PUBLICATIONS OF THE ICMCS: Volume 5, Pages 29–50 (2012)

ISBN-978-37246-4-9. Printed in Nigeria.

Constraints and Prospects of Research Capacity Building for Engineering Undergraduates in Nigerian Universities

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ABSTRACT

Research is an organizational study, which is concerned with methodical investigation into a subject in order to discover facts, to establish or revise a theory or to develop a plan of action based on the fact discovered. Universities, as centers of knowledge production and generation play a critical role in national research by maintaining research infrastructures and standards in all existing academic disciplines, creating new disciplines, and building research capacity through training of new researchers and influencing university teaching. Research capacity building is the process of enhancing the abilities of individuals, organizations and systems to undertake and disseminate high quality research efficiently and effectively. It involves improving research skills, as well as access to research

information and resources. This study examines the constraints and prospects of building research capacity among engineering undergraduates of Nigerian universities. Based on the report of the last accreditation exercise of engineering departments across Nigerian universities, which showed that only 55% of engineering departments were fully accredited; the study identified the problem of low funding, poor curriculum design, lack of adequate industrial practice and the problem of staff qualification and experience as major constraints for effective research capacity building in the Nigerian engineering education sector. The study concluded by proposing a research capacity building framework for engineers that will assist in integrating research capacity building into the university engineering education curriculum in the country. The framework recommends improved funding of engineering departments, enhancement of university - industry relationship, renewed emphasis on industrial training, improved role of the accreditation bodies and changing of the licensing requirements for Nigerian engineers, as measures that will considerably improve the research capacity of engineering undergraduates.

Key words: research, capacity building, engineering education

1 Introduction

Research can be defined as the application of scientific methods of studying any problem, with the objective of gathering useable solutions to the problem. It is an organizational study, which is concerned with methodical investigation into a subject in order to discover facts, to establish or revise a theory or to develop a plan of action based on the fact discovered. It is the most important source of knowledge generation and occupies a critical position in promoting a nation's well being in the knowledge-based era (Etzkowtz et al, 2000). Research not only helps solve practical problems and bring about material improvements, it also provides insights and new ideas that enrich human understanding of var-

ious social, economic and cultural phenomena. It is also regarded as a major indicator of a nation's economic competitiveness for the present and the future. (Abbott & Doucouliagos, 2004; Creswell, 2008). Universities as centres of excellence and knowledge continue to play a prominent role in knowledge production, particularly in the pure and applied research fields (Guena, 1998). The importance of university research is twofold. Firstly, it is a strategic and long - term and contributes a fair share of effort and quality to a nation's overall research endeavours and secondly, the influence of university research is profound and penetrates into various sections, making it indispensable to the survival and development of any nation (Conroy, 1989). Some of the important role played by university research include maintaining research infrastructure in all existing academic disciplines and creating new disciplines, maintain the research standard and the nation's research excellence in specific areas, and training new researchers and informing university teaching (Conroy, 1989).

Given the central role university research plays in a nation's competitive capacity in the world's market and the prominent position it occupies in the nation's overall research efforts, research becomes an important component of a university's mission and a key indicator of its performance. In most countries, higher education is primarily government funded, so it is essential that university research fulfils the nation's research objectives (Ito & Brotheridge, 2007). However, it is research capacity building, the building of a nation's capacity to generate knowledge that is of central importance to countries all over the world (Conroy, 1989; Tanimoto & Fujii, 2003; Waworuntu & Holsinger, 1989).

Research capacity building is the process of enhancing the abilities of individuals, organizations and systems to undertake and disseminate high quality research efficiently and effectively (Trostle, 1992). It involves improving research skills, as well as access to research information and resources. Policy initiatives to build research capacity include support in developing research for

practice, where research is conducted by academics to inform practice decision making, research within or through practice, which encompasses research being conducted in collaboration with academics and practice, and research by practice, where ideas are initiated and research is conducted by practitioners (Mant, 1997 & Marks, 2000).

This study examines the constraints and prospects of building research capacity among engineering undergraduates of Nigerian universities. The paper then proposes a framework for effectively introducing research capacity building into the curriculum of engineering education in Nigeria. The paper is structured into five parts. The first section is the introduction, while section two discusses extensively the concept of building and sustaining research capacity in universities. Section three discusses engineering education in Nigeria and section four examines the constraints and prospects of building research capacity among engineering undergraduates and proposes the framework for its accomplishment. Section five concludes.

