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Engineering Graduates & the Practice of Construction Management

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Abstract
The education and training of civil engineers in South African universities, and internationally is done with the full intention of impacting knowledge and understandings that could spur graduates to contribute significantly to the physical transformation of the environment through innovative designs and construction. However, the practice of construction management by civil engineering graduates requires general management skills and core competencies central to the ability to manage construction projects and businesses successfully. The principal theme of this discourse is concerned with the need to examine the adequacy of construction management related education and training that civil engineering students and graduates are exposed to in South African universities. Through document analysis in terms of university curricula examination and a survey conducted among fellows of the South African Institution of Civil Engineering (SAICE), salient issues were identified. The research outcome identified gaps in teaching / curricula that could further develop the ability of civil engineering graduates to become astute construction managers, especially in a developing country context. Such gaps pertain to knowledge, skills and core competencies required for both business and career ascendancy in the field.

Keywords
Construction Management, Developing Countries, Education and Training, South Africa

1. Background

After conceptual and design phases, construction is the realization phase of the civil engineering process. In the process, the primary role of contractors is to turn the ideas of clients and the detailed plans of designers into physical reality. For the process to be considered successful, the reality has to meet the expectations of the end users - the general public. Thus, civil engineering construction projects are complex activities that require the interaction and cooperation of many different professionals for the accomplishment of stated goals (Hancher, 2002). All civil engineering construction projects are however unique because of different elements that are not limited to soil type, exposure to weather, socio-economic climate, human resources assigned to projects, and so on. In other words, proficiency in terms of the practice of construction management is essential for civil engineering graduates that are directly involved in physical construction project realization and the business of construction.

As illustrated in the literature, the practice of construction management can be viewed in two dimensions, the management of projects and the business of construction (Smallwood, 2006). Whereas the latter is on-

going, projects are unique, they are temporary in nature, involve the establishment of a team, and require the attainment of specific objectives and goals (Forbes and Ahmed, 2011). The achievement of such goals and others that are specific to each project is reportedly becoming a challenge in South Africa (Emuze and Smallwood, 2011). For instance, Construction Industry Development Board (CIDB) reports pertaining to quality (CIDB, 2011) and H&S (CIDB, 2009) conclude that there is a major scope for performance improvement. Central to the improvement is the knowledge (information regarding content) and skill (ability to perform a task) of those charged with project delivery responsibilities (Sanghi, 2004).

2. Rationale for Management Know-hows in Sub-Sahara Africa

It is estimated that sub-Saharan Africa's population will grow from 800 million people in 2007 to reach 1.5 billion people by 2050 at an estimated 2.3% rate (Population Institute, 2011). Population growth with increasing urbanisation will therefore require increased investment in basic infrastructure that are unlimited to roads, airports, water supply and sanitation, housing, hospitals and so on (Wamuziri, 2012). The construction of such infrastructure projects will depend not only on a substantial injection of funds, but also it will rely on a steady supply of the right quality and numbers of experience civil engineers and civil engineering graduates (Wamuziri, 2012).

Such arguments indicate the extent of the impact that the practice of the civil engineering profession has on the infrastructural transformation of the region. Because civil engineers can play multiple roles (as clients, contractors, designers) in public sector projects, the effect of their expertise on project delivery cannot be over emphasised. In other to avert future problems and also to stem the tide of project failure and / or poor performance, the expertise needed must henceforth be developed. The past works of Flyvberg *et al*. (2003; 2004) show the extent of the need to improve performance in developing countries. This is where the role of the civil engineering education and training becomes critical to business competitiveness and socio-economic development in developing countries.

The major theme of this paper is concerned with the need to examine the adequacy of construction management related education and training that civil engineering students and graduates are exposed to in South African universities. The purpose is not about questioning existing curricula in tertiary institutions, but rather, it is about being up to speed with emergent knowledge and skills that will benefit civil engineering as a profession that is vital to the infrastructural development of South Africa.

3. Methodology

Through an exploratory survey conducted among selected Fellows of the South African Institution of Civil Engineering (SAICE) and document analysis in terms of university curricula examination, salient issues were identified. Because universities and university of technologies act as the pipeline for the supply of new civil engineering graduates for the industry, the existing undergraduate curricula (management related) were examined and analyzed, so that identified gaps can be tied together.

