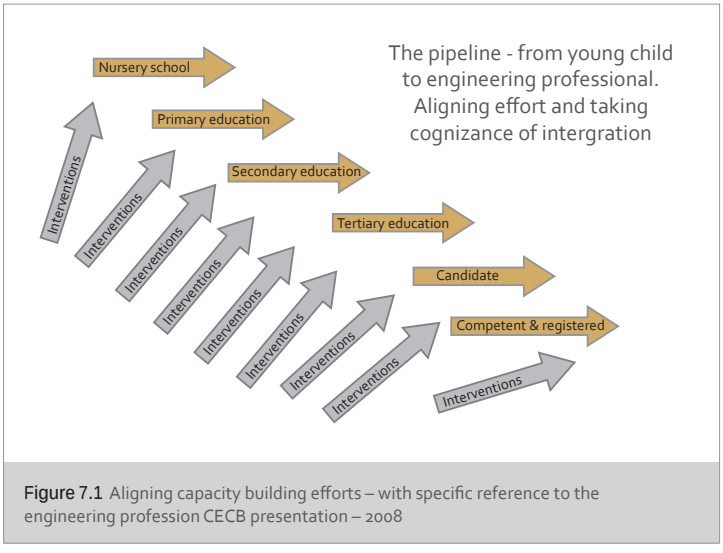


Figure 7.1 Aligning capacity building efforts – with specific reference to the engineering profession CECB presentation – 2008

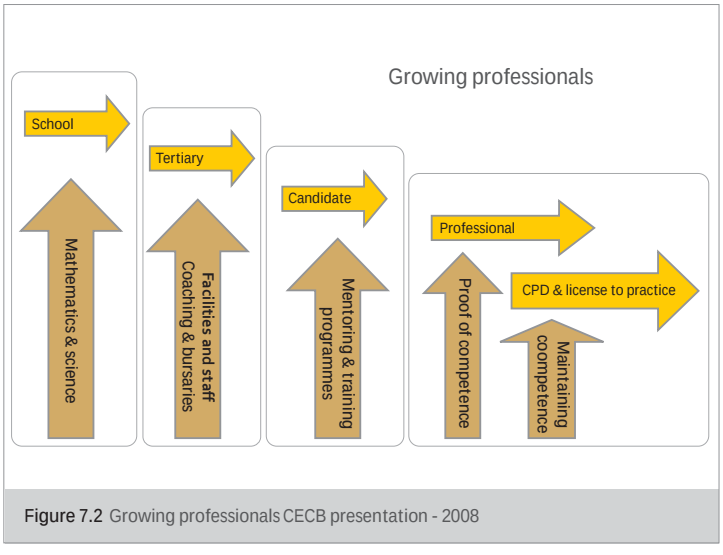


Figure 7.2 Growing professionals CECB presentation - 2008

- Whether science and maths teaching could lead to cultural estrangement due to the method of delivery that could be incompatible with culture or beliefs
- Recognition for indigenous science and technology, even if this material is not covered in classic science and technology textbooks
- Getting engineering professionals to adopt schools in the capacity as role models, advisors, mentors, part time and even full time teachers in subjects like maths and science and technology
- Promote understanding that engineering uses science as basis to develop technology that is needed and used by everybody every day and that without engineering very few amenities and pre-requisites like potable water and sanitation, transportation as a means to access places of work and recreation opportunities associated with modern day civilization would exist
- Resource materials to enable teachers to better deliver science, maths and technology curricula that are likely to inspire students
- Working with school principals and careers advisers and assist with training material, resources and preparation of lessons to enable them to understand the role in and contribution of engineering to the health and safety and wellbeing of society and to overcome negative perceptions that engineering is for example an elitist and exclusive profession
- Utilising modern ways of communication including media that young people use like Mixit, Facebook, Youtube, Twitter and so forth
- Recognise the importance of and assist key role players like parents, family, and friends to understand and build a profile of the engineering profession through public campaign to facilitate and promote support for initiatives to encourage young people to consider the engineering professions as a career
- Recognize different interests and learning styles of young people and their lack of a uniform knowledge of maths and science, adapt tertiary programmes accordingly including the provision of bridging programmes
- Utilise problem-based learning as a means to make the learning process more interesting and practical
- Consider scholarships that have strict conditions concerning incentives and requirements with reference to ensuring that graduates will remain in and serve their respective communities or nations

- Identify and recognise those communities, ethnic groups and for example females who are under-represented in engineering and other technical education fields, identify their needs and desires and how to attract them in a meaningful way
- Provide ways and means for females who have taken time off to start and grow families, in terms of retaining their competencies by means of for example CPD, re-entry opportunities as well as work place facilities and allowances for working mothers including flexi time arrangements
- Utilising engineering heritage programmes, and anniversary dates of major engineering achievements as a means to improve public perceptions of engineering but also utilise the opportunity when both human induced as well as natural disasters occur, to explain and inform the public as well as communities
- Promote engineering professionals as the people who are responsible for economic, environmental and many parts of social development, sustainability, health and safety and as the people who take responsibility for creating a better life for all, general wellbeing and wealth
- Identify and promote key role models and get them to communicate and identify publicly they are engineering professionals
- Pursue a media and communication strategy to engage politicians into a "talk it up" programme to increase public understanding of the need for engineering
- Overcome the perception in many countries that engineers tend to be a profession that is not only male dominated, but not meant to be for females and in other cases only suitable for specific demographic groupings
- School-based competitions contribute substantially to image building and creating interest
- Using illustrations to show career pathways from "school to CEO"
- Creating of ways and means to communicate the fact that engineering careers are not only personally satisfying but in general ensures above average remuneration opportunities
- Celebrate success of engineers by means of engaging with the media
- Utilise public perceptions and design programmes to address issues of concern to elevate the role and importance of engineering by means of surveys, infrastructure report cards and failures of infrastructure

In spite of valiant and laudable efforts the issue of attracting and retaining a balanced and demographically representative cadre of individuals to the practice of engineering remains a vexing challenge in any environment. There is however hope in the sense that a number of countries have achieved success to a certain extent, but in the majority of developing countries the indication is that a serious imbalance and inequity still exists and persists.

A further debate is around the fact that engineering is notorious in terms of achieving a gender balance and only a few countries seem to have broken down the barriers in terms of which females enter the professional reasonable numbers. In most cases the engineering field remains a huge challenge for females in terms of the working conditions, flexibility of employers to allow them to attend to family matters and even equal remuneration for equal work and positions.

A serious change of heart and policy will have to be developed to level the playing fields to ensure all individuals will have equal access to engineering.

8. Professional networks and support systems

Life support

Holding hands

Service delivery takes place in an institutional environment meaning that institutions of many types have ongoing statutory, legal, funding, governance, auditing, and other responsibilities. In any programme or project, undertaking tasks such as needs discovery, project motivation, coordination, design, funding, one or other part of implementation, quality control, operation, and so on. Each entity has to have specific mandates and specified responsibilities and will have rely on network and support systems as well as having appropriate governance structures. In many environments there is a serious lack of integration or aligning of effort. This often leads to confusion or even conflict and ultimate waste of valuable resources.

If one or more of these institutions is not fully able to carry out its responsibilities, service delivery will inevitably be hampered. Service delivery could, among other issues, be delayed, run over budget, not meet design criteria, cause environmental harm or even fail altogether. If for example a government department or agency is not adequately equipped to deal with engineering matters within its mandate, such as enforcing building regulations, approving operational requirements, or ensuring on-time payment to contractors, this will impact on the success of a project, and hence on service delivery.

This chapter does not however deal with all institutions or other related entities but focus on organised professional structures, statutory councils and boards, technical interest or focus groups, quality assurance institutions and so forth. These play an important role in building and retaining capacity. In a sense these entities are, or attempt to be, the custodians of engineering capacity. Their chosen or statutory responsibility is to provide support so that engineering work can take place in enabling environment.

The very nature of engineering practice is to rely on technical and personal support in terms of mentorship and exchange of ideas. In addition the practitioner needs access to "tools of the trade", including specifications, codes, codes of practice, guidelines and procurement documents. These tools are in developed nations supplied by technical institutions focussing on or attending to various specialised or discipline specific areas of engineering.

Pilot studies in the early 2000s in Mozambique, executed by ICE in association with SAICE, and funded by DFID, highlighted the severe difficulties that professionals face in the absence of the substantial networks that their counterparts in more developed nations are used to. The same no doubt applies in many other developing nations. It is clear that in the absence or shortage of networks as referred to, the challenges faced by individuals and by small or isolated groups of professionals, can be substantially

more formidable than those faced by their counterparts in developed nations. This issue can be a major contributing factor when professionals have to decide about whether to stay in such poorly endowed locations or relocate to places where network and access to professional tools of the trade exist in a more advanced form.

Although electronic access to networks may alleviate some of the problems faced by the isolated professional, the human being functions more effectively and is generally happier in a networked environment. However in many parts of Africa, for example, access to electronic and especially broadband facilities remains poor or non-existent and therefore the professionals are often left to their own devices.

One may argue that the principles of engineering and pioneering as well as the making a plan attitude of engineering practitioners are synonymous with the profession and that many engineers of the past, especially in the 1800s and early 1900s, had to make do with inadequate, limited and unsophisticated resources, tools and knowledge while building roads and railways and bridges and dams in far-flung places and in the so-called frontier locations of those times. Although that is true, technology and associated needs of humankind have moved on at an exponential rate. In addition human beings have became accustomed to and rely more on modern day amenities and are more dependent on extensive support and networking systems.

It is also important to note that for various reasons the engineering network and support system has had to be extended beyond the technical fields into the so-called softer issues. Human and societal interaction has for example become an integral component for sustainable engineering solutions, which must by definition incorporate appropriateness and affordability principles. In addition, related scientific, legal, governance, economic and socio-economic, cultural, equity and gender aspects have to be engaged with and embraced by the engineering professional as demonstrated in the ASCE Engineering BOK.

Professional networks and support systems consist of various elements and components that affect or support efficient delivery of engineering services at an acceptable, appropriate and level of professionalism and competency. Networks and support frameworks are not only there to support individuals in their practice but also to support one another in one way or another and to provide a common, aligned and integrated approach as well as a common voice. A major challenge is to ensure that effort and energy is optimised by means of collaboration and integration, and that addressing issues of common interest and concern happens on a common platform. In addition optimisation of resources and resilience is enhanced if institutions take a common approach.

Where a community of professionals is too small to organise itself for mutual support among its members, agency arrangements might greatly assist. For instance, a nation may be too small to sustain a tertiary education facility but it may develop its own professional engineering capacity and resources by means of agreements with a neighbouring nation, institution or society that has sufficient capacity and expertise. In the same vein, a regional approach in terms of providing continued professional development course materials and roadshow events may create a critical mass and render such programmes viable.

An added benefit would be that regional harmonisation in terms of standardization of specifications, engineering standards and procurement could facilitate sustainability in more than one way especially where countries share common boundaries, water catchment areas and rivers, transportation corridors, commerce and industry aspects and so forth. This is particularly important where nations are co-operate on economic development and/or where they share borders and resources such as water and energy.

Common web portals and accessing and using joint publications for communications can provide cost-efficient methods to keep individuals informed where a nation or an institution cannot find resources to offer these resources by itself. Such arrangements can also include a facility by means of which the publication of a stronger institution carries contributions from members of a weaker institution, thereby enabling members of the latter to communicate and be networked, for their knowledge to be enhanced, and for their voices to be heard.

Agreements to share mentorship or expertise can enhance the transfer of skills, provide resilience and enhance cooperation among participants. Agreements can also assist with building and retaining engineering professionals. They can also help to retain professionals that otherwise would feel isolated and feel that they lack opportunities for personal growth.

In all of this, it must always be recognized that local circumstances and factors must be taken into account, since one size of solutions or structures does not fit all.

Structures, elements and issues that contribute to the professional well-being and effectiveness of an individual engineering professional can be grouped as indicated below. If one or more of the following are absent from a specific environment, there is a real risk that the nation as well as the individual will not reach its potential.

Technical:

- Research ability and facilities
- Statutory regulation
- Learned and professional societies and structures
- Discipline-specific interest institutions
- Commercial products
- Quality assurance and standards

Networks, liaison and co-operation:

- Professional society agreements of co-operation within the entire built environment framework
- Central, regional and local government interaction and liaison
- Ethics, codes of practice, value systems and anti corruption systems
- Community liaison and outreach
- Non governmental institutions liaison and integration of effort

Tertiary institutions:

- Universities
- Universities of technology

Information and communication technology:

- Online electronic communication, worldwide web facilities, portals, blogs, chat rooms and Internet "products" such as Facebook
- Mobile phone and personal computer
- Technical journals and magazines
- Research papers
- Media

Funding and finance structures:

- Established commerce and industry
- Banks

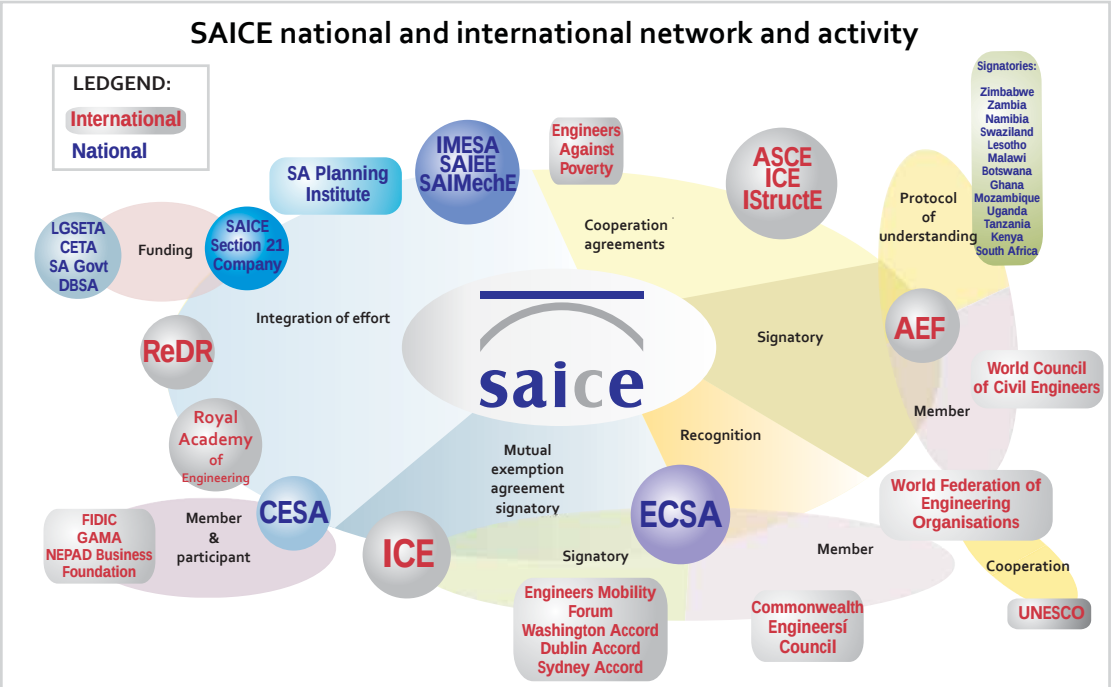


Figure 8.1 SAICE national and international network and activity diagram 2009

- Development banks
- Foundations for supporting programmes and initiatives
- Government development programmes
- Private sector contributions, grants, loans, donations, sponsorships

Professional standards:

- Accreditation and benchmarking, voluntary and statutory, by various institutions and accords.