2 The concept of building research capacity

Research Capacity Building (RCB) is an approach to the development of sustainable skills, organizational structures and resources that enhances the ability of individuals, organizations and systems to undertake and disseminate high quality research efficiently and effectively (DFID, 2010). It is a useful process which can be seen as a means to an end, the end being useful research that informs improvement in the general quality of life and leads to social and economic development, by emphasizing developments in skills and structures which enables research to take place.

There are three levels of RCB, these are at Individual, organizational and institutional levels. At the individual level, it involves the development of researchers and teams via training and scholarships, to design and undertake re-

search, write up and publish research findings, influence policy makers, etc. At the organizational level it involves the development of the capacity of research departments in universities, thinks tanks and so on, to fund, manage and sustain their activities; while at the institutional level it involves changing over time, the 'rules of the game' and addressing the incentive structures, the political and the regulatory context and the resource base in which research is undertaken and used by policy makers. The goal of research capacity building is to facilitate individual and organizational learning which builds social capital and trust, develops knowledge, skills and attitudes and when successful creates an organizational culture and a set of capabilities which enables organizations to set objectives, achieve results, solve problems, and create adaptive procedures which enable them to survive in the long run.

RCB is a dynamic process that is often part of a broader developmental or change process. As a consequence it is difficult to plan in advance which steps will need to be taken, or in which order. Research has not indicated any single model or framework or set of approaches which is guaranteed to succeed in building capacity and improving performance. Nevertheless, recent research by the European Centre for Development Policy Management (ECDPM) has examined the factors that encourage it, how it differs from one context to another, and why efforts to develop capacity have been more successful in some contexts than in others. The outcome is an analytical framework and elements (Figure 1), which proposes an understanding of and approach to RCB. The framework shown in Figure 1 identifies capacity, institutional rules, the external context, external intervention and stakeholders as the key elements of RCB. In the framework, capacity comprises the sum of the capabilities of a group, organization or network; the ability of the group or organization to learn and adapt, and the performance of the organization in delivering good research and having an impact on policies and practice. Poor performance is often attributed

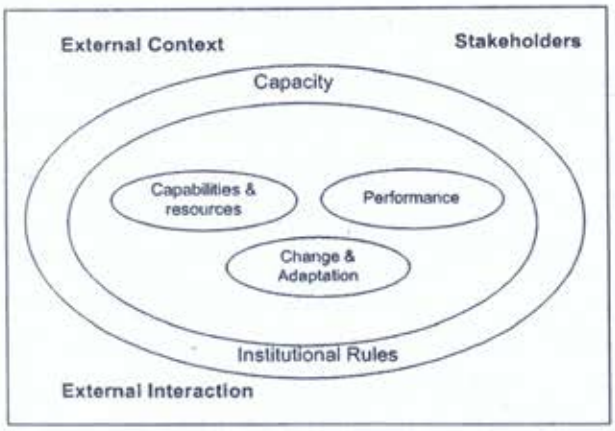

Figure 1: **Key elements to research capacity building**

to a lack of capacity. The ECDPM research encourages stakeholders to look beyond the formal managerial and systems capacities and identify other factors that drive organization and system behaviour. It identifies five core capabilities which enable an organization to perform and survive. These core capabilities are:

1. *To commit, relate and engage*: empowerment, motivation, confidence and the management of relationships.
2. *To carry out technical, service delivery and logistical tasks*: core functions directed at the implementation of mandated goals.
3. *To attract resources and support*: resource mobilization, networking, legitimacy building.
4. *To adapt and self-renew*: learning, strategizing, adaptation, managing change.

5. *To balance coherence and diversity*: encourage innovation and stability, manage complexity, and balance capability mix.

Also six basic principles have been identified as underlying the effective development of RCB. This includes building skills and confidence, developing linkages and partnerships, ensuring that research are close to practice, developing appropriate dissemination, investments in infrastructures and building elements of sustainability and continuity (Cooke, 2005). These principles are shown in Table 1 below.

In the development of RCB, a four step approach has been proposed (DFID, 2010). The key steps in the process are capacity assessment, strategic and plan implementation and monitoring and evaluation. This RCB process development proposed cycle is shown in Figure 2.