The sample stratum was surveyed per NMMU online survey portal using a semi structured questionnaire consisting of eight questions. Seven of the questions were close-ended and one was open-ended. Four of the seven close-ended questions were five-point Likert scale type questions. The method was used for data collection because the Fellows of SAICE are geographically dispersed in the country. The 22 responses that were received after two months were included in the analysis of the data. The descriptive statistics, namely a measure of central tendency in the form of a mean score (MS) and the Cronbach's Alpha were computed. Standard deviation's 'rank differential' rule was used whenever a tie occurs among more than one MS in a table. The rule dictates that the MS will the lowest standard deviation is ranked higher than others. The four principal questions used to elicit information from the Fellows include:

1. Using a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), rate civil engineering graduates in terms of their knowledge and skills relative to the following functions in a contracting organisation in the civil engineering sector [please insert a rating or number in each cell: if you are 'unsure', then insert a 6].
2. Using a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), rate civil engineering graduates in terms of their use of the under listed knowledge areas when managing projects and / or businesses in the civil engineering construction sector [please insert a rating or number in each cell: if you are 'unsure', then insert a 6].
3. Using a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), rate civil engineering graduates in terms of their skills relative to the respective functions of management work in terms of their overall management of standard resources in construction [please insert a rating or number in each cell: if you are 'unsure', then insert a 6].
4. On a scale of: 1 (minor extent); 2 (near minor extent); 3 (some extent); 4 (near major extent), and 5 (major extent), rate the extent to which the following core competencies could contribute to success in terms of the practice of construction management in the civil engineering sector [please note the 'unsure' option].

The data were considered enough for analysis despite the few responses received because the goal of the field work was not to generalize widely at this stage, but rather, it was done to come up with perceptions (that could be construed to be credible) from experienced civil engineers in South Africa. The sample stratum was therefore purposively compiled. Purposive sampling is a procedure in which the research samples whoever he or she believes to be representative of a given population (Springer, 2010: 107). The background information provided by the respondents indicate that 19 of them have worked and / or are working on transport related projects (roads, ports, harbor); 17 of them have experience in storm water and water treatment plant related projects; and 15 have been involved in other non-residential construction projects. These suggest that all the respondents have varied experiences in the South African infrastructure sector. When asked to indicate the kind of organization that they have either worked for or working for, the responses show that 6 have acted / are acting for employers, while 13 have worked / are working as consultants. It was also observed that only 5 of the respondents have extensive experience as a contractor in the industry. The length of industry experience that the respondents indicated corroborated their status as Fellows of the SAICE. In particular, 18 of them revealed that they have more than 21 years of work experience in the industry.

4. Findings of the Survey

Table 1 indicates that the reliability of scale relative to the question used to examine the rating of civil engineering graduates in terms of their knowledge and skills. The question achieved a Cronbach's alpha score of 0.88 and average inter-item correlations of 0.48 (Q1). The table also show that the Cronbach's alpha coefficients related to knowledge areas (Q2), functions of management work (Q3) and core competencies ranged from 0.86 to 0.91. In effect, the questions achieved reliability of scales that ranged from good to excellent according to the rules of thumb proposed by George and Mallery (2003). This is based on the premise that the closer Cronbach's alpha is to 1.0, the greater the internal consistency of the items in a scale, that is, the higher the alpha coefficient, the more reliable the test (Yu, 2001; Gliem and Gleim, 2003).

Table 1: Reliability statistics

Test	Questions			
	Q1	**Q2**	**Q3**	**Q4**
Average Inter-Item Correlations	0.48	0.43	0.55	0.53
Cronbach's Alpha	0.88	0.86	0.91	0.89

Given that none of the functions in a contracting organisation in the civil engineering sector attain a mean score (MS) rating greater than 3.00 in Table 2, it can be assumed that the respondents were of the opinion that the knowledge and skills exhibited by civil engineering graduates in terms of the functions ranges from very poor to poor. Although 'production' and 'administration and IT' were ranked number 1 and 2 respectively, their MSs suggest that the performance of civil engineering graduates as evident in their perceived knowledge and skills is below average. Functions pertaining to human resources, marketing and legal received the lowest ratings. As mentioned earlier, using a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), the respondents were asked to rate civil engineering graduates in terms of their use of certain knowledge areas when managing projects and / or businesses in the construction sector (Table 3). It is notable that with the exception of productivity that was ranked 1st on the table, the MSs for the other areas suggest that civil engineering graduates are perceived not to have average / above average knowledge of what is required to manage projects and / or businesses in construction. Most importantly, the respondents were of the opinion that graduates are lacking in knowledge concerning how to manage subcontractors, documents, and clients.