Even in well developed nations the engineering professional would no doubt not be able to access all of the elements of professional support that he or she would ideally like to have. It is most desirable, however, that there is a network and support system that is able to provide the following, at least at a basic level:

- The knowledge about where to find what he or she needs in order to practice effectively.
- Access to appropriate networks or repositories of support and information.
- Access to physical or virtual networks or circles of individuals, institutions and other entities which would provide membership benefits and opportunities for association with peers and or assistance.

The organised engineering professional and institutions and associations and other entities should be encouraged to provide their members with network maps and similar tools to enable them to readily access the information they need.

Figure 8.1 is an example of such a network map.

Individuals and groups should be encouraged to identify and link into support and networking facilities including learned and vocational societies that are appropriate to their engineering focus and fields of interest and focus. They should mobilise themselves, and actively and progressively engage with other professionals, institutions, entities and associated and relevant communities of peers at large, in order to contribute, share, develop, grow and participate in meaningful manner, for their own good. But, more importantly, to enable them to deliver engineering services and products to communities in a professional manner. Arecent development is the initiative that was first mooted by the Royal Academy of Engineering in the UK that has developed into the Africa-UK Partnership that has identified Institutional Capacity Building as a major challenge in Africa. The need to have viable engineering institutions in support of the engineering practitioner has been singled out as a crucial component or building block towards sustainable engineering and local capacity.

Established engineering institutions focus on different activities but all have certain basic characteristics deemed to be core items. The following list is only aimed at giving a guideline and does purport to be complete or exhaustive. It must also be noted that not each and every institution or society is obliged or able to attend to each and every item, activity or service.

The list distinguishes between what could be deemed basic and therefore essential, and the items that re possibly less important. Apart from that separation, no attempt has been made to prioritise items.

Activities or programme items that professional engineering institutions could or should take responsibility for:

Basic items

Membership data base
Membership canvassing
Constitution, bylaws and regulations
Strategic planning
Policy documents
Continued professional development programmes including courses, seminars, site visits
Geographical branches
Technical divisions or institutes
Magazines, newsletter, technical journal
Career guidance
International recognition for educational standards
International recognition for professional standards
Best and good practice manuals, technical guidelines and codes of practice
Code of ethics and code of conduct for members
Education and training curricula
Professional remuneration and fees
Experiential training
Mentors and mentoring
Engineering Personnel and human resources
Image of the profession
Liaison with government structures at all levels
Liaison with media
Capacity building programmes
Networking with other Built Environment Professions
Publications including the Institution's Presidential address and the Annual Report
Website
Administrative support structure
Office accommodation

Other items

Electronic technical paper data base
Awards for technical excellence
Awards for members
Best published paper awards
Specifications
Training manuals
Conditions of contract
International business and technical networks like FIDIC
Construction industry development boards
Legislation
Accreditation of academic institutions
Liaison, networking and affiliation locally
Liaison, networking and affiliation regionally
Liaison, networking and affiliation internationally
Bursaries
Business support
Specialist technical input & working groups

Market support
Mediation and arbitration
Funding and sponsorship initiatives
Competitions
Annual calendar
Annual activity programme
Events data base
Meeting facilities
Skills development
Qualifications framework
Research & development
Health and safety issues

Capacity building initiatives relating to engineering practitioners and professionals are deemed to be crucial but are often neglected and under rated especially by entities and individuals that do not understand the role and contribution of engineering to sustainability and the wellbeing of humankind.

Although many *"ready-made"* capacity building solutions for engineering professionals may be available care should be taken to research specific needs related to specific regions, circumstances and environments.

Innovative solutions

The sum of the parts are greater than the whole - elements of nature

9. Developing and implementing norms and standards

9.1 Introduction

Capacity building needs to relate to specific norms and standards, the achievement of which is, or should be the objective of building the capacity.

Putting it simplistically, it should be ascertained what *activities*, what *services*, what *quality,* what *reliability* and so on are intended should be achieved as a result of the capacity building.

The corollary to this is the question as to what systems are needed in order to improve the extent of achievement of a these norms and standards.

Decisions with respect to all of these matters are intensely context-specific.

This chapter endeavours to address various issues including:

- An attempt to differentiate and define terms such as norms, standards, and parameters.
- In respect to what is it that norms, standards and so on are needed for and for what purpose.
- The types as well as ways of expressing and or measuring of norms, standards and so on that might be required for the kinds of situation envisaged by this guidebook, and whose responsibility it would be to set these.
- What should be taken into account when setting the standards.
- When uniformity might be needed, and when flexibility might be needed.
- The need for precedence, prioritisation and trade-offs.
- Some of the means of improving levels of achievement.

9.2 Norms, standards and parameters

An attempt is made to differentiate and define terms such as *"norms"*, *"standards"*, and *"parameters"*.

Capacity building obviously needs to be towards a purpose since there is no point in building capacity for its own sake with no intention of using that capacity in order to achieve a purpose even if that purpose is initially undefined.

It is all very well if that purpose is stated in general terms, but sooner or later there is a need to specify in some way or another

the levels of performance expected - performance, that is, both in terms of the improvement in capacity, and in terms of the progress towards achieving that purpose.

The terminology is by no means uniform. The same words are often used in different connotations but it is generally agreed that progress towards any purpose needs specification of:

- A set of discrete and preferably measurable characteristics *"that belong within the categories of process or of outcome"*, and that in some specifiable way, are relevant to the definition of quality or of progress. *"These characteristics can be viewed as elements, components, attributes, or the characteristics of either process or outcome."*
- *"Some general rule as to what constitutes goodness with respect to each element, for example, that its presence is better than its absence, or that a larger quantity is better than a smaller one."*
- *"A more precise, and numerical statement of what constitutes acceptable goodness"* is needed. (Donabedian 1981)

For the purposes of this guidebook the words used are, in order of process or sequence, and referred to as:

- criteria, or parameters;
- norms; and
- standards.

A medical example might be in the same as:

- measuring blood pressure;
- the lowering of an abnormally high blood pressure is a desirable outcome of health care; and
- specification of a specific set of results from the measuring of blood pressure.

Note that *"standards"* are highly likely to be context-specific. Relating to the medical example it means that what is "an acceptably high" measure for one person, might be acceptable for another.

9.3 What norms, standards and parameters, and what purpose

What is appropriate in respect to what is it that norms, standards and so on are needed for and for what purpose are necessarily a component of the debate.

These elements can be drawn up for anything that one can think of and can be applied to any activity, and can be compulsorily enforceable on any persons or groups, or can be voluntary.

In the general sense these are however invariably needed in order for quality or progress towards a process or outcome to be measured. In the engineering environment, these are likely to be of a technical nature and also of a nature that, for want of a better word, can be referred to as "business".

A mixture of *"technical"* and *"business"* can be seen in the example used below. The following list of norms, standards and so on need to be prepared or refined for a public library service *(RSA Department of Arts and Culture, 2008)*:

- infrastructure and buildings, including library buildings, mobile libraries, furniture and maintenance;
- *"user services"* including services to the general public, services to children, services to people who are print-handicapped, circulation, reference collection, interlibrary loan service;
- *"technical services"* including classification, cataloguing, database maintenance;
- *"access"* including library location, facilities for handicapped persons, opening hours, charges, signage, electronic access;
- *"library material and equipment"* including choice of material and visual and audio devices;
- Information and communication technology;
- human resources including staff composition, salary and benefits, training, ethical standards;
- Marketing, publicity and promotion, community participation and so on.

Water standards - South Africa

"9 (1) The Minister [of Water Affairs and Forestry] may, from time to time, prescribe compulsory national standards relating to –

(a) the provision of water services;
(b) the quality of water taken from or discharged into any water services or water resource system;
(c) the effective and sustainable use of water resources for water services;
(d) the nature, operation, sustainability, operational efficiency and economic viability of water services;
(e) requirements for persons who install and operate water services works; and
(f) the construction and functioning of water services works and consumer installations.

(2) The standards prescribed under subsection (1) may differentiate between –

(a) different users of water services; and
(b) different geographic areas, taking into account, among other factors, the socio-economic and physical attributes of each area.

(3) In prescribing standards under subsection (1), the Minister must consider –

(a) the need for everyone to have a reasonable quality of life;
(b) the need for equitable access to water services;
(c) the operational efficiency and economic viability of water services;
(d) any norms and standards for applicable tariffs for water services;
(e) any other laws or any standards set by other governmental authorities;
(f) any guidelines recommended by official standard-setting institutions;
(g) any impact which the water services might have on the environment; and
(h) the obligations of the National Government as custodian of water resources.

(4) Every water services institution must comply with the standards prescribed under subsection (1)." (South Africa 1997.)

For each of these, criteria or parameters, norms and standards would need to be defined. With the *intended objective and outcomes* being *to achieve a minimum, equitable, acceptable and uniform level of library services across the nation.* (Ibid, page 8)

Key elements to consider when developing these in any conceivable field include:

- Sustainability
- Appropriateness
- Affordability
- Safety and health
- Human ability and limitations
- Science and technology aspects.

Clause 9 (3) of the South African Water Services Act illustrates a well thought through process that deserves mentioning. The need, when developing criteria/parameters, norms and standards, to take account of context, and to allow for differentiation where and when appropriate, is captured in Clause 9 (2). See box "Water standards".

Just as much as when developing these, the same elements must be taken into account when applying and or implementing them.

9.4 Expressing the norms, standards and parameters

The types or for example ways of expressing, and or of measuring of norms, standards and so on are described that might be required for the kinds of situation envisaged by this guidebook, and whose responsibility it would be to set these is discussed. Also a discussion is begun on what should be taken into account when setting the standards.

This discussion needs to take place in the context of a specific situation - or, at least, in the context of a particular service in a particular nation with its own set of historic, geographical, economic and other characteristics. Nonetheless some introductory points can be made, as follows. For the sake of brevity, the examples refer only to standards - which, in an actual situation, should only have been arrived at after due consideration of criteria/ parameters and norms.

Standards are "the tools of the trade" or the instruments that the individual as well as the organised professions, industry, clients and employers need to attend to or (in the context of the needs of this guidebook) procure and maintain engineering infrastructure and products.

Referring by way of example for the moment only to technical standards: these can be classified into three distinct groups which are:

- Basic non-negotiable universal or generic standards:

  For example, for items like potable or drinking water for human beings there is an absolute minimum to what the human body can tolerate.
- Standards dictated by the current limits of technology:

  For example, standards that would have to relate to minimum practical dimensions or composition of products or materials. Window glass may for example be limited to a practical minimum of say 3mm and galvanised roof sheeting may not be viable if manufactured in sheets unless the thickness is fixed at a minimum of say 0,3 mm.
- Discretionary standards:

  For example, the geometric design of roads are dictated by a number of issues which range from

Example of drinking water quality standards

In South Africa, the quality of the water exiting a water treatment works, and entering the municipal reticulation system, is laid down in SABS 241-2001 "Compulsory national standards for the quality of potable water". Individual treatment works are not licensed, as the drinking water requirements are the same throughout the nation. (SABS 2001.)

This document is specific on requirements, such as in terms of physical requirements including odour, suspended solids, and total dissolved solids, inorganic non-metallic chemical requirements, inorganic metallic chemical requirements, toxic substances, substances not in solution, and biological limits including faecal coli forms count. "Maximum allowable" limits expressed in units such as milligrams per litre are set for each parameter, and also "recommended" targets for each.

standards associated with speed or service, whether the road is for access purposes or for high volume high speed commuting. In this case the standards relate "only" to what the owner of the facility or the manufacturer of a product want or what, say, the funding limitations are in such a case.

A major risk that must be mentioned, is that in the engineering world quality and sustainability is very often compromised due to a lack of funding and in many cases life cycle costing is not taken into account from the very beginning.

However appropriate standards are to be pursued at all times. Standards should always take cultural and ethical issues into account. Sanitation and hygiene issues are highly emotive issues often related to cultural practices or beliefs and require careful research and consideration in terms of standards.

Clear and transparent and consistent standards can contribute considerably to clean governance and to reduce corruption.

Another factor is the so-called "brown and green agenda" debate that amply illustrates the need for standards to be appropriate, and how what is regarded as "appropriate" vary from community to community and or from time to time. At the risk of generalising a very complex issue the developed world is often demanding that the highest order of environmental standards be followed by everyone while at the same time the developing world is demanding a reprieve and to be allowed the "luxury" to apply lower standards until they have developed to a stage at which they can also afford the "higher cost" environmental standards applied by certain members of the developed world. This debate is even more complex if taking into consideration that certain developed world countries have not or unwilling to subscribe fully to the so-called green agenda protocols.

The debate ranges further to the matter of wastage where the developed world has standards in place that could easily be defined or classified as extremely wasteful and causing environmental stresses and strains. Many products and services are "over the top" and it has been argued that standards in many cases should in fact be lowered to control waste and excesses which very often has major detrimental effects on the developing world. Energy usage and excessive packaging practices are but two examples that could be cited.

Table 9.1 highlights some of the elements concerning the brown-green debate.

9.5 Harmonization versus unnecessary differentiation

Where and when uniformity instead of flexibility might be needed as well as the need for precedence, prioritisation and trade-offs need to be established in each case.

	Brown Agenda	Green Agenda
Key concern	Human well-being	Ecosystemic well-being
Time Frame	Immediate	Forever
Scale	Local	Local to global
Concerned about	Low-income groups	Future generations
Nature	Manipulate and use	Protect and work with
Services	Provide more	Use less

Table 9.1 Brown Agenda - Green Agenda - Ron Watermeyer (SAICE Presidential Address 2005)

This is in essence a debate that needs to be conducted in the context of a particular product or service, and in the context of a particular nation. Some points can however facilitate the process that would have to followed.

Given a situation in which the criteria or parameters and the norms have within the above context been agreed upon, the basic decision that needs to be made is to what extent uniformity of standards is desirable or necessary.

In spite of the principle, "that one size does not fit all " which was earlier mentioned, it can be argued that there are in some cases many benefits in harmonising, at least on a regional basis referring to the standards used to promote integration and enhance efficiency and economic benefits. Examples of this approach include the benefits that could accrue if the variety of plugs and connectors for electrical appliances and fittings, the number of frequencies used and the voltage prescriptions could be reduced or harmonised. The plethora of battery chargers used by the mobile phone industry is another example of wasteful specification practices that necessitate a different charger for every different mobile phone even when these phones are made by the same manufacturer. There may also be benefits in harmonising standards on a global basis, if that assists in levelling the playing field for competition and commercial trade in the global markets. It must however once more be stressed that the "horses for courses" principles must be kept in mind.

A case in point is that many developed nations have put in place unreasonable barriers in terms of deemed to be unrealistic standards required in terms of products and services. In addition commerce and industry sometimes develop and manipulate consumer expectations to unrealistic levels to sell either more or to make more money on basic products which are perfectly acceptable at "lower" standards. To illustrate this statement it could be argued that certain nations will only allow "perfect" fruit that are symmetrical, evenly coloured and size controlled. There may even be a demand that the fruit have to be grown organically and so forth to allow it to be imported to their markets. These standards make it very difficult for emerging producers to enter and compete with highly subsidised agricultural economies of many northern hemisphere countries .