Table 1: Principles for developing research capacity

Principle	Statement
1.	Research capacity is built by developing appropriate skills, and confidence, through training and creating opportunities to apply skills.
2.	Research capacity building should support research 'close to practice' in order for it to be useful.
3.	Linkages, partnerships and collaborations enhance research capacity building.
4.	Research capacity building should ensure appropriate dissemination to maximize impact.
5.	Research capacity building should include elements of continuity and sustainability.
6.	Appropriate infrastructures enhance research capacity building

2.1 Capacity assessment

This step is primarily concerned with identifying the main strengths and weaknesses of the research and institutional framework at the individual, organizational and institutional levels. This first stage must start with an appraisal of

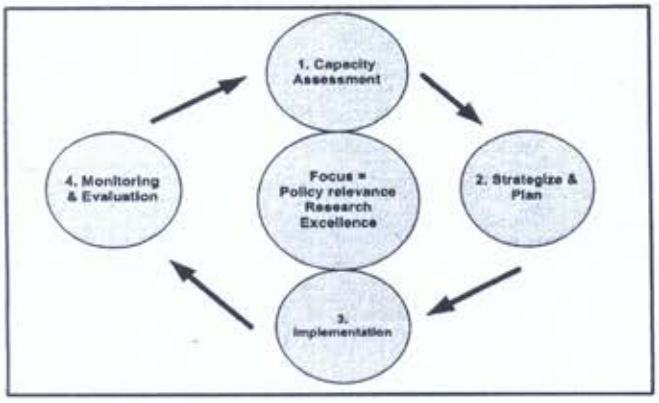

Figure 2: **The process of research capacity building**

the current research and institutional framework; it is an essential part of the inception phase. Such an analysis should focus as much on identifying assets, or areas of relative strength, as weaknesses. In general, it is easier to build on the former than to transform the latter. This analysis should include an assessment of the position at the three levels: individual, organizational and institutional, and should, as far as possible, be conducted as a collaborative exercise with key partners. RCB begins with a shared and explicit awareness of individual, organizational and institutional strengths and weaknesses in all partner teams and organizations. Table 2 shows the elements that should be assessed at the individual, organizational and institutional levels.

Table 2: Elements for capacity assessment

ELEMENT	CAPACITY ASSESSMENT
Individual	1. Training needs – Skills and Knowledge gap 2. Quality of Research Output
Organizational	1. Systems and Resources 2. Core Capabilities
Institutional	1. Stakeholder Analysis 2. Incentive Structure and "rules of the game"

2.2 Strategize and plan

This step involves planning the detailed activities required to deliver the programme outcomes; costs and timescales and monitoring and evaluation arrangements which will include organizational mapping and establishing a capacity baseline. Planning a CB intervention in a research environment should initially be structured around the desired outcomes from the programme. This requires taking each programme outcome and constructing a list of key activities to deliver the outcome. This approach can be accomplished in four steps namely:

Balance between results and process

The process approach to RCB must emphasize proper recognition of the centrality of learning, adaptation and power relations, as well as the need for performance. Performance is an indicator of capacity and without performance RCB is rather pointless. It is therefore necessary to seek a balance between the importance of process and the critical nature of results and outcomes in the approach.

Plan at individual, organizational and institutional level

The building of policy relevant research capacity needs to focus on all three levels to be effective. Most effort has traditionally been focused on individuals through training and scholarship programmes. However interventions which

increase the skills base of individuals and the resources of organizations are necessary but not sufficient; it is also necessary to encourage the development of an environment which both rewards and values research and also encourage the development of an environment in which research contributes to national policy debates. Also researchers should be encouraged to exert themselves beyond acquiring technical skills necessary to conduct quality research, to cover the full research cycle from fund raising and project planning through research design and delivery, (including writing up the research), to dissemination and policy engagement.

Build on existing assets

Planning should aim as far as possible to build on existing assets for research, including: human capital, organizational infrastructure and research networks and communities of practice. Thus assessment and planning should not just focus on weaknesses, but must also build strengths and support broader change in the research environment. This requires an approach which involves extensive peer collaboration to identify priorities for action.

Build an enabling research environment

High quality and policy relevant research emerges from organizational and institutional environments that encourage and facilitate good academic practice. This involves three main activities: research; professional training that leads to intergenerational transfer of research capacity; and participating in the life of a research community and in public debate. Each of these components requires organizational underpinning and institutional incentives. These might include resources such as libraries; and professional rewards such as international recognition.

The Output

At this stage there should be an Inception Report which must be approved by

government and/or the donor/sponsor agency prior to the continuation of the research programme. In this report, programme managers will be expected to outline a capacity building strategy for the programme.

