Journal of Construction Project Management and Innovation Vol. 5 (2): 1139-1151, 2015
ISSN 2223-7852

CONTEXTUALISING URBAN ENGINEERING EDUCATION FOR FUTURE CITIES

Dillip K DAS[1] and Fidelis A EMUZE[2]

[1]Department of Civil Engineering, Central University of Technology, Free State, Bloemfontein, South Africa, 9300, PH (+27) 0-51-507-3647, FAX (+27) 0-51-507-3254, Email: ddas@cut.ac.za
[2]Department of Built Environment, Central University of Technology, Free State, Bloemfontein, South Africa, 9300, PH (+27) 0