A further challenge concerning standards is that there is sometimes a notion that the same standard has to be used in all places for all conditions. This is however a fallacy since it even creates problems within the boundaries of countries with diverse circumstances. There are substantial climatic, geotechnical and other differences across the globe and if one decides on a single standard, care should be taken when a product is ultimately used in untested circumstances.

In a specific instance in the pacific region major losses were incurred when vaccines were rendered useless when refrigerators broke down repeatedly. The cause of the problem was that the local power supply was very erratic and parts in the cooling systems were not able to cope with the irregular defrosting incidents. It was simply a case of the product used in the wrong place. In many cases products made in developed nations or projects destined for developing nations would have to be designed to be more resilient, depending on where it has to be used.

Standards to protect against disasters have to be carefully matched with what is appropriate and affordable. In river delta communities, regular annual flooding in rainy seasons may be inevitable and in such a case the appropriate measures could be to provide shelters for humans to retreat to in stead of building levees which are not affordable or fail proof. There are several examples of where

human beings have adapted to live in adverse conditions like deltas, without applying the levee standard that a city like New Orleans is trying to maintain.

Harmonisation of standards has in other cases yielded substantial results and benefits. The development of so-called "world cars" can be cited as a success story with reference to reduced numbers of parts leading to reduced costs, smaller inventories owing to interchange-ability and in the end also leading to price advantages in some cases, which in turn provided wider access to this mode of transport.
Common and standard approaches to procurement, products and projects could provide major savings by the mere fact that it reduces the inputs and maximises outputs. In developing nations standardised contract documents assist greatly with engaging and attracting emerging contractors in addition to reducing risks for all concerned.

However, the debate cannot be conducted and neither can the necessary decisions be taken, except in a particular context.

9.6 Improving levels of achievement

Some of the means of improving levels of achievement in terms of meeting the standards needs to be addressed.

As stated at the beginning of this chapter, one of the purposes of criteria or parameters, norms and standards is to clarify expectations of individuals, communities and institutions under specific circumstances, and to measure progress and achievement of the outcomes that are the subject of the norms, standards and so on.

While it is anticipated that the individuals, communities and institutions are self-motivated to progress, willpower alone, without capacity and resources, is likely to be insufficient for them to achieve the outcomes. Capacity building would under most circumstances be of great assistance to overcome inherent inertia and barriers.

Applying the "three spheres thinking" as explained in Section 3.2.4 it suggests that depending on the specific circumstances, measures other than building capacity and providing more resources could assist. Prominent among these are:

- the support of an external agency;
- forms of incentives.

Which one, or which combination is used and to what extent, is once more dependent on the specific circumstances and also on the resources and willpower of the external agency. It is also very

much dependent on the importance of the issue, what the risk is if the standards were not being met, and what are the consequences would be.
It is not justifiable to take this discussion any further without specific and or local circumstances in mind other than to present the lists on the page below, and to refer briefly to the role of regulation and the role of support, in the context of engineering services. These services could often be the subject of regulations, laid down by a national government or a statutory body, to ensure compliance with what is for example required for drinking water quality.

Issues to be considered include:

- an essential step towards ensuring compliance which implies monitoring whether there is, or is not compliance;
- in the event of non-compliance, the regulator could choose to enforce compliance by whatever means, to penalise for non-compliance as an inducement to comply, to assist the institution to become compliant, or to intervene directly and to some or other extent to take over from the institution.

The role of monitoring has not up to this point been discussed in this chapter. However it plays a significant part in measures, whether in terms of support or regulation, to improve performance and enable the individual, community or institution to achieve the desired or appropriate standards.

Regulation however has its limits. Regulation might for example be able to ensure that the budgets of any institution are better spent, and might even lead to improvement of the revenue stream owing to a reduction of unaccounted-for water, but regulation in itself will not substantially increase the financial resources available to the institution.

Some of the following combinations of standards with supporting measures such as guidelines, pro forma documentation and practice notes can assist with understanding the principles discussed.

Examples of "technical" standards and supporting measures include:

- Specifications
- Design criteria
- Standards for materials, products, performance, procedures and methods
- Procurement documents, including general conditions of contract
- Codes of Practice for technical procedures
- Manuals and guidelines on a variety of items
- Technical handbooks
- Software and hardware
- Technical information from research papers
- Practice notes
- Quality requirements and service levels
- Statutory and regulatory requirements and prescriptions
- Incident management manuals or guidelines.

Examples of "business" standards and supporting measures include:

- Procurement documents and procedures
- Specific procurement requirements like preferential procurement systems to develop local or target groups
- Risk assessment and risk reduction procedures
- Codes of ethics and codes of practice
- Anti-corruption systems like those developed by Global Infrastructure Anti- Corruption Centre - GIACC
- Model forms of agreement
- Codes of practice in terms of how a business should be managed
- Quality assurance systems for procedures
- Statutory and regulatory requirements and prescriptions
- Organisational requirements set by either governments or by professional societies and organisations
- Occupational health and safety requirements
- Capacity building guidelines
- Commercial and financial systems and benchmarks.

Capacity building efforts towards sustainable engineering should more vigorously consider the substantial benefits that standardization and harmonization can bring , especially since it facilitates empowerment of individuals and reduce margins of cost and error but taking into account that it can only work when applied with due diligence and by keeping the specific environment in mind.

10. Capacity building by utilizing capital projects

Executing and managing projects throughout their lifecycle and how to identify and apply key factors in terms of which one takes projects from their initial conceptualisation right through to their successful completion and subsequent operation, maintenance and decommissioning phases present interesting and effective opportunities for capacity building initiatives.

The concepts of capacity building and the need for capacity building have been covered in previous chapters. The purpose of this chapter is to provide a guide for planning and implementation of capacity building that can be applied to any project for the improvement of capital works related to engineering infrastructure.

The content of this chapter is not intended to claim that capacity building is an essential component of any or any specific project, but it compliments other sections in the guide book where the benefit of capacity building as a mechanism to improve project sustainability is covered. The purpose of this chapter is however aimed at explaining how capacity building can be planned and implemented as an integral part of a project of which the primary purpose is to build capital works.

A number of approaches have been developed and used successfully to reach the desired objectives of sustainable results and strengthening local capacity referring to capacity of local stakeholders, where the capital project is being implemented.

Therefore, there is no single approach that must be followed and the "not-one-size-fits-all" way to build capacity is once more not per se promoted or supported.

It is considered to be the best approach to begin with a structured, disciplined process, with ample provision for flexibility to accommodate current, on-the-ground conditions. Various government and private institutions may be engaged in a specific project. These institutions are stakeholders in the project outcome and provide important and unique perspectives that are necessary to tailor capacity building activities to best fit the current conditions.

The lessons learned from projects over the years have shown that capacity building must be consciously planned into and provided for in the project process since it does not "just happen" by itself. The process demands defining the right level and approach for capacity building in terms of scope and providing sufficient time and funding both in terms of schedule and budget, to conduct the capacity building activities at the programme and project

levels, to track performance, and to measure the outcomes over time.

This chapter describes the top level or most comprehensive way of the application of capacity building principles. The assumptions made are:

- The context is a "mega-project" with a capital works budget of many millions;
- The capacity building budget is substantial;
- Capacity building is in the care of a well resourced team that started working well before construction commenced, perhaps even before the feasibility study was undertaken and members of the team would retain a strong involvement well past commissioning, and into the operating, maintenance and evaluation phase;
- Only a small minority of projects would justify this effort;
- In addition to major construction projects they could be general development projects that are significant at the national scale, and which have capacity building as one of the major focus areas;
- Smaller projects could only justify smaller efforts.

The detailed descriptions in this chapter of the steps to be followed in capacity building on very large projects must be read and interpreted with the foregoing in mind. However the principles of the approach as described in this chapter, must be followed irrespective of project budget or duration, starting with the attention that must be paid to all levels of the three-level framework as depicted in Figure 10.1.

In Chapter 3 the limits that should be set to capacity building efforts are described in more detail. That section suggests that over and above this question of the appropriateness of capacity building in each instance, for example whether it was correctly targeted and correctly designed, there is always another reason to call a limit to the building of capacity, and this reason is based on cost-effectiveness, or "*effort-effectiveness*".

This translates into the approach that if the problem which is to be resolved is small, then anything more than a "small" effort to resolve capacity problems is probably not justified. If however if the problem to be resolved is "huge" and for example very large amounts of money is at stake or the services delivery to many people is affected, it may be imperative that a substantial capacity building effort might well be justified.

In Chapter 3 these issues are described in more detail.

Chapter 10 and especially the section "Capacity development process" describes a comprehensive process, which is appropriate only to circumstances where a huge effort, accompanied by a substantial budget, is justified. In other circumstances, this process needs to be simplified and scaled down as appropriate in terms of the needs resources pertaining to each circumstance.

10.1 Capacity building principles

In gathering material for this chapter, various approaches and experiences of capacity building around the world were reviewed. This brought forward four consistent themes or principles which are critical to the planning and implementation of capacity building.

A number of these issues have already been discussed in previous chapters but it is deemed appropriate to once more mention these issues which should promote an enhanced and better all round understanding.

The principles are summarised as follows:

- Local ownership and participation at the national, regional, and local levels are vital. Capacity building is fundamentally an endogenous process that involves attaining, strengthening, adapting, and maintaining capacity over time, in response to emerging opportunities and challenges. When communities have direct input into design, implementation, management, and evaluation of projects, returns on investments, and sustainability of the project are enhanced.
- Actions must be consistent with societal, political, and cultural context. Effectively

conducting capacity building requires a good understanding of how that society organises itself, how development takes place and what critical capacities are required to make capacity building work.

- Considered thought must be given to sequencing of capacity building activities and a think and act process should be applied in terms of sustainable capacity outcomes. Achieving a "best fit" approach to capacity building implies an appropriate level of flexibility in implementation methods.
- Timing of capacity building assistance is an important factor for success as well as the fact that the process cannot and should never be rushed.

The general approach explained in this chapter begins with conceptualisation and early project planning and continues through the detailed engineering and design phase. The process is ultimately supported by a robust approach of assessment and incorporation of lessons learned to identify those areas that worked well and those areas in which improvement is needed on future projects.

10.2 Capacity building framework

The purpose of a capacity building framework is to set the basic parameters for planning and implementation and to serve as a focal point for all parties involved in the project. Benefits and drawbacks of each existing framework can be identified when applied to a particular project. This means that there is no framework that will work "best" in every case. Flexibility within a structured capacity building approach is always advisable when applying it to a project.

Capacity building frameworks of the following organisations were reviewed, and the best ideas drawn from them in order to compile a guideline for WFEO's purposes:

- United Nations Development Programme
- Organisation for Economic and Cooperation Development
- European Commission
- Japan International Cooperation Agency
- Asian Development Bank
- Swedish International Development Cooperation Agency
- U.S. Project and Contracting Office
- U.S. Army Corps of Engineers.

A three-level framework, as shown in Figure 10-1, provides an effective compromise of various existing frameworks. The three levels are interdependent that in practical terms means that capacity building would be optimum when the three levels are supportive of each other.

Level 1 – Enabling environment

The enabling environment sets the conditions under which capacity development are conducted for programmes and projects at the institutional and individual levels. This includes policy frameworks, legal systems, regulations, political institutions, and market economy considerations.

Level 2 – Institutional

The institutional level is comprised of leadership, administrative structure (e.g., payroll system, human resources system, decision-making processes), and culture required to achieve external and internal goals. Institutions are strongly influenced by the enabling environment.

Level 3 – Community and individual

The community and individual level pertains to the knowledge or skill of a community or an individual charged to conduct a particular work scope. This includes the motivation and ability to appropriately set behavioural objectives and achieve those objectives using that knowledge and skill set. Communities and individuals are strongly influenced by the institutions with which they work.

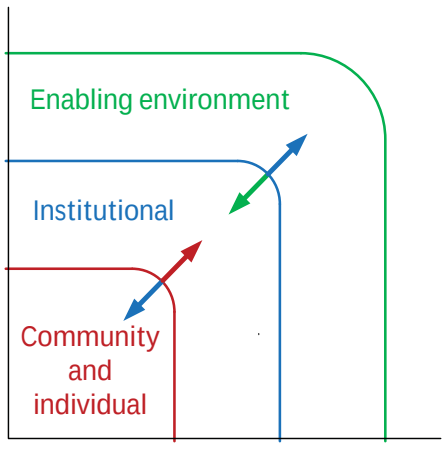


Figure 10.1 Three-level framework

10.3 Stakeholders

Stakeholders are those institutions or individuals that have a positive "stake" in the outcome of the project or have the ability to influence the outcome. The outcome can be either short-term or long-term and its effect can be either direct or indirect. The level of involvement by each stakeholder varies significantly depending on scope, size, circumstances, and eventual impacts to the international community.

Stakeholders can be representatives of national, regional, or local governments, non-government organisations (NGO) or the private sector. Each stakeholder offers a different perspective regarding the need for capacity building on the project. A stakeholder may have a direct role in management or administration of the project, it may be implementing another programme or project that has a linkage or direct connection with the programme or project, or it may simply have a strong interest in the outcome.

The commitment of local institutions, communities and individuals, and their active and substantive participation, can be the factor most critical to successful capacity building complimenting a successful capital works project. It is therefore imperative that they be committed, engaged, and willing to participate before beginning a project that requires capacity building.

The composition of the stakeholder group for a project varies from project to project and is dependent on factors such as project size, cost, and complexity, current capabilities and capacity of the local stakeholders, political, social, and security status. The stakeholder selection process should begin at project inception and the involvement of stakeholders may vary over the course of the project meaning that, different stakeholders may be involved at different times. Representatives from each stakeholder institution should be able to speak on behalf of their institution or, at a minimum, they should be able to obtain rapid decisions from their institutions related to capacity building for the project.

The capacity building process should include a process regulating documenting the roles and

responsibilities of each of the stakeholders during the initiation and planning phases of the programme or project. This documentation provides each stakeholder with information about what the other parties will be doing on the project. There is no single mechanism for documentation due to the array of scenarios, number of stakeholders, size, and scope of programmes or projects, and existing systems that may be in use. A simple Memorandum of Understanding (MoU) between the stakeholders can be an effective method of formalising and placing on record stakeholder agreements and commitments. This is not the only mechanism that can be used and the formality of the document should reflect the size, complexity, and number of stakeholders involved in the project.

The objectives of this documentation process are to:

- allow each stakeholder to understand the roles of other parties;
- provide a means of coordination of activities within the stakeholder group;
- avoid redundancy, conflict, or gaps in capacity building implementation actions; and,
- formally commit each stakeholder to the general implementation actions that they will undertake (including scope and funding) to make the project successful.

Commitment of each stakeholder to a defined role in the process should be documented in a Project Management Plan or comparable document.