2.3 Implementation

RCB is often thought of in terms of *machine building* – the bolting on of different parts to form a whole. Some elements of capacity (formal training, equipment, even managerial mentoring) can be supplied in this way, other less tangible elements such as ownership, identity, legitimacy and values cannot. Because RCB has to take account of politics and power relations, the process is as much about negotiation and accommodation as it is about the supply of resources and tangible assets. Thus in seeking to support RCB processes, it is vital that external actors are able to identify the factors that can stimulate or inhibit RCB; and which will differ from one context to another and which will evolve over time. The implementation stage must balance the requirement to build ownership, motivation, professional pride and respect for high research standards with the specific inputs and outputs identified in the planning stage.

2.4 Monitoring and evaluation

The same balance to be struck between *process* and *performance* that was highlighted in the planning and implementation stages, also needs to be present in *Monitoring & Evaluation*. RCB is not a stable target: people change and contexts change. The approach to M&E for RCB must be flexible enough to adapt to all the changes inherent in RCB, and must ensure that learning is captured. Thus consideration must be given to both organizational learning and external accountability requirements. M&E systems should be able take account of process as well as outcomes. At the same time, M&E systems need to be kept simple in order to avoid burdening organizations with complex and time

consuming demands that may lose support. M&E must start with the logframe. There are four key principles of this stage to appreciate from an M&E perspective.

1. *Logframe outcomes and indicators* must include *process* as well as *product* indicators to reflect desired changes in attitudes and behaviour as well as more tangible results.

2. There should be a clear link to the *baseline mapping studies* (i.e. what level of capacity existed when we started) carried out at the assessment stage. It must be possible to track changes in key indicators over time, even if direct causal links cannot always be made.

3. The *logframe outcomes and key indicators* should be reviewed as part of the inception phase and adjusted as necessary in the course of interventions. The iterative nature of CB must be reflected both in implementation and in a greater degree of flexibility in M&E approaches.

4. Methods of M&E should be evolved which respect the *partnership and ownership* ethos of the RCB approach. This means helping to develop a local M&E capacity and using methods which, as far as possible, involve internal actors as active participants in the M&E process. At the same time, participation is costly in terms of time, resources, skills and leadership; this dilemma leads to trade-offs between respecting the process and getting things done.

3 Engineering education in Nigeria

Engineering is the application of science for the efficient utilization of natural resources to produce wealth and as the application of the laws governing forces

and materials of nature through research design, management and construction for the benefit of mankind (Alabe, 2003).

In the training of the engineer especially at foundation levels i.e. levels one and two it is generally and globally agreed that mathematics, material science, mechanics and humanities must be taught (Weidman, 1990). Mathematics is the language of the engineer, while material science teaches about matter that when transformed, it becomes a reality. Mechanics is the toolkit for the engineer, while the humanities teach the engineer how to handle the complex relationship between man and machines much better. At the subsequent engineering levels, levels three to five, candidates pursue various fields of engineering with varying specialization. To serve as watchdogs and to gauge the performances of the engineering profession, two major bodies the National Universities Commission (NUC) and the Council for the Regulation of Engineering (COREN) has been carrying out accreditation visits to Nigerian Universities. While for the purpose of practicing, the licensing of engineers for practice is done by COREN and the Nigerian Society of Engineers (NSE). At the last major accreditation exercise conducted in 2007 by the NUC accreditation team, 90 engineering programmes were examined. 50 (55%) got full accreditation status, 39 (43%) obtained interim accreditation status and 1 (1%) obtained denied accreditation. For full accreditation a score of 70 and above, in addition to scoring at least 70% each in the area of staffing, academic content, library and physical facilities is required. For a programme to earn interim accreditation it has to score less than 70% in any of the 4 - core areas mentioned above. Those programmes with a score of less than 60% will earn denied accreditation status (Ramm - Yunu et al, 2008). The accreditation status of engineering programmes in Nigerian universities is also a reflection of the research capacity potential of many engineering faculties in the country. Other major factors which have severely constrained the development of RCB at the university level

of engineering education include:

3.1 The problem of low funding

Engineering schools in Nigeria are beset by: Inadequate staffing, Poor library facilities and inadequate facilities. These problems are directly caused by inadequate funding of the academic sector. Funding for Nigerian Universities has traditionally been from grants by governments and international agencies, research donations and contracts usually tied to specific projects, consultancy and other services rendered by the university, and endowments (Akintunde, 1994). The first generation institutions, with very large overheads and have existing facilities for teaching, are the most deeply affected by low funding. Whilst engineering education in Nigeria cannot be described as substandard, it is nevertheless inadequate to completely equip students to cope with the challenges of modern day society. The Government funding amounts are grossly inadequate to support existing staff, maintain infrastructure and facilities, much less embarking on new project which are capital intensive. Except, of course, such projects are funded by grants from international agencies.

3.2 The problem of the minimum academic curricula

Another problem hindering effective RCB in engineering education in Nigeria is the issue of curriculum design. The academic content of most of our engineering courses conforms to the minimum academic standards prescribed by the NUC. The approved minimum academic standard in engineering for all universities by NUC is quite adequate, but as the name implies, it is the minimum that is expected from the programme. The engineering education curriculum in Nigerian Universities should not be static but dynamic i.e. changing with time and relevance. The content should also be compatible with the expectation of the industry and society.

In the last accreditation exercise of the NUC and COREN; NUC observed very strongly the inadequate attention given to technical writing and presentation is not given the necessary and required attention in the academic content of most engineering programmes in the country. There are compelling arguments why engineers must be good communicators and write well; firstly, engineers do not work in isolation they work in teams, consisting of people with different professional background and knowledge and experience. They need to communicate the results of their work by writing, and hence must be skilful in writing to make their communication effective.

Engineering students are required in the course of their training to write various reports such as laboratory reports, essays, theses, projects and assignments, thus they must just not learn how to write but how to write very well, so that their communication will be effective. It is for these reason that just as any engineer needs to be good in mathematics in order to pursue their studies, they also need the rudiments of technical writing in order to write meaningfully and communicate well.

COREN in their accreditation report stated that even though the curriculum is adequate, it is apparent that most Nigerian engineering students are computer deficient. The council observed in some engineering programmes computer based design packages such as AUTOCAD are not taught in design programmes in some of our universities. Instead, where computers would be used in developed nations, some of our students continue to use drawing instruments. Even the instructors are not proficient in the use of computers. This is a deficiency in our engineering education, which can be linked directly to the lack of adequate funds for university and also exposes the need for curriculum revision.

3.3 The problem of student exposure to industrial practice

The leading qualities of a good engineer are technical ability, imagination and solid judgment. Technical ability depends on technical knowledge (Akintunde, 1994). Engineering education must impart technical skill as well as financial, communication and social/political skills. Early exposures of students to technical programme as well as developing their computer knowledge base will develop their creative thinking and technical skills, and help them understand easily what they are taught.

In Nigeria, engineering students gain exposure to professional engineering practice through the Student Work Experience Programme (SWEP) and the Student Industrial Work Experience Scheme (SIWES). These programmes constitute part of the requirements for the award of an engineering degree. The SWEP program is usually conducted within the students' local university at the end of the second year and lasts for about a month. The SIWES is an exposure to industrial practice. It runs for three months at the end of the third year plus a minimum of four and maximum of six months after the first semester of the fourth year.

Sadly, the universities have not gained the cooperation of industries in the SIWES programme. Students still find it difficult to get positions for industrial attachment and when they do, they are not properly supervised to ensure that they actually acquire knowledge as well as technical skills. This is partly because the industrial/manufacturing base in Nigeria is very low and also because of the reluctance of industries to allow their facilities to serve as training grounds.

3.4 The problem of staff qualifications and experience

Another major problem affecting the quality and RCB of engineering education in Nigeria is the low number of Senior Lecturers with PhD qualifications.

There exists presently in Nigerian universities, especially in the engineering faculties, an unhealthy situation where most of the academics belong to the junior cadre (Lecturer II, Assistant lecturers who are still learning the ropes) by virtue of their qualifications (having only Masters degree) and a small minority, of professorial rank, most of whom are fast approaching the age of retirement. Thus, a vacuum exists in the middle stratum, occupied by very few senior lecturers. How this vacuum came to be, isn't quite clear. However it is clear that if this situation persists, the standard and quality of engineering education in Nigeria will drop when the more experienced staff retires.

4 Proposed framework to improve research capacity building in engineering (RCBE)

Based on the above deficiency in engineering education, a framework is proposed for building research capacity in engineering education in the country. This framework is shown in Figure 3 below. The framework has two dimensions. The first dimensions represented by concentric circles represents the three structural levels at which RCB is developed at the individual, departmental and institutional context within the overall framework of the policy context of government, institutions and regulating bodies. The second dimension represents the five major areas of intervention to developing RCB. These are improved funding, enhancing university - industry relationship, industrial training, improved roles of accreditation agencies and changing of the licensing requirements for engineers. This are discussed further.

4.1 Improved funding

Inadequate funding is a most serious problem. The Science and Engineering programs at Nigerian universities feel the pinch more than others because they

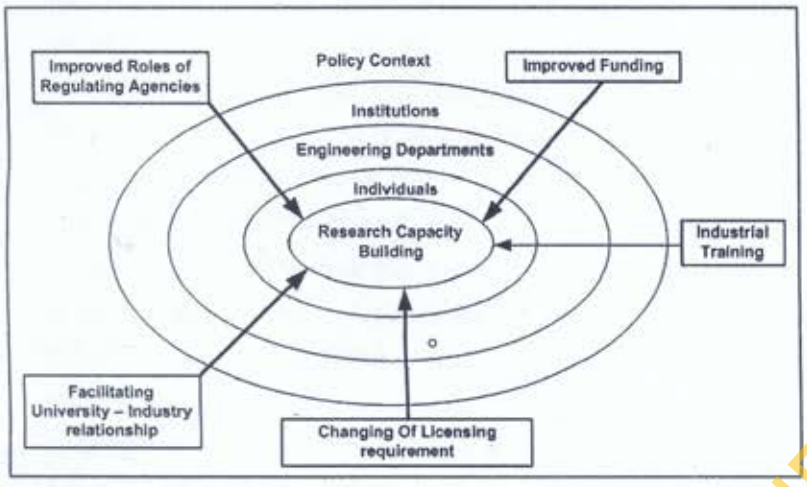

Figure 3: **Proposed framework for developing RCB in engineering departments**

depend on laboratory, workshop and industrial activities. The Direct Laboratory and Teaching Cost (DTLC) which is used for funding the maintenance of equipments in laboratories and workshops is a step in the right direction. However this is not enough there is need to augment funding of all laboratory and workshops through special interventions by the Tertiary Education Trust Fund (TEFF). The fund will take care of updating as well as maintenance of current facilities. Also COREN, NUC and the Federal Ministry of Science and Technology should also work out modalities and proposals for the increased funding allocation to DTLC of engineering programmes and overall engineering programmes in our universities.

4.2 Enhancing university-industry relationship

Government policy must be directed towards removing obstacles such as the small industrial base and the unwillingness industrialists to cooperate with

the SIWES and SWEP programmes. Another benefit of university-industry partnership is in the area of staffing. A system could be developed to enable practicing professional engineers from industries to serve their community in academia, even if only on a part-time basis. This could be a way of filling the midcareer- stratum vacuum identified above. If experienced engineers can be convinced to work at the university, they will add their wealth of professional and practical experience to the development and improvement of engineering education . Universities are also expected to aggressively seek industry-university cooperation. Such partnerships are expected to enhance the relevance of universities to both students and to the nation more generally. It is thought that industry collaboration will enrich lectures with practical real life problems of contemporary importance, as well as providing much-needed revenue (Tener, 1996, Videon, 1996).

4.3 Industrial training

The SIWES programme should be reviewed and critically assessed with a view to make it more effective and dynamic, It requires periodic review if it has to serve the purpose for which it was created. Also industrial attachment for engineering staff should also be considered and encouraged. Staff members are expected to use their semester breaks and part of their leave periods to acquire some industrial experience.

4.4 Improved role of accreditation bodies

Accreditation bodies are currently playing a wonderful role in the regulating of engineering education in the country, it is suggested that there should be follow up on regular basis on recommendations made to ensure compliance before the next exercise.

4.5 Changing the licensing requirements for Nigerian engineers

In Nigeria, licensing of engineers is done by the Council for the Regulation of Engineering in Nigeria (COREN) and the Nigerian Society of Engineers (NSE), the regulatory bodies for the Engineering profession in the country. The process entails the presentation of a written report on relevant post-graduation work experience and an assessment by examination. There is need for a new licensing model. COREN and NSE should consider the possession of a Masters degree in any engineering program as an alternative requirement for licensed practice, apart from further examination as the sole route to licensure. This of course, would only be possible if our universities are able to satisfy accreditation requirements and our engineering students graduate from COREN and NSE accredited programmes, which would provide necessary and sufficient evidence of educational preparation.

5 Conclusion

The paper explored extensively the concept of research and research capacity building, and discussed the process of developing research capacity building at the individual, organizational and institutional level. The paper also examined engineering education in Nigeria in relations to its research capacity potential and asserts that the accreditation status of engineering departments is a reflection of the research capacity status. The paper thereafter identified the factors that have constrained development of research capacity in engineering departments and concludes by recommending a Research Capacity Building in engineering department framework for the improvement of research capacity in the engineering education sector of the Nigerian university system.

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ISBN-978-37246-4-9. Printed in Nigeria.