Table 2 Rating of Civil Engineering Graduates in terms of their Knowledge and skills

Functions	Production	Administration and IT	Purchasing	General management	Financial	Public relations	Human resources	Marketing	Legal
MS	2.85	2.70	2.35	2.30	2.20	2.10	2.05	1.85	1.75
Rank	1	2	3	4	5	6	7	8	9

Table 3 Rating of Civil Engineering Graduates in terms of their Knowledge areas

Knowledge areas	Productivity	Construction methods	Planning and scheduling	Quality management	Contract administration	Cost control	Client / customer service	Contract documentation	Subcontractor management
MS	3.05	2.85	2.70	2.60	2.60	2.55	2.40	2.30	2.05
Rank	1	2	3	4	5	6	7	8	9

Furthermore, Table 4 indicates how the Fellows rated the graduates in terms of their skills relative to the respective functions of management work concerning their overall management of resources in construction. The ratings that were based on a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), suggest that the skills of graduates were mostly either average or below average. As indicated on the table, none of the resources to be managed achieved an MS greater than 3.00. This suggests that in general terms, the respondents were of the view that civil engineering graduates were not performing well when tasked with the management of these standard resources. For instance, 60-80% of the respondents rated the skills of graduates relative to the management of manufacturers, finance, suppliers and subcontractors to be either poor or very poor. It was also observed that with the exception of information (5%), none of the respondents rated the management of the other resources as excellent

Table 4 Rating of Civil Engineering Graduates in terms of their skills relative to the functions of management work

Resource	Functions of management work						
	Very poor	Poor	Average	Good	Excellent	MS	Rank
Information	5.0	20.0	55.0	15.0	5.0	2.95	1
Materials	5.0	20.0	55.0	20.0	0.0	2.90	2
Plant and equipment	5.0	30.0	50.0	15.0	0.0	2.75	3
Labour	5.0	45.0	45.0	5.0	0.0	2.50	4
Manufacturers / Fabricators	0.0	65.0	30.0	5.0	0.0	2.40	5
Finance	5.0	60.0	30.0	5.0	0.0	2.35	6
Suppliers	5.0	65.0	25.0	5.0	0.0	2.30	7
Subcontractors	15.0	65.0	15.0	5.0	0.0	2.10	8

Table 5 shows the extent that the respondents perceived that core competencies could contribute to success in terms of the practice of construction management in the civil engineering sector in South Africa based on the scale mentioned previously. It is notable that all the MSs are greater than 3.00, which suggests that in general the competencies can be deemed to be vital to the practice of construction management in the civil engineering sector. A closer look at the MSs provides additional information concerning the ranges of the results. It was observed that the Fellows rated team player among the traits; attitude among self-concept; and the preservation of personal integrity as a motive higher than the other core competencies. The perceptions expressed suggests that the ability to function as a team player while displaying the required attitude that is rooted in the preservation of personal integrity could significantly and / or majorly contribute to success in the construction management domain.

Table 5 Core Competencies and successful construction management

Core Competency	Unsure	Minor……..…….……..Major					MS	Rank
		1	2	3	4	5		
Self-concept:								
Values	0.0	0.0	0.0	52.6	21.1	26.3	3.74	5
Aptitude	0.0	0.0	5.3	31.6	47.4	15.8	3.74	4
Attitude	0.0	0.0	0.0	35.0	25.0	40.0	4.05	2
Self-image	0.0	0.0	0.0	52.6	36.8	10.5	3.58	9
Traits:								
Self-confidence	0.0	0.0	10.0	30.0	40.0	20.0	3.70	6
Team player	0.0	0.0	0.0	15.0	60.0	25.0	4.10	1
Handle ambiguity	0.0	0.0	0.0	52.6	42.1	5.3	3.53	10
Motives:								
Focus on client success	0.0	0.0	5.3	42.1	31.6	21.1	3.68	7
Preservation of organizational integrity	0.0	0.0	5.3	47.4	21.1	26.3	3.68	8
Preservation of personal integrity	0.0	0.0	10.5	31.6	21.1	36.8	3.84	3

4.1 A Brief Overview of the Civil Engineering Undergraduate Curricula

Civil engineers and the education that they received, either formally in higher educational institutions or informally at work places, have contributed significantly to the development of infrastructure in South Africa. A desktop investigation revealed that approximately 23 publicly backed higher institutions in South Africa form the pipeline for the provision of civil engineering graduates in the country. Of the numerous undergraduate modules that are currently offered at these institutions, the module entitled

'project management' or / 'engineering management' seems to address elements of construction management. Such modules are also included in the national diploma programs that extend over three years at the comprehensive / technology universities in the country.