Figure 10-2 illustrates the types of stakeholders that may be involved in a health sector project. The Lacor Hospital[11] is a construction project in Lacor, Uganda. The number of stakeholders shown in this example underscores how a single facility or project can be of interest to a wide variety of stakeholders. The interrelationships between the numerous stakeholders in this example were mutually reinforcing and contributed to the development of the hospital's overall legitimacy and resilience. Stakeholders who found themselves part of conflicting systems and sets of interests, on the other hand, faced quite different capacity building challenges.

Source: Capacity, Change and Performance Study Report, European Centre for Development Policy Management

11 Source: Capacity, Change and Performance Study Report, European Centre for Development Policy Management.

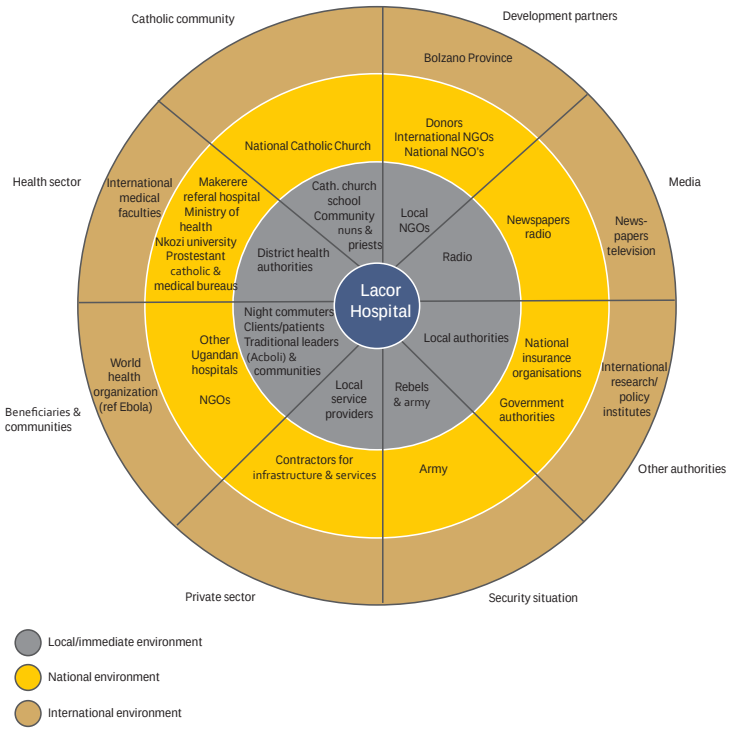


Figure 10.2 Stakeholders involved in construction of Lacor Hospital, Uganda

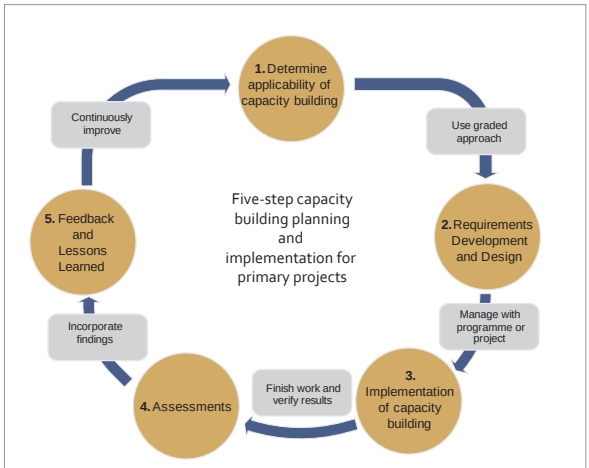


Figure 10.3 WFEO five-step planning and implementation process

10.4 Capacity building process

10.4.1 Process outline

The three-level framework described in figure 10.2 serves as the foundation for the five recommended process steps for the planning and implementation of capacity building. These steps provide the stakeholders with a full-circle guideline beginning with initial project planning through implementation, reviews, and lessons learned. Other processes have been used on projects around the world, so again, there is no ideal process to fit every project in every setting. The five steps, as described more fully below, align closely with recognized project management processes.

The WFEO planning and implementation process for capacity building, shown in Figure 10-3, begins during the project planning stage and continues through completion, transition, and evaluation of results. This model for capacity building is based on a traditional five-step approach of:

Step 1 - Determining applicability of capacity building to the primary project;
Step 2 - Planning the capacity building actions;
Step 3 - Implementing the capacity building actions at the primary project level;
Step 4 - Assessing the results of the planning and implementation of capacity building; and,
Step 5 - Incorporating feedback to continuously improve results on future programmes and projects.

In this chapter, "primary project" refers to the capital works or development project, of which capacity building is a part, and not to the capacity building only.

These steps provide a guideline on how capacity building can be planned and implemented as part of primary projects. The intent is not to require rigid application of these steps on every primary project. The ideal solution is for the stakeholders to use flexibility within a structured approach. "On-the-ground" conditions must be considered on every project and adaptations must be made to reflect changing conditions. Figure 10-4 shows some of the factors to be considered in designing a flexible, effective approach to capacity building.

The description now follows of each of the five steps in what is henceforth in this guidebook referred to as "The WFEO capacity building process".

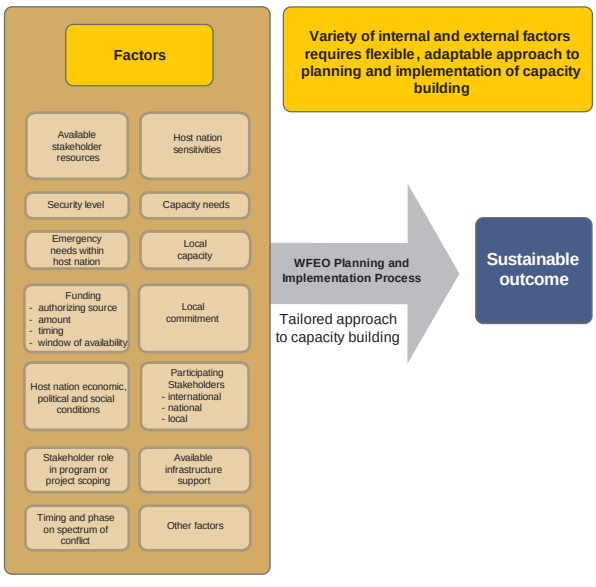


Figure 10.4 Use flexible approach to achieve sustainable outcome

10.4.2 Step 1 – Determine applicability of capacity building

The stakeholders determine the extent to which capacity building is required in order to achieve the primary project objectives and the desired end state. This determination can range from "not applicable" to an extensive level of capacity building implementation that is critical for success. The capacity building framework adopted by WFEO, described in Section 10.3, illustrates the three levels of capacity building that may require coordinated effort by various individuals, communities and institutions. It is a useful tool to help the identification and integration of levels of responsibility for capacity building at the detailed project level. The capacity building applicability determination must be made by the stakeholder group.

The following are the main elements useful to determining the appropriate level of capacity building to be conducted within a primary project. The approach for determining the applicability of capacity building at the project level is typically more specific than the programmatic level, because the project generally has additional parameters that must be considered in detail. The following describes the sequence of activities that comprise the phase of determining capacity building needs and applicability at the primary project level.

Determining applicability in terms of key elements

Step 1a - Identify stakeholders.

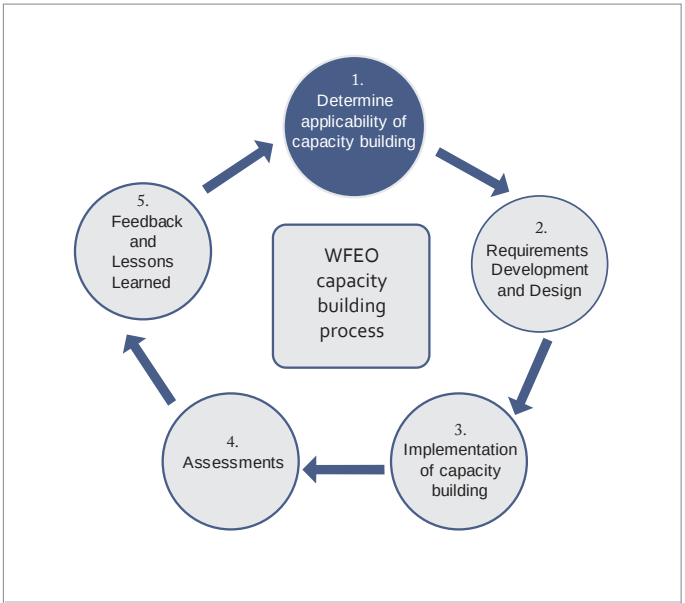
The initial step in determining applicability is identification of the various institutions or individuals that have a stake in the outcome of the primary project. These are the "stakeholders".

Step 1b - Determine capacity needs to implement and sustain the primary project.

The capacity needs are equivalent to the capacity requirements or capabilities that must be available to plan, implement, and sustain the primary project. The project management and stakeholders should consider capacity needs for the project at all three levels of the WFEO framework (i.e. enabling environment, institutional, and community and individual) shown on Figure 10-1.

Step 1c - Conduct initial capacity assessment.

Details of the project can typically not yet be well defined during project initiation; however, an initial capacity assessment should be conducted at this point. The level of assessment detail should be commensurate with the knowledge of the project and information available from similar projects. An early assessment, before substantial commitment of resources, identifies key risk drivers that could significantly impact project success and



Step 1 Determine applicability of capacity building

sustainability. It allows time to consider general mitigation strategies that could be used to close the identified capacity gaps during project planning and project execution. Mitigation strategies for the "show stoppers", i.e. factors that have the potential to alone cause the primary project to fail, should be the focus of stakeholder attention and should later be integrated into the primary project management plan.

The initial assessment is done by comparing the capacity needs, described above, to the capacity currently available at local level to meet those needs. This is done through a two-step process to identify and characterise any capacity gaps that may be present, and to determine the appropriate number, scope, and delivery mechanism(s) for project-level capacity building activities.

Step 1d - Assign general capacity building responsibilities.

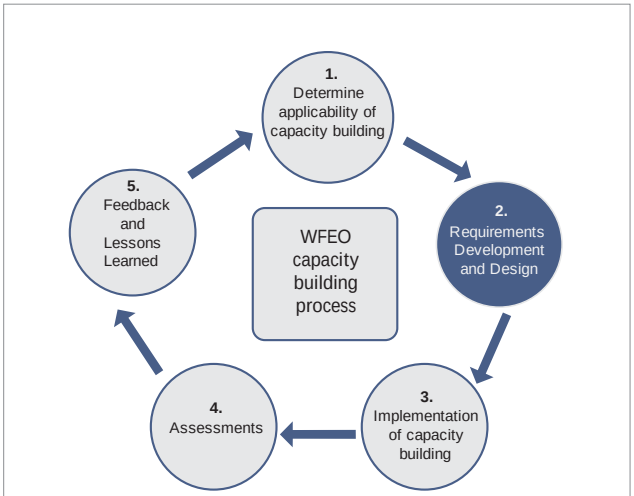
The project management and stakeholders should identify general actions that they can employ to reduce the identified gaps and risks. The stakeholders should then prioritise the actions and agree on general responsibilities for actions that may be required by their respective institutions with the objective of closing the gaps and reducing the risks. Each stakeholder should have clear authorisation to implement the capacity building activity and should have funding available, as necessary, for successful implementation. It is important that there be stakeholder consensus on the way ahead for capacity building at the project level before proceeding to Step 2 (Requirements Development and Design) of the WFEO capacity building process.

10.4.3 Step 2 – Requirements development and design

This key step involves planning and stakeholder coordination in order to ensure that capacity building activities are incorporated into the project specific planning documents. This begins with the output from the initial capacity assessment (Step 1, above) and builds on the results to refine the estimate of project risks associated with gaps in available capacity and to develop specific capacity building mitigation actions to reduce or eliminate the gaps. The process now proceeds to definition of the specific capacity building activities to be completed and assignment of each activity to one of the stakeholders authorised and funded to conduct that activity. This step also addresses other capacity building design elements such as development of capacity building metrics and an acquisition strategy. Finally, the capacity building activities must be priced, scheduled, and added into the project management plan or corresponding document, as appropriate.

Requirements development and design -- key elements

Step 2a - Complete the capacity assessment.



Step 2 Requirements development and design

The stakeholders should analyse the capacity assessment that was conducted in Step 1 (Determine applicability of capacity building). This will provide an understanding of the baseline conditions and the general level of capabilities and capacity that will be required of all of the stakeholders, to help them to develop the project, to participate in the project, and to sustain the project. Each stakeholder should contribute to this understanding through its expertise on technical issues and on implementation of capacity building at all three framework levels.

Step 2b - Identify specific capacity building mitigation actions.

The stakeholders should develop mitigation actions to close each capacity gap and to reduce the overall capacity risk to the primary project. The stakeholders share the responsibility for developing the capacity building activities for the project. Each stakeholder identifies candidate activities, based on areas of expertise and project responsibilities. The capacity building activities should be focused on filling the gaps identified in the capacity assessment and should be integrated to meet specific project needs and to obtain specific results. More than one mitigation action may be appropriate to address a particular gap. The capacity building activities should be focused on filling the gaps identified in the capacity assessment and should be integrated to meet specific needs and to obtain specific results. The local stakeholders, especially, must fully participate in this identification process, and must agree to the capacity building mitigation actions for the project.

Step 2c - Assign specific capacity building mitigation actions to specific stakeholders.

Once their responsibilities have been assigned, all stakeholders must work within their authorities, areas of expertise, and established budgets as they implement capacity building in support of a primary project.

The capacity building objectives should be refined into specific capacity building tasks, and each task should be assigned to a stakeholder that has the legal authority to accomplish the task, the necessary funding to accomplish that task, and the willingness to serve as the lead for design and implementation of the capacity building mitigation action. Each action should be assigned to a stakeholder that will assume the lead role for implementation of that action.

Step 2d - Develop capacity building metrics.

Metrics provide a method by which capacity building activities can be assessed during project implementation and, in some cases, after project completion. Metrics are pre-determined,

measurable elements that are necessary as part of any assessment and are used to determine the effectiveness of the capacity building activities in meeting the goals of the primary project. A metric(s) should be established for each capacity building activity that is considered key to primary project success. Each metric should be accompanied by a schedule so the capacity building activity can be evaluated against the project timetable. A contingency plan may be appropriate for certain critical capacity building activities, so as to provide a pre-determined pathway for immediate corrective action in the event the assessment indicates the capacity building activity is insufficient. Metrics should be based on quantifiable outputs and outcomes wherever possible.

Assessments of capacity building performance will consider a combination of output metrics and outcome metrics. Output metrics are readily available during and immediately following the capacity building implementation and can be directly compared to the planned capacity building activities. Output metrics should be quantified, with benchmarks established during the project planning process so there is a clear understanding of expectations during project implementation and a documented record of activities to support any assessments or inquiries regarding project accomplishments. A project plan, for example, might include a provision for training 300 workers on a particular topic within the first year of the project. Through evaluation of training records, an assessment can readily determine whether that provision was met with.

However the effectiveness of capacity building in support of a primary project will - or ought to be - eventually be measured by outcomes, rather than outputs. Measurable outcomes provide a more comprehensive picture of the long-term effectiveness of capacity building and its contribution toward sustainability, increased self-reliance, knowledge, skills, and abilities of the stakeholders. Outcomes, by their nature, are much more difficult to measure than are outputs. Also, they typically become evident over a much longer period of time - they might even be ongoing into the indefinite future. For these reasons, it could take some while - even years - before a reasonable assessment of effectiveness can be made.

Desired outcomes should be identified as the primary project is developed and they should be included in the Project Management Plan, as stated in Step 2 (Requirements Development and Design).

Step 2e - Develop acquisition strategy.

This section addresses both the general acquisition strategy for the primary project and specific contracting elements that should be considered for prime contractors. The WFEO capacity building process does not dictate the specific project acquisition strategy, but it should be one of the factors considered by the stakeholders. The stakeholders must determine how to best carry out the primary project - this determination should be made during the initiation and planning phases.

Capacity building should be planned as a fundamental project element during the initiation and planning phases of the primary project so that the appropriate language regarding capacity development can be developed and included in the prime contracts. The prime contractors should have responsibility and accountability for completion of assigned capacity building activities and the contracts should include incentive or penalty provisions related to this work scope.

10.4.4 Step 3 – Implementation of capacity building

This is the step during which capacity building activities are carried out by the stakeholders and their representatives. Implementation of capacity building activities is done as part of overall primary project implementation, since capacity building has been planned and integrated into the project planning documents.

Final resource planning and assignment of specific resources is the first step of implementation. The responsible parties then conduct the capacity building activities consistent with the project plans and schedules. It may be necessary to make mid-course adjustments to capacity building activities in order to accommodate on-the-ground conditions, so flexibility for such adjustments is an important element of successful implementation.

Finally, documenting and tracking the capacity building activities is necessary for easy retrieval of information to support internal management requests, external requests and audits, and to support the lessons learned programme.

Step 3a - Finalise capacity building planning, and assign resources.

Each stakeholder with capacity building responsibility should conduct its final planning and coordination activities to support implementation. This includes aligning resources, making minor schedule adjustments, finalising contracts, and interfacing with other stakeholders. Close communication is especially required with the local stakeholders, in order to ensure their full participation and support.

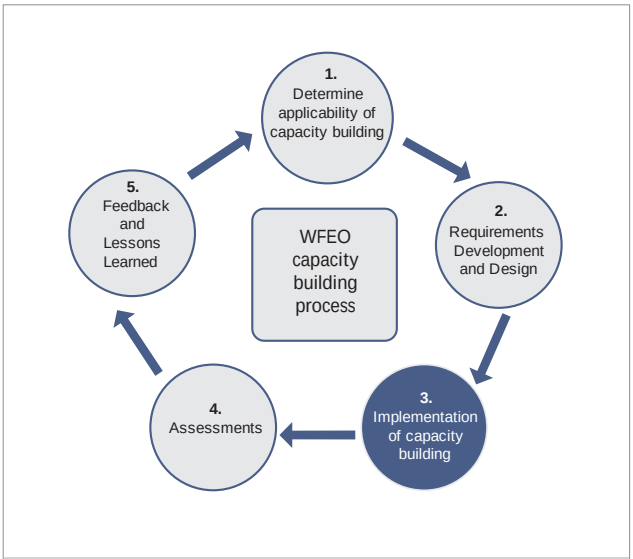
Step 3b - Conduct capacity building activities.

Everything done thus far has been part of the planning and preparation that leads up to capacity building implementation. Implementation is the stage at which capacity holding activities are carried out, as appropriate for the project. Each stakeholder conducts its work in an integrated manner, coordinating with other stakeholders and other engaged parties as necessary to support the project. A high degree of interaction is required between the stakeholders during the implementation stage to optimise the capacity building process.

The role of the local stakeholders during the planning and implementation of capacity building activities is critical to success and cannot be overstated. This is a lesson that has been learned by international institutions, non-government organisations, and foreign governments on numerous projects around the world. The level of involvement by local stakeholders will vary, depending on the scale and complexity of the capacity holding activities, the extent to which capacity gaps exist, the security environment, and other factors that must be considered on a case-by-case basis. The manager of the primary project should work closely with other stakeholders in an effort to engage the local stakeholders in a meaningful way throughout the implementation process.

Step 3c - Make mid-course adjustments to capacity building approach.

The planning activities leading up to capacity building implementation will rarely be implemented without some degree of mid-course adjustment being required. The on-the-ground conditions will be dynamic and it is important that the stakeholders have sufficient flexibility to alter the capacity building approach as necessary to meet the primary project objectives. Mid-course adjustments may be based on real-time information and feedback obtained during project implementation or on the



Step 3 Implementation of capacity building

results of formal assessments conducted during implementation.

Step 3d - Track progress and report.

The manager of the primary project, or someone designated by him/her, will be expected to track and report on the capacity building activities undertaken, and their results. A method of tracking and reporting will be required to allow the management chain to view the status of capacity building planning and implementation at any time. Progress should be tied to the metrics (see Step 2, Requirements Development and Design) whenever possible. Previous experience has shown that it is necessary to have readily available information to enable managers to reinforce or change direction and to establish priorities for future actions. Experience has also shown that project managers can expect to receive information requests from their chain of command and from outside organisations on the number and type of capacity building activities being conducted and on the efficacy of the capacity building activities as a whole.

10.4.5 Step 4 – Assessments.

Assessments of capacity building effectiveness will be valuable tools contributing to the goal of continuous improvement. Assessments or audits can be done in a variety of ways and can focus on specific elements of a project or can serve as a review of an entire project. Appropriate metrics will be developed during the project planning stages and will serve as benchmarks for future assessments. Adjustments to metrics can be made during project implementation to reflect the dynamic nature of the project.

Periodic management assessments or internal project assessments of capacity building's effectiveness will be valuable in reaching the goal of continuous improvement. Assessments or audits can be done in a variety of ways and can focus on specific elements of a project or can serve as a review of an entire project.

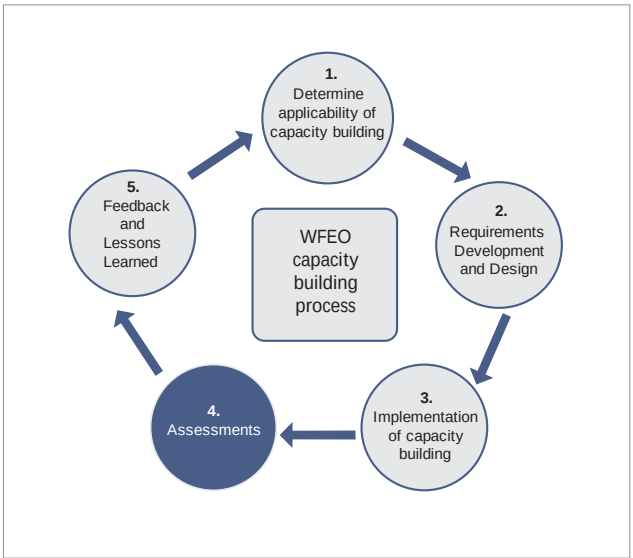
External assessments must be conducted by institutions that have no role in the primary project – these could be third parties that specialise in assessments and audits. These assessments should focus on the extent to which (1) capacity building was incorporated in the planning of the primary project, and whether adequate funding for it was provided, (2) the assigned stakeholders conducted the capacity building activities as planned, and (3) the completed capacity building activities achieved the desired outcomes.

Step 4a - Review and refine metrics for assessments.

Metrics developed in Step 2d should be reviewed to determine if any adjustments are necessary prior to assessment of capacity building activities. The dynamic aspect of projects in international settings can be significant and some refinement of capacity building objectives, mitigation actions, schedules, and overall expectations may be necessary to reflect current conditions. Assessments of any type should always be conducted against current metrics.

Step 4b - Conduct management assessments.

Management assessments or internal project assessments should be coordinated through the manager of the primary project, but can be performed by any stakeholder provided the assessment scope is within the jurisdictional scope of that stakeholder. Contractor support can be used to support the assessment, as appropriate. These assessments should focus on the extent to which (1) capacity was built into the primary project during the requirements development stage and



Step 4 Assessments

whether adequate funding for it was provided; (2) the assigned stakeholder conducted the capacity building activities as planned; and (3) the completed capacity building activities achieved the desired outcomes. The purpose of conducting management assessments is to identify and document ways in which future capacity building can be planned and carried out more effectively.

Step 4c - Support external assessments.

The manager of the primary project should assign a staff member to serve as liaison to any external agency staff conducting an audit or assessment of capacity building activities on the project. The liaison should have access to other project team resources, as needed, to support the assessment. All transfers of documents and requested information between the project and the assessment institution should be coordinated through the liaison. The liaison should provide the project manager and stakeholders with updates at agreed regular intervals and at completion of specific project milestones, regarding the current status of the assessment.

10.4.6 Step 5 – Feedback and lessons learned.

Gaps or deficiencies noted during assessments and the associated recommendations for improvement should be incorporated into a lessons learned system, as appropriate, to further improve the effectiveness of capacity building planning and implementation. Positive findings or noted good practices should also be used to document and reinforce specific capacity building activities that add value.

The manager of the primary project is the one responsible for providing feedback to the appropriate members of the stakeholder group. These lessons will then be incorporated into current and future practices to ensure the stakeholder investment is not lost or reduced and that local citizens are supplied with the essential services necessary to support a sustainable economy, government, and infrastructure.

Step 5a - Develop feedback.

Development of a record of capacity building implementation steps, along with findings from formal and informal project assessments, provides the information necessary to make project improvements. The project manager or designate should assemble and record positive and negative project impacts that are related to capacity building. The project manager obtains this information or feedback from staff involved in the project, national representatives, contractor staff, and other stakeholders. Formal and informal assessment findings provide a valuable feedback resource of feedback on the effectiveness of capacity building activities. The project manager should distribute significant feedback to the appropriate stakeholders whenever it is received.

Step 5b - Input to lessons learned programme.

The programme that should be available to any given project for capturing the lessons learned will vary. Each stakeholder institution will likely have some type of formal lessons learned programme available to them. Each stakeholder institution should add to its own lessons learned programme the capacity building lessons it learns on each new project, even if entry into multiple systems appears to be redundant.

The manager of the primary project should take a lead role in ensuring that all capacity building feedback is screened and considered for entry into a lessons learned programme. Other project staff and stakeholders can assist with this.

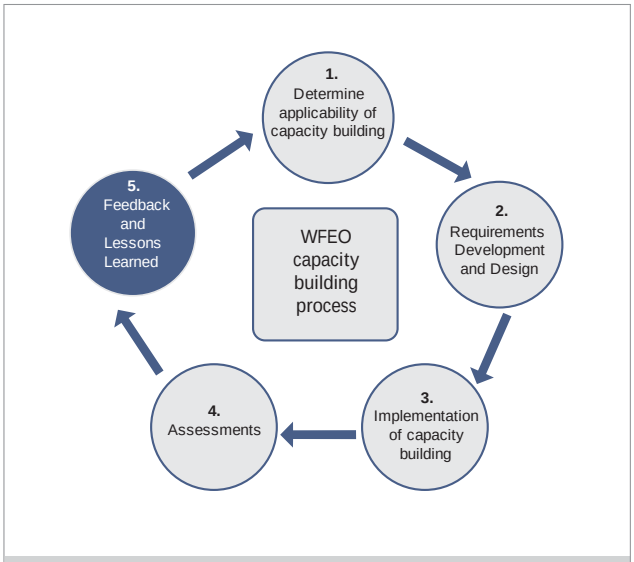
Step 5c - Incorporate lessons learned.

Before commencing a new project, or at key decision points during the course of new or current projects, project managers should access the lessons learned programme for his/her institution, to determine if there are any capacity building lessons learned that would add value to the project, increase project effectiveness, and support sustainability. The project manager should also request other stakeholder institutions to do a similar search to see if their lessons learned systems contain information that would of value to his/her project. The project manager, along with other stakeholders, should bring all applicable lessons learned to the attention of the stakeholders for consideration and possible incorporation into the existing project, other ongoing projects, or future projects.

Conclusion

Capacity building should not be a separate process, but should rather be an integral part of each capital works project. Regrettably, it has often not been considered during project planning, so budgets and schedules for capacity building actions have not been part of the project baseline. This has caused problems, for example when the need for capacity building has been recognized during the course of project execution or even as late as at the point of transfer of ownership to the operator of the infrastructure.

This chapter has aimed to provide engineering organisations with insight as to how capacity building can be effectively and efficiently planned into and integrated with a capital works project.



Step 5 Feedback and lessons learned.

This integration will result in a higher degree of sustainability for the infrastructure, fewer missed expectations on the part of all parties, and greater return on investment in the project.

Appendix 1 Special policy needs of developing nations

Appendix 2 illustrates how capacity building can enhance a capital works project in a developing nation rural area.

Appendix 3 discusses external funding and assistance sources that could be appropriate for capacity building.

Appendix 4 provides a checklist for evaluating technical capacity building plans.

Example:

Capacity building associated with capital projects

The following example illustrates how in the case of how capacity building was integrated in two major capital projects in South Africa. These two projects included a dam and a road in rural areas.

In these two cases the one concerned a major dam project in Mpumalanga and the other a major rural road of about 70 kilometres in the Eastern Cape that was upgraded to a provincial road standard. In this case the approximate project cost in 2007 amounted to R 360 million (US$ 80 million)

Extensive capacity building took place.

The capacity building associated with these projects inter alia included:

- Adopting schools along the route and doing civil engineering career guidance with the learners
- Limited adult based education and training in basic skills regarding numeracy, literacy and elementary life skills including training on how to handle personal finances and banking
- Providing on the job skills training for individuals
- Providing for a portion of the work to be so-called labour-intensive
- Micro, small and medium contractor development and pre-determining portions of the project to be allocated to the small enterprises
- Providing child care facilities for the females with young children to enable them to participate in the project as contract workers.

11. Additional generic capacity building areas

11.1 Introduction

Previous chapters include advice, drawn from the experiences of the international engineering community on a number of issues that would generally need to be addressed during the course of an idealised capacity building project. Alternatively, or in addition, the various issues that would need to be addressed in order to create or enhance an environment that is enabling of successful capacity building include:

- public policy;
- training and developing skills;
- participation in engineering and technology;
- building professional networks and support systems; and
- developing and implementing norms and standards.

The purpose of this chapter is to suggest and briefly describe additional generic areas where capacity could be built that would enhance or be mutually supportive of the capacity building measures hitherto described in this guidebook and therefore enable and develop an environment capable to support successful capacity building.

The generic areas are as follows:

- Incubation of pilot enterprises to promote selected development sector objectives;
- Nurturing and expanding the professional engineering work force;
- Increasing the engineering education and development research capacity;
- Enhancing international IT connectivity, in the interests of sharing information and facilitating collaboration.

11.2 The generic areas

Incubation of pilot enterprises

Capacity building and incubation of pilot enterprises in selected industries of national priority can promote development sector objectives. Initiatives in specific types of agro-industries, mining, manufacturing, or other natural resource preservation or harvesting can contribute measurably to improvements in employment and living standards. A collection of compatible initiatives can be aggregated to form a centre of excellence to receive priority attention from national governments and regional administrations. Capacity building and workforce development financing and investments should be closely calibrated with job creation and expansion of employment opportunities. Internal investment, development bank financing and bilateral partnerships for this area of capacity building require active engagement and competent management over several years.

Professional engineering workforce development

Support for professional engineering workforce development in nations particularly needful of this can, according to the circumstances, be provided by a variety of structures, including foreign agencies, including engineering societies in other nations, other national governments, and the private sector. In addition, intermediate term capacity building programmes to maintain and upgrade the existing base of professional engineering workforce in developing nations can be accomplished, sometimes with the help of IT. Examples of interventions or initiatives include :

Engineering societies of developed nations have training programmes, workshops and professional development courses that can be shared with partnering engineering societies in developing nations. Also, engineering society chapters in developing nations can be matched with national and regional chapters in developing nations.

National government agencies in developed nations have research and technology transfer programmes in various areas that offer training and technical resources to public sector professionals in regional and local branches.

Collaborative connections between professionals through IT can accelerate capacity building in

specific areas of need at relatively low cost. Access to journals, periodicals, books and manuals can be provided through a virtual library platform and other portals. Web portals can be established for technical assistance and information sharing with engineering societies and professionals in developing nations. Even where the broadband internet capacity of a developing nation is limited, information and resources can be provided on local servers and data storage devices.
Duplication of effort in developing codes, standards, professional development courses and accreditation programmes can be significantly reduced through collaboration.

External funding agencies can help to encourage and facilitate closer contact and interchange between developed and developing nation engineering associations through cooperation agreements.

Public sector engineering agencies at national, state and municipal administration levels in developed nations can be twinned with counterparts in one or more developing nations.

Capacity building in engineering higher education and research

Capacity building in engineering higher education and research can benefit from external funding and technical assistance. Developing nation investments, financing by development banks and foreign government aid for higher education and research infrastructure can be complemented with academic partnerships between universities within and outside developing nations. This can include collaboration in curriculum and course or programme development, research partnerships, sharing archival resources and laboratory facilities.

Increasingly, given growing investments in fibre optic trunk lines, microwave and satellite links, virtual libraries in developed nations can be made accessible to schools and universities in developing nations. Students across several universities can attend webinars in real time or on demand. Students and instructors can also access teaching materials from internet sites that offer open courseware. With strategic coordination of real or virtual fellowships, scholarships and sabbatical programmes; beneficial academic and professional interconnections for capacity building can be facilitated.

Information Technology infrastructure

Collaborations under a new paradigm for capacity building rely on availability of hardware and access infrastructure to broadband IT resources.

For example:

- There are now submarine trunk lines, connected to global networks, along large segments of the coastlines of all continents. These trunk lines have landing points for broadband connections to coastal and landlocked developing nations.
- Fibre optic based broadband internet or intranet service can be used to support capacity building initiatives.
- Many developing nations are geographically located along the equator and within the tropical belt. This global position is ideal for geostationary satellite coverage. Thus, at a relatively small fraction of comparable investments for physical infrastructures, satellite ground stations can be used to establish broadband connections to remote sites at relatively low cost.
- Sites that cannot afford satellite connection can establish local servers or use individual computers to run capacity building related programmes from storage media which relates to communication and liaison that need not be in the real time category but contact and gathering of information could be managed by means of utilizing information about capacity building programmes from material stored on tapes, CDs, DVDs and so on.
- Wireless reading devices and compact storage media, technical references, building codes, engineering standards, and training manuals can be organised and packaged for appropriate capacity building purposes.

Environmental concerns, production and distribution costs, convenience and ease of access all point to virtual libraries, electronic books, journals and engineering documents. IT systems or electronic system advances offer shortcuts for developing nations to invest effort and resources in new communication technologies as is best possible for capacity building. While there are inherent structural and systemic development challenges to overcome during the period in which broadband capacity expands and engineers of the internet age enter the profession, innovative and cooperative ways of implementing capacity building are becoming more feasible. Universities, engineering societies and professionals that are familiar with the challenges and opportunities of developing nations can fashion and implement capacity building programmes with their counterparts in these nations.

Partnerships must take advantage of the paradigm shift in communication capacity and information sharing that IT has made possible, and also the fact that the IT-based delivery cost is continually decreasing. Well-planned and implemented IT-based capacity building can be much more effective than traditional external funding and deployment practices.

12. Conclusion and way forward

Conclusion

Capacity-building is needed in order to assist individuals, communities, institutions and governments to develop secure, stable, viable and sustainable economies, governments, and other institutions through mentoring, training, education, physical projects, the identification and mobilisation of financial and other resources, and, most importantly, the motivation and inspiration of people to improve their lives.

A basic principle concerning capacity building is that it can only be successful if the following principles are applied:

- It must be focused on the purpose of improving capacity, and consequently on improving service delivery by those in whom capacity is being built and not be about building capacity for its own sake;
- It must address priorities before other needs;
- That the approach followed is appropriate to the needs of those whose capacity is to be built.
- That a systematic approach is adopted that adheres to the following structure:
  - to recognize and define the elements of capacity and sustainability as for example described in the six pillars model illustrated in Section 3.3, ensuring that these are always in place and "in balance";
  - to make sure that the following issues get attention:
    - identification of stakeholders;
    - assessment of requirements and identification of priorities for capacity-building (that is, priorities in terms of both what capacity to be built, and whose capacity to be built);
    - identification and mobilisation of entities for the building of capacity;
  - to ascertain to what extent it is necessary to address all three of the following, and to design the capacity building accordingly:
    - the level of the enabling environment,
    - the institutional level, and
    - the individual level;
  - to develop mechanisms for assessing:
    - assessment of the results of capacity building, including assessing in what way that capacity enhanced the

required improvements in terms of outcomes - e.g. not just that people are more skilled, but that they apply those skills, and that this brings about better results in terms of achieving whatever it is they are supposed to be doing;

- feedback, leading to continuous improvement in capacity;
- to be iterative in the sense that a first round of capacity building might be of a basic nature only, with each round successively raising the bar and/or addressing issues that have not been identified or covered previously.

Part of the assessment of the results of capacity building must be an assessment of its cost-effectiveness meaning that it has to be assessed whether the effort is justified by the improvement in, for example, service delivery If it was not, then capacity building was possibly not the highest priority, and some other way to improve service delivery should have been undertaken, and should rather now be undertaken.

Part of that assessment prior to deciding upon that capacity must be built should be an assessment of where the weakest link in the process or delivery chain might be. If the objective is to improve service delivery, for example, should priority attention go to capacity building or alternatively to some other link in the service delivery chain that is considered to be weaker.

If capacity building is for the purpose of supporting a project or programme of some sort, e.g. an infrastructure delivery programme, it must be integrated with the programme life cycle.

A suggested way forward

This version of the guidebook was launched at World Engineers' Week in Argentina in October 2010. A process is envisaged to receive comments relating to this first edition and to revise it in order to produce a second edition in due course. The complexities regarding Capacity Building and achieving sustainability in engineering terms are extensive and it is extremely difficult not to generalize. The drafting of this publication was a collaborative effort by a number of authors coming from vastly different and diverse backgrounds and therefore approaches may not be consistent , but the contributions and end product should be viewed as a first and pioneering initiative that should and must ultimately lead to higher ground.

It is envisaged that the guidebook will be utilised as a source of reference to assist the creation of common understanding, the improvement of decision making, the promotion and alignment of integrated and multidisciplinary modes of development, and the improved planning and implementation of development programmes and initiatives.

Not only would each developmental situation require capacity building specific to that situation, but each individual, community or institution significant to that situation would require capacity building appropriate to its own needs.

In a sense, the guidebook and its later editions will always have to be treated as «work-in-progress», and will never be «complete». Apart from soliciting comments on an ongoing basis, the CECB will be on the lookout for material to improve and expand the guidebook at some date in the future.

The compendium of programmes, projects and initiatives, at the time of writing in the course of preparation, will be only be a complementary resource, adding value to the guidebook. The compendium is however intended to be more than just a resource to be consulted. The intention also is that it will stimulate and facilitate exchange of ideas and programmes, and that an appropriate selection of these will be captured and added to the compendium. This exchange of ideas will also no doubt identify aspects that need to be covered and that will in turn hopefully stimulate the development of programmes and initiatives that could fill the gaps.

The compendium cannot therefore be a static document, but will need to be updated from time to time. Contributions will be promoted and encouraged. For this purpose, the compendium will ultimately most probably be in the form of an electronic database, hosted on the WFEO website at **www.wfeo.org**

References and acknowledgements

The CECB gratefully acknowledges the contributions of the small team of engineering professionals and their colleagues who gave generously of their time, expertise and experience. The CECB also acknowledges the professional institutions that made the services of these individuals available.

Please note that where possible due recognition is given to source material and sources where these could be identified other than that which represent original intellectual property as developed and contributed by the CECB team and their collaborators. Any omission or oversight can be communicated to the WFEO secretariat for rectification in further editions of this guideline

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Capacity building - reaching for the moon is not impossible

Appendix 1: Special policy needs of developing nations

Policies of developing nations, in particular, need to address the following issues:

- The need for multi-disciplinary graduates, since engineering professionals in developing nations need strong business acumen as well as technical skills
- An ongoing commitment and programme to retain engineering professionals and to promote and facilitate the return of citizens who have emigrated. Returning citizens bring with them foreign experience, network contacts and the ability to see new opportunities in their home nations
- The need to specifically consider the possible impact of disaster incidents. Developing nations generally lack the resilience provided by the greater capacities of more developed nations. For a simple local example, a lack of appropriate fire fighting systems, which could in the event of a disaster disrupt engineering services delivery. On the other hand, there is ample evidence of a lack of skills and capacity to deal with both natural as well as human-made disasters even in developed nations, which indicates that the need for capacity building is not necessarily confined to developing nations
- Risk management approaches as used in the developed world to isolate communities from risks, such as building levees to prevent flooding of urban areas, may not be affordable in developing nations. Thus alternative mitigation and alleviation measures must be considered
- The need, when developing policy plans, to establish what the appropriate affordable and sustainable technologies appropriate might be, particularly those to take cultural matters and the level of communities into account

Policies of developing nations need also to recognize issues such as the following, and for them to engage with developed nations in order to address these:

- One-sided tariff protection and subsiding, used by developed nations, are destructive in terms of building capacity in developing nations
- Tied aid type funding, funding intended to force the purchasing of services and goods from the funding nation, is not desirable. It can lead to the receiving nation not automatically benefiting in transfer of skills and knowledge, because, to the extent that the aid is tied, local participation is excluded. It might also be that local circumstances and the principles of appropriate and affordable infrastructure and standards may be ignored or disregarded. This in turn leads to serious problems with long term sustainability and development of indigenous capacity

Appendix 2: Capacity building on a construction project in a developing nation rural area

Using practical projects and development to build capacity is a powerful tool to add benefit to and enhance outcomes. It is often a by-product of any project in any case, but with some planning and possible limited additional funding the multiplying effects can be substantial.

The typical engineering project has a number of distinct phases including:

- Identification of need
- Feasibility study
- Planning
- Preliminary design
- Detail design
- Procurement
- Implementation which could be manufacture, construct
- Operation
- Decommissioning

Each of these phases has a potential for capacity building in various areas and formats, including:

- Technical skills
- Business enterprises
- Life skills
- Attitudes, including personal "ownership" and taking responsibility
- Needs identification by communities
- Social, community and personal development and growth as well as broadening of horizons
- Identification and utilisation of local resources
- Personal character building and gratification

The capacity building initiatives which are relevant, appropriate and practical in a project can be planned and designed into the project from inception right through the life cycle of the service or facility. The various phases of the project offer different capacity building opportunities and most of these can be designed into the procurement approach.

The following example of a construction project in a rural area of a developing nation can be used to further illustrate the principles. As follows:

Phase 1 - Identification of need

Local needs, expectations and anticipations require to be explored, which process could reveal other associated and non-associated needs. Also, opportunities to add value should be explored - these could for example include utilising stormwater runoff from a road to replenish local water resources, and quarries could become reservoirs for watering stock or food crops. During this process the research could be expanded into other areas, for example into household sizes and composition, educational levels, health and safety issues, social and cultural issues and so forth.

All of this could enhance the project design and construction as well as operation and maintenance. If for example the engineering team finds out during this process that the livestock in the area are free to roam, and therefore have to cross the road at any place, and in the absence of fences which are expensive to erect and to maintain, the sightlines on a new road can be designed to improve safety for vehicles and livestock alike.

If this community does not as yet have a set pattern for the location of local small shops and service centres, a road can assist in engineering a development corridor along which access for residents and communities, as well as the needs of through traffic, can be addressed in an integrated fashion. In such a case, after fact finding and analysis, both the engineering team and the community would emerge with enhanced understanding and decision making capacity.

Phase 2 - Planning

During the planning phase concepts should and must be tested and this phase can become an exercise of team and trust building for "both parties". Philosophies and "engineering figments of the mind" will become clearer for the community. During this phase one can also start to identify specific areas of need and opportunity for capacity building. Due to funding and constraints envisaged for the project, priorities will have to be identified.

Examples of capacity building during this phase could be:

- Training local community members for positions in the construction operation and maintenance phases
- Adult based numeracy and literacy education and training

- Career guidance for young people living in the area in association with schools
- Assistance with teaching and help for teachers and parents
- Facilitating the establishment or enhancement of micro, small and medium enterprises along the road which could supply from basic local produced foods to construction materials and so forth
- Health and safety education including HIV/AIDS
- Basic financial and budget training, for example how to access a banking system
- Technical support in local matters related to engineering – cell phones, solar power, wind mills, building practices, building materials for houses and other buildings

During this phase the preferred construction mode should be identified – for example labour based, "yellow" machine based, or any optimisation of labour and machine to provide for an injection of money into the local area by means of remuneration.

Another important aspect is to plan the way in which the local community would take ownership of the project in terms of risks, managing, caring, maintaining and using it with respect.

Aptitude testing can assist with getting the right local people to participate in the life cycle phases of the project. It has been said that since women has traditionally been the family member responsible for water in a household in many rural situations, that they may be best suited to care for a water facility.

Phase 3 - Detail design

During this phase, which would traditionally be done in "a controlled office" environment, regular feedback and opportunities for input by the community can assist with building relations and trust, informing amendments and alternatives, reducing risks, and in general getting a product better suited "best suited" to the local environment.

Phase 4 - Procurement

During this phase, transparency, equity value for money and good practice must prevail. This is the phase which often makes or breaks the project in many ways. Strictly controlled transparent and clean governance will not only enhance trust, but will facilitate ownership. This is also the phase during which anti-corruption measures should be agreed upon and introduced.

If a capacity building component is envisaged as part of contracts, adequate funding for this element should be provided, since

skills transfer operations would have a substantial influence on the execution of and the time required to deliver the project. Increased risks may be experienced as well and these should be identified, quantified and addressed. The ability of local firms to meet pre-qualification requirements to tender should be investigated and if necessary special arrangements may have to be made to ensure that these firms can tender.

Phase 5 - Implementation and or construction

A number of the principles mentioned previously apply. Feedback, reasons for decisions, and reasons for changes are crucial blocks in the building of trust. Support for local micro, small and medium enterprises set up to service the project is essential since the early phases of setting up a business are the most important.

Taking responsibility for the project remains an important issue. Skills development and skills transfer must be a major focus in this phase. Post-project skills could be identified for those who would be left "jobless" at the end of the implementation phase, and these skills could be put to good use in the long run.

For the main contractor and the trainers associated with the capacity building activities, there should be additional benefits from their efforts. One such benefit could be that, due to its acquired and accumulated expertise in the area of capacity building, this contractor becomes a preferred bidder in similar future projects.

During this phase it can be beneficial for experts associated with this project to either live on site or become regular visitors. This will in turn build their expertise, build trust and reduce risks to the project or associated with the project. Skills needed for the long term operations and maintenance should or could be developed in construction phase.

Opportunities should be taken during this phase to inform individuals and communities in close proximity to the project of the responsibilities associated with using engineering services, and of the value of adequate operating and maintenance standards. Career guidance opportunities at schools in close proximity to a project may enhance not only the future prospects for learners, but can also serve to assist parents and teachers to get a better understanding of engineering.

Phase 6 – Operation

How the project is operated and maintained is crucial for its long-term success in delivering the outcomes expected of it and for its sustainability. In capacity building terms, regular performance inspection during the life cycle of the project, and the ongoing further training of operators and/or maintenance crews, will greatly facilitate and enhance ownership. It will also ensure that those snags which inevitably occur do not develop further, and eventually threaten the facility or delivery of the services.

In addition, longer term performance assessment and monitoring assists in making decisions about the future. For example, if a road sign fades or show signs of excessive corrosion, alternative materials can be sought for new projects of the same design or in the same area.

In terms of operation it is crucial to observe whether the facility or product delivers what it was intended for. This contributes to future capacity for both the beneficiaries as well as the engineering teams in terms of technical and other decisions.

Ongoing governance in terms of budget provisions for operation and maintenance needs attention. For life cycle viability both the owner and beneficiaries needs to be provided with manuals for operations and maintenance and training is essential. Many projects fail due to "misunderstanding" of the designed performance parameters.

Provision should be made for periodic inspections by the project funder or owner to ensure that problems are identified and addressed and if necessary that refresher training for the operation and maintenance gets attention.

Communities often tend to think that engineering projects are built to last forever, or that they can

perform outside design parameters. Unintentional consequences can arise from misuse, or using the facility for the wrong purpose. As an example one can cite the problems associated with fuel spillages on bitumen surfaced parking areas at filling stations, or erosion of concrete due to high pH discharges from a facility like an abattoir. Information about the behaviour of materials is crucial for making the right decisions, and to assist communities to understand how facilities will perform and what would be harmful in any way.

Phase 7 - Decommissioning

All facilities get decommissioned at some or other point, even if this is long delayed thanks to periodic refurbishment or upgrading, or simply thanks to careful operation and regular maintenance. Building capacity to deal with decommissioning can assist to reduce effects and outcomes de-traumatise the situation.

The example of mining operations can be quoted. When Governments grant mining rights, they also need to build in life cycle issues, including decommissioning plans and guarantees. That means that informed decision-making capacity is necessary for Government, private enterprises and communities associated with such ventures. If proper capacity building is timeously developed to deal with the closing of mines, infrastructure could be preserved and put to different use. For example in areas where the water table has had to be lowered in order to permit mining, the rehabilitated mining areas could possibly become productive agricultural communities once water levels are allowed to rise again. On the other hand, toxic material may pollute water emanating from the mines, and needs to be treated adequately.

Conclusion

The opportunities to build capacity associated with projects are almost limitless. Circumstances may differ, but engineering projects and products have enormous potential, although it remains essential to identify capacity building opportunities that can be developed in each product or project.

The mobile phone revolution, which brought connectivity and an array of services to remote and underdeveloped communities in a very short space in time, is a living testimony to how much and how fast capacity building can advance.

Appendix 3: External funding and sources of assistance

A3.1 Introduction

This Appendix discusses sources of external funding and other forms of assistance that could be appropriate for capacity building.

By "external" is meant funding and assistance that is not sourced from the local area or local stakeholders among whom are the primary beneficiaries of the capacity building.

Finding appropriate funding for capacity building can be difficult for a number of reasons, which include:

The expectations and aspirations of capacity building institutions are often not understood

Related to that, the benefits of capacity building can be very difficult to measure

Related to again, many capacity building initiatives take a long time to show results

Funders are generally risk-averse. Some have had bad experiences, including that instances related to the stability and credibility of institutions, and to corruption and instances of misappropriation of funds. These inhibit the lending and granting of funds

Funders each have their own sets of rules, areas of interest and so forth.

In addition funds are often subject to stop-start conditions that play havoc with multi-year projects and programmes. This of course also applies to internally sourced funds, and not only to external funding.

Contributions from local communities that are partners or participants in capacity building should be considered, since buy-in is an invaluable and crucial component of any programme, and would usually enhance the success rate and improve the outcomes.

A3.2 Discussion and detail

External funding agencies seldom integrate their efforts. The institutions and agencies that provide funding, and also those that provide capacity building, are a diverse group, and often not only do not integrate, but might not even see the need for a common approach (e.g. common criteria for granting a loan). The need to develop generic approaches and to align and integrate effort has often been identified.

Results, outcomes and benefits of capacity building are very difficult to measure or quantify. In addition, most interventions take a long time to come to fruition and this complicates matters in a world where instant gratification is a way of life. To take the example of a career guidance initiative: if this starts at a pre-school phase, it will take the passing of a whole generation of learners - say twelve years - before it is possible to see any effect on numbers entering tertiary institution studies in engineering. The monitoring of the benefits in such a case becomes almost impossible if long term funding has nor been granted and if such monitoring has not been provided for in the business plan.

National governments and donor agencies provide funding according to priorities that they determine. At times, these priorities are influenced by perceptions of need, and especially of urgency. Thus, for example, disaster relief and humanitarian aid in times of emergencies tends to receive highest priority. A lesser, but nonetheless high priority, is usually accorded to development projects that show short-term results. In contrast, capacity building is seldom regarded by funders as high priority. Also counting against it is its intangibility -- the results of the building of capacity, and the return on funding investment, are notoriously difficult to demonstrate.

Although it should be, it is seldom recognized that there may be unintended benefits of capacity building projects. The visibility of and recognition for engineering professionals and

professional structures may be enhanced if they are involved in capacity building. This could in turn lead to building credibility, networks, understanding and enhanced decision making within communities.

The solution to some of these issues would be to develop a common approach that is underwritten by recognized international groupings of professional bodies, such as WFEO. This will bring a measure of trust, comfort and credibility that the funding entities, the capacity building service providers and last but not least the communities and target groups who take part in the capacity building initiatives, projects and programmes, perceive to be necessary.

An important element that is often overlooked is that capacity building is in essence a means to increase the abilities and resourcefulness of individuals, communities and institutions. This means that there should be very careful consideration when there is an offer that has characteristics of so-called "tied aid", in terms of which the provider [1] of funding, goods or resources may have an ulterior motive to benefit itself, and make the recipients of the aid dependent on it for a period of time. This could for example be by means of demanding exclusive use of its own human and other resources, equipment, goods or methods.

In the long term, the following factors, among many others, need to be considered and resolved:

- To ensure that funding agencies agree on using the same set of rules and principles concerning capacity building
- To ensure that WFEO, UNESCO and other bodies representing the engineering profession and associated groups agree on a set of rules and principles concerning capacity building, including a system by means of which applications for funding could be standardised before they are considered
- To get development banks and other funding entities to recognise the need for local content and participation in spite of increased risks that could be associated with such an approach
- To develop and maintain a database that lists:
  - providers of capacity building;
  - whether these providers are recognized within international benchmarking systems or are recognized members of international professional organisations such as the WFEO; and incorporates

1 This provider could be public or private sector.

- a checklist of the financial resources, expertise and capability required of providers before they can become eligible to provide capacity building

- To establish the longer term plans for individuals and organisations within which capacity is built, against the time when formal funding comes to an end
- To understand the role of the government structures and whether or why their support may be critical for a specific initiative
- To develop an information pack on each funding agency that will at least contain:
  - what types of project and what geographic regions the funding agency prefers;
  - the protocols of the funding agency that would address for example the allocation of tasks and responsibilities, how variations would be handled and what outcomes would be expected;
  - governance and decision making processes;
  - priorities and strategies followed;
  - risk assessment model applied;
  - requirements for accreditation or evaluation of the provider or applicant;
  - who the role players would be in terms of the funding agency principles and policy;
  - general information, including whether they do or do not favour multi-party projects
- To develop a system and protocols by means of which the viability, the appropriateness as well as the priority and sequence of programmes can be evaluated to ensure that there is a pragmatic and developmental approach that does not tempt funding agencies and providers of capacity building to take on "easy" or "high profile" initiatives for the sake of earning short-lived recognition

The different ideas suggested for allocating and using external funding for capacity building can be coordinated, and then tested with one or more developing nations. Technical information and resources assembled for a specific nation can be shared with other nations with similar challenges.

A3.3 Sources

The most likely sources of external funding for capacity building are development banks, aid agencies and possibly large foundations. Global partnerships for finding and using external funding for capacity building to promote long term sustainability and sustainable development can be adapted for individual nations or groups of nations.

In broad terms, funding and other forms of assistance for capacity building, if not from internal sources, can be externally sourced from international, foreign and local sources, including from investment banks, aid agencies, professional institutions, foundations, nongovernmental institutions, universities, engineering societies, private donations, private investment and other sources.

Each of the following possible external sources of funding and other forms of assistance for capacity building is briefly described below:

- **development bank loans and credits;**
- **foreign aid programmes;**
- **support by professional engineering societies and partnerships;**
- **support from the private sector;**
- **Other sources such as social corporate investment grants and levies for specific purposes**

Funding through development bank loans and credits

Table A3.1 lists major international development banks. The total capitalisation for these banks is of the order of US$0.5 trillion. The combined capitalisation of all the development banks, excluding the World Bank, is about 2/3 of the capitalisation of the World Bank. The World Bank has been a very significant source of external funding and extends development loans through the International Bank for Reconstruction and Development (IBRD). The International Development Agency (IDA) is a sub unit of the

Development bank	Affiliated nations	Capitalisation (%)
Africa Development Bank	78 (53 / 25*)	5
Asia Development Bank	67 (48 / 19*)	12
Inter-American Dev Bank	48 (26 / 22*)	22
Islamic Development Bank	56	2
World Bank	186 (168 IDA)	60
*from outside the region	Total	100

Table A3.1 - Major international development banks

World Bank and offers special low interest loans and credits to selected developing nations. The World Bank Group includes the International Finance Corporation (IFC), Multilateral Investment Guarantee Agency (MIGA) and International Centre for Settlement of Investment Disputes (ICSID) in addition to IBRD and IDA. IFC and MIGA are sources for foreign direct investments (FDI) into developing nation economies.

Development bank loans and credits for projects can include funding for capacity building, as shown in Table A3.2. The table is a summary of information for roads, health and education, management and economic support loans to six nations in Sub Sahara Africa over 10 years. About $2.2 billion or 35 percent of the total of more than $6.2 billion US dollars in development loans was provided for capacity building. Depending on the project and the specific request, the actual amounts of allocation to capacity building vary. On a per capita basis, the entire capacity building support varies from about $0.5 for Ethiopia to over $3 for Mozambique per person per year.
The other banks in Table A3.1 also extend development financing as loans and credits for nations in the respective regions. Capacity building engagements that are linked to infrastructure projects can be financed by developing nations through loans or credits from international banks and matching internal investment to meet foreign and local currency requirements.

Support through foreign aid programmes

Some developed nations have international aid agencies that administer assistance programmes to developing nations. A by no means complete list of major donor nations, aid agencies and links is provided in Table A3.3. Such aid programmes may be directed to special areas and to preferred nations or regions. The terms of assistance may restrict purchases and hiring of professionals to be from the donor nation. Prevailing political, historical or economic ties between nations may also influence the type and level of foreign assistance. Technical assistance under a bilateral agreement with a developed nation can be a basis for instituting a comprehensive programme of capacity building in a developing nation. External funding for capacity building through bilateral agreements likely require joint commitment and underlying common interests between the donor and recipient states.

Nation	Total loan (million US$)	Capacity building (million US$)	Capacity building (% of total loan)
Benin	246	95	37
Ethiopia	1743	426	24
Ghana	1725	634	37
Mali	579	211	36
Malawi	340	96	28
Mozambique	1619	749	46
Total	6,252	2,210	35

Table A2.2 - World Bank development loans to selected nations 1994 - 2005

Nation	Development aid agency	Link
Australia	AusAID - Australian Agency for International Development	www.ausaid.gov.au
Canada	CIDA - Canadian International Development Agency	www.acdi-cida.gc.ca
China	MOFCOM – Ministry of Commerce	http://mofcom.gov.cn/
France	AFD - Agence Française de Développement	www.afd.fr
Germany	GTZ - Deutsche Gesellschaft für Technische Zusammenarbeit	www.gtz.de
Japan	JICA - Japan International Cooperation Agency	www.jica.go.jp
Sweden	SIDA - Swedish International Development Cooperation Agency	www.sida.se
United Kingdom	DFID - Department for International Development	www.dfid.gov.uk
United States	USAID - United States Agency for International Development	www.usaid.gov

Table A3.3 - Major development aid agencies that may provide funding for capacity building

Professional engineering societies and partnerships

Professional associations in developing nations tend to be young, and to have limited infrastructure and financial resources. Engineering associations in developed nations and international societies can help engineering societies and professionals in developing nations with various capacity building and institutional activities. Engineering societies and professional institutions in developed nations publish journals; develop codes and standards as well as produce continuing education courses and training materials. Much of these resources can now be made accessible to corresponding engineering societies, educational institutions and institutions in developing nations through the internet. Members of professional engineering societies can also exchange views and experiences through discussion forums and group sites. Table A3.4 is a partial list of national and international associations that can provide assistance for a variety of capacity building partnerships with developing nations. Partnerships between technical associations and solidarity with engineering professionals can transcend political changes to help maintain continuity of capacity building programmes.

Support from other sources

In certain instances, government policy or legislation prescribes statutory contributions or impose levies to develop and promote capacity at various levels. In South Africa there are for example a number of such levies, grants and contributions that are aimed at accelerating transformation and opportunities for those whom has been defined as the previously disadvantaged population groups. One of these vehicles is called the corporate social investment contributions that can be accessed for certain types of capacity development, with very specific and defined purposes and groups. such as social corporate investment grants and levies for specific purposes.

Universities in developed nations have been investing in e-learning and distance education capacity over the past decades. Many engineering research and higher education institutions have staff members that have linkage to developing nations. Engineering students in developed nations participate in small scale capacity building initiatives in developing nations through internships and organisations such as Engineers Without Borders (EWB). Major universities in developed nations have established centres and study abroad programmes in developing nations. The considerable technical and human resources capacity at major universities, individually or as consortia, can support capacity building initiatives in developing nations. Through partnerships between universities in developed and developing nations, the productivity of investments in capacity building from other sources, such as banks and foreign assistance programmes, can be increased. Friendships and working relationships that form between engineering student participants can also follow into future professional careers through networking and as social media evolve and expand.

Professional engineering society or group	Link
ACECC – Asian Civil Eng Coordinating Council	www.acecc.net
ASCE – American Society of Civil Engineers	www.asce.org
AEF – Africa Engineers Forum	www.africaengineersforum.org/
ECCE – European Council of Civil Engineers	www.ecceengineers.eu
ICE – Institution of Civil Engineers	www.ice.org.uk
JSCE – Japan Society of Civil Engineers	www.jsce-int.org
SAICE – South African Institution of Civil Engineering	www.saice.org.za/
UPADI – Pan American Federation of Eng Societies	www.upadisede.org
WFEO – World Federation of Engineering Organizations	www.wfeo.org

Table A3.4 - Selection of engineering societies that can provide support for capacity building

Appendix 4: Checklist for evaluating technical capacity building plans

Current situation

1. What engineering programmes are currently producing graduates and how many are graduated each year, and is this consistent with other similar nations seeking to develop quickly
2. What systems are currently in place for the educational quality assurance of engineering programmes, and do these comply with internationally recognised accreditation systems such as the Washington, Dublin and Sydney Accords

Assessment

3. Is the number of engineering graduates sufficient for current and future needs
4. Is the current quality assurance system adequate for the nation's purposes, and appropriate for mutual recognition agreements in the global arena
5. What is needed to enhance current engineering programmes to global quality with reference to, for example, quality of staff and its leadership, computers, libraries, laboratories, workshops and other facilities, including venues for lecturing and practical demonstration.

Needs

6. If the number of adequately prepared engineering graduates is insufficient for current and future needs, what is needed to increase the flow with reference to, for example, additional schools or programmes, increased size of current programmes, more financial aid for students, and so forth.
7. If the quality of programmes and their graduates is below global norms for competitiveness, what remedies are needed with reference to, for example, developing an accreditation system.

Plans

8. If appropriate, what is planned to meet the need for increased quantity of adequately prepared engineering graduates
9. If appropriate what is planned to meet the need for increased quality assurance of engineering programmes
10. What plans are in place for retention of engineering and other graduates in the nation's public sector, and for professional development of those graduates, so that they make consistently appropriate policy and infrastructure-related decisions

Funding

11. What funding is required for the needed quantity and quality enhancements
12. What sources of funding are available with reference to, for example, government, development banks, industry, centres of tuition, and so forth.

Leadership

13. What is the timeline for execution of these plans
14. What evaluation and/or assessment mechanism will track progress, review results, and take steps to implement improvements
15. Who takes responsibility for execution of these plans

Appendix 5: Case studies and special issues

Whilst this Guidebook sets out to identify good practices, much can also be gained from case studies, particularly if these involve issues specific to a nation or a region. This Appendix presents a current collection of examples. The collection is not comprehensive illustrative rather than comprehensive. Future editions of the guidebook could include further and more recent case studies of that time.

A5.1 South Pacific

This case study illustrates how capacity can be built in island nations with small populations. In summary, the concept is to build capacity by an island-led but New Zealand-supported association of engineers, which is developing multi-lateral regional standards and approaches to overcome the issues of small population and geographic isolation.

The South Pacific region comprises two developed nations (Australia and New Zealand), one nation with a good size population (Papua New Guinea), and a further 15 or so island-based nations. The largest of the latter group is Fiji, with Samoa, Tonga, Vanuatu and the Solomon Islands all having populations of 100,000 or more. The remaining nations have small populations.

Typically, each of the nations (other than the first three) comprises a number of small islands in vast areas of ocean. Some of these islands are volcanic and have steep central mountains, whereas others have low elevation above sea level and are therefore at risk from the sea. Earthquakes and tropical cyclones impose significant natural hazards.

The nations, other than Australia and New Zealand, have long been recipients of international aid funding for infrastructural development projects. Many of these were completed to good engineering standards, if that was the requirement of the donor, but generally the expertise was brought in temporarily and no residual capacity building took place. In the last decade more private capital has become available, and a wider range of funding agents are offering assistance into the region, not necessarily with good technical standards enshrined.

The challenges differ in their importance from nation to nation, but in all cases the ability to tackle significant infrastructural issues like control of building standards, water supply and waste treatment, electricity supply, communications, ports and airports and roads are vitally important, while the technical capacity in each nation is below a sufficient critical mass to be able to develop and enforce technical standards. However, technically qualified personnel tend to be in capital cities on the larger islands, and in those locations have access to reasonably reliable broadband communications.

In 2008, the Institution of Professional Engineers New Zealand (IPENZ), recognising the needs of its closest neighbour region, invited representatives of the engineering communities in Samoa, Tonga, Cook Islands, Fiji and Vanuatu to visit New Zealand on a study visit, and then asked them to collectively identify their specific needs. The outcomes were then taken by the representatives back to their own nations and re-debated in their communities. There were teleconference report backs, and then a further face to face meeting at which the representatives re-worked the assistance model they felt they needed. At their request Papua New Guinea was brought in. IPENZ visited several of the nations to ensure that it could provide the package of assistance sought.

The outcome is that IPENZ is working with lead engineering institutions (or, in the absence of any institution, with selected individuals and/or organisations) to develop a regional approach, the goal of which is to support the improvement of engineering standards in the region.

The principles applied are:

- That a multi-lateral regional structure must be developed to achieve sufficient critical mass to provide a stable structure supporting engineers. Launched in 2009, this is now known as the South Pacific Engineers Association (SPEA). It will have national chapters, initially in up to six nations
- Decisions must be taken and led by a multi-national decision-making process through

participation from the affected nations, and not imposed from New Zealand. The Council of SPEA will have national chapter representatives, and New Zealand will attend, but without voting rights

- The role of IPENZ is to support local decision making with underpinning administrative support
- IPENZ will assist supply of engineering knowledge to island-based engineers through supply of its publications and development of short courses to tour the region, each co-developed by a regional engineer and a subject expert in new Zealand. This builds capacity for the future so the island engineers can eventually deliver their own CPD
- Where tertiary engineering education programmes exist IPENZ will act as an accrediting agent to assist the local engineering institution to make accreditation decisions, and support engineering education development, eventually leading towards international best practice as represented by the Washington, Sydney and Dublin Accords. The nations do not want inferior quality
- IPENZ will assist in development of regional competence registers, benchmarked to international best practice. Training of assessors will be conducted so that assessments can be made locally using support systems from New Zealand
- In due course, development of regional technical standards is envisaged, although this may need external funding. The goal will be to use local experts, working with a small number of New Zealand experts to develop relevant technical standards such as building codes
- SPEA and IPENZ will work collectively to influence governments through informing them of the initiative and how it will assist resolve issues
- IPENZ will work with SPEA to identify partners for government regulatory agents so that they can draw mentoring and support from an equivalent New Zealand institution.

As SPEA builds up strength, further South Pacific nations will be added.

A5.2 Oil-rich nations

This case study illustrates the building of a capacity in nations rich in natural resources but, other than directly related to the resource, poor in infrastructure development and in technical capacity.

Developing nations that currently are very wealthy thanks to significant oil production present a special case in building capacity for long term economic development. Many such nations have primarily focused their engineering education resources on current needs for petroleum engineers and related fields, and have neglected other areas of engineering.

Such nations need to develop strategic plans for the eventuality that their oil reserves will be depleted, when they will have to rely on other technical products and services to continue to flourish in the global competitive economy. Some of the current largess of funds should be invested in developing technical expertise in areas of long term potential, such as biotechnology, cybertechnology, nanotechnology, etc. Strategic investments should be made in the education of engineers and other technical graduates to develop such areas, and stake out future economic strength areas.

This strategic planning will require the collaboration of governments, universities, and commercial interests in the oil rich nations.

The leadership of Abu Dhabi in the United Arab Emirates has made such a strategic decision. Its Masdar initiative, a $15-billion commitment, is focused on future energy developments, including solar and wind, as a complement to its current favored position in petroleum. The initiative includes strategic investments and demonstration projects in alternative energy, a six square kilometre carbon-emission free demonstration city, and a new university to provide the human capital for future leadership in alternative energy and sustainability.

A5.3 Afghanistan

This case study illustrates the building of capacity in war-torn nations substantially lacking in both infrastructure development and technical capacity.

For many decades, the infrastructure in Afghanistan has been poorly maintained through neglect and the loss of professionals. This has, in the case of Afghanistan, been extremely aggravated by decades of conflict.

Afghanistan is not unique. Many other nations have suffered similarly. How to develop capacity and physical infrastructure without going through all the developmental stages that developed nations have undertaken over the last 40-50 years is a major challenge, and opportunity. There need to be effective ways to shortcut to state of the art technology and approaches, while ensuring that the skills to use and maintain it are firmly embedded in local stakeholders. Not embedding the skills and capability will lead to projects increasingly not achieving their objectives.

At a meeting sponsored by the American Society of Civil Engineer (ASCE), Society of Afghan Engineers (SAE -- an organisation of engineers in North America and Europe committed to the reconstruction of Afghanistan) and Kabul University, Julie Fraser, a senior financial analyst for the World Bank, said:

"Capacity building is something that we have struggled with in Afghanistan. The nation has had more than twenty-three years of civil conflict. A lot of good people left the nation, so you didn't have educational systems there. And now when we go back and try to reconstruct, especially in the first couple of years, there's a lot of tension in trying to get something on the ground quickly and build up the current institutions and the human capacity necessary to do that. So we've really been struggling with this quite a bit. But we're also trying to tackle these challenges in different ways. We're focusing on education – higher education as well as lower education. We're also working on a skills development programme, and within each sector we're working with various donors to try to integrate capacity building into programmes."

Over the last several years, ASCE has been working with the SAE to develop infrastructure projects than can promote economic growth in that nation. The ASCE, SAE and Kabul University initiative is a practical means of advancing professional knowledge and improve the practice of civil engineering, and foster technical training. The effort involves collaboration with Kabul University to provide a pilot round of training focused on engineering professionals working for Afghan

engineering firms. The goal of the project is to develop Afghan firms, and the capability of the University to deliver professional development, so Afghan engineering firms become effective partners in donor funded infrastructure projects. In 2007, SAE, ASCE and Kabul University held three 10-day workshops covering topics ranging from project management through to marketing engineering and consulting services. Expatriate engineers from SAE delivered the programme in Farsi and Pashto to their colleagues in Afghanistan. Over 60 professional engineers working for Afghan firms on World Bank, USAID and Asian Development Bank donor-funded projects have participated. There are calls for additional professional development, for engineering firms, key infrastructure ministries and skilled trades, to be delivered by Kabul University in collaboration with engineering professional societies in Afghanistan.

A5.4 Build Change

This case study illustrates, through the experience of an NGO, the difficulties presented by a number of common challenges -- and what the NGO is doing about some of them.

A non-profit organisation called Build Change trains builders, homeowners, architects and engineers to build earthquake-resistant houses in developing nations. It worked in Indonesia a process towards a programme in Peru was initiated for 2010. In post-tsunami reconstruction in Aceh Indonesia, it built 33 earthquake-resistant houses in partnership with local builders, improved the design and construction of over 4,200 houses in partnership with international organisations such as Mercy Corps, Catholic Relief Services, Oxfam International and International Organization for Migration, trained over 130 builders in an intensive on-the-job training programme, permanently improving skills and increasing wages, and trained over 245 technical high school students.

Build Change has developed a range of capacity building interventions focused on local engineers and architects, including hiring and mentoring local engineers, architects, and construction professionals directly. All staff are Indonesian except the founder, a graduate PhD engineer from Berkley. Build Change holds short seminars for local engineers on topics such as earthquake-resistant design and construction, building inspections, soils and site screenings; running week-long seminar and practical training courses for technical high school students; to doing intensive, on-the-job apprentice-type training for builders. For the technical high school student training, the end goal is to leave the curriculum with the school so that they can teach the course themselves in future years.

Build Change has been working in West Sumatra, in areas affected by earthquakes March and April 2007, using similar interventions for Aceh Indonesia. In addition, they are collaborating with the local university on experimental testing. Design guidelines are prepared in local languages, as well as translating useful resources on earthquake engineering from other nations, so they can benefit the local engineering community.

Challenges include the following:

1. Lack of building code enforcement as a direct result of lack of will, knowledge and corruption.
2. Lack of a clear code for simple, single story construction that is typical and preferred. Like many other nations, Indonesia has an international standard seismic code for multi-story frame structures, but no code for the common type of simple house built in rural and semi-urban areas. There is a growing global working group of engineers and academics promoting improved design and construction of confined masonry buildings, which is the structural system of choice for single family homeowners in many nations. This group will produce locally guidelines, training materials, and programmes for engineers and architects in nations in which this construction type is common. More information is available on the Earthquake Engineering Research Institute's World Housing Encyclopaedia website, http://www.world-housing.net/
3. Lack of selected knowledge within the engineering community. Not many universities teach specific concepts and skills needed for building design and construction in a developing nation. Few civil engineering schools have courses on masonry, and even fewer on adobe, two of the most prevalent construction materials. As such, there is a tendency for both foreign and local engineers educated at major national universities to apply techniques and design concepts to rural/single family houses that are too expensive to build or maintain, require materials that are not available in the local market, or are too difficult to build with locally available skills and tools.
4. Lack of resources in local languages.

A5.5 Southern Africa

A number of initiatives have been launched since 1990. SAICE has for example established a special structure that was looking after projects and programmes funded by government related funding. The initiatives include:

- Administration of bursary schemes
- Identifying potential students for engineering studies in deep rural areas under the name of 100X100
- Career guidance efforts to ensure an extensive outreach to previously disadvantaged learners in the form of Engenius
- Mentorship schemes for graduates and students in engineering under the name of ENERGYS and its successors

Other SAICE outreach efforts inter alia include

- Two extensive research project that culminated in two comprehensive publications
- An orientation programme for Local Authority councillors and officials to learn about infrastructure and related issues in order to enhance informed decision making
- An infrastructure Report Card similar to the ASCE and ICE models
- A number of other initiatives including Africa Engineers Forum workshops funded by UNESCO as well as by the RSA department of Water Affairs and Forestry as it was called previously, utilizing European Union funding.
- The UNESCO International Engineering Programme initiative
- Supporting capacity building in terms of initiating the Africa Engineers Forum in the middle nineties and providing the secretariat
- Providing human resources to participate in the WFEO Engineering Capacity Building and other committees and task groups and many other international events
- Contributing in terms of the perspective of a developing country at the ASCE International

Round Table

- Providing the Africa secretariat and organizing needs of the UK – Africa Partnership initiated by the Royal Academy of Engineering in the UK – a project funded by various donors. The focus is on Institutional and technical capacity building, initially in Sub Saharan Africa in collaboration with the Africa Engineers forum

Much is being done by other players in the field of capacity building in general but there is a general lack of integration and or co-operation and even collaboration. Serious challenges remain in all areas.

A5.6 Engineering for the Americas

This project, being carried out in conjunction with the Organization of American States, is focused on developing plans for enhancing engineering education and practice throughout Latin American and the Caribbean. The focus is on upgrading engineering education and on its quality assurance for that education.

A5.7 Engineers Without Borders - Africa

Working with Engineers Without Borders International (EWB), CECB organised a workshop in Cameroon in 2005 to stimulate interest in the formation and development of EWB cells in sub-Saharan Africa.