However, in most cases the scope of the syllabus can be deemed to be high on overview of project management, project scoping and organization, planning and scheduling of projects, costing and cash flow, productivity and work study, and project procurement and control. It is notable that the management related course only addressed issues pertaining to surface competencies. Although job performance and competence, the sources of competency models, teamwork and conflict management form aspects of the management course delivered at the BTech level in one of the comprehensive universities, the amount of information disseminated were limited. Without prejudice to the intent of the analyzed documents, the visual analysis shows a strong support for the notion that certain knowledge and skills failed to capture the attention of tutors and therefore limits related learning among the students

4.2 Contextualizing the Views of the Surveyed Fellows of SAICE

When the findings of the analyzed documents were triangulated with the perceptions of the Fellows of SAICE as presented in the two previous sections, it was discovered that the findings corroborated each other. Given the fact that students are limited in terms of surface and core competencies that forms part of their undergraduate syllabi, it is clear that they need to improve and develop a variety of skills when they graduate. Although as they gain experience, management expertise can be further developed, the mere fact that the foundational knowledge may be lacking poses a challenge to the industry and the graduates. Students that undertake construction management programs are often exposed to significant amount of learning endeavors that emphasize people skills, either in the form of surface competencies or core competencies (Smallwood and Emuze, 2011). However, this is not the case for civil engineering graduates. The situation potentially marginalize the graduates in that while they may be quick to become adept at resolving technical problems within the first 10 years after graduation, their ability to manage people may become an uphill task for a long time. Because of the importance of core competencies and surface competencies that is supported by the construction management literature, it can be argued that the enhancement of the civil engineering curricula in this regard should be considered by stakeholders. Since the ratings of civil engineering graduates in terms of knowledge, skills and certain knowledge areas, especially their ability to perform concerning the functions of management work, can be deemed to be below expectations; their education and training should be deliberated upon by all concerned parties.

This will require the balancing of the throughput from higher educational institutions in South Africa in terms of quality and quantity. In effect, as rightly opined by one of the respondent, civil engineering graduates are expected to be good managers from day one after spending time in non-supervisory roles to learn appropriate construction procedures and people skills. For example, people skills are useful when involved in public sector project execution either as clients, consultants or contractors. According to Aritua, Male, Bower and Madter (2011), the intelligent client should essentially be capable of specifying its requirements to external participants and managing the delivery of outcomes. Aritua et al. (2011) contend that in public sector infrastructure projects, the intelligent client should be able to maximize value from the private sector by managing the relationships and increasing the value that is added by the private sector partners. In other words, problems in procurement and constraints on infrastructure projects require the intelligent client to think through the balance of competencies needed to obtain value for money (Aritua et al., 2011). Rethinking the civil engineering curricula is important as the post-modern view contend that technical solutions are not absolute, uncertainties are present and the engineering solution is often a compromise that involves wider issues, that is, civil engineering graduates should be able to recognize uncertainties and then consider the wider impact it has on engineering projects (Mills, 2011).

In the South African context, a 2005 research project has presented an overview of the educational offerings and experiential training in construction management and civil engineering at Universities of Technologies. In order to achieve a global perspective of the current position relative to educational

offerings and experiential training, model preference, continuing professional development and professional registration, construction management courses at universities of technology, civil engineering courses at universities of technology and participation in construction, the study by Haupt et al. (2005) was contextualised against international experiences as extracted from a review of international literature and study visits. Haupt et al. (2005) further indicates that civil engineering academic departments needs to significantly improve delivery in the subject Communication Skills given its importance in the transfer of knowledge and the language of communication in industry. They also contend that it was evident that the content driven subjects Construction Materials, Construction Methods and Management needs attention. There may therefore be opportunities for extending the integrated teaching approach to these subjects so that students improve their communication skills in the context of the discipline.

5. Concluding Remarks

The need to examine the adequacy of construction management related education and training that civil engineering students and graduates are exposed to in South Africa formed the basis of this discourse. Through a survey conducted among selected Fellows of the SAICE and curricula analysis, it was observed that the practice of construction management by civil engineering graduates may be marginalised by certain core competencies that are central to the ability to manage projects and businesses successfully. Thus, given that the environment within which civil engineering construction management is practiced undergoes changes constantly, the debate about the content of civil engineering undergraduate courses either in terms of the physical construction of infrastructure should be an on-going concern. It is hoped that this exercise shall take the debate further and contribute to the improvement of civil engineering education and training in South Africa because civil engineers should not only be technically adept, but also, they should become astute managers of people. Bridging the identified gap in curricula could further enhance the practice of construction management among civil engineers in South Africa. Thus, civil engineering education in developing countries has to rethink pedagogy and undergraduate curricula so that the education and training of future civil engineers will contribute to project success and business competitiveness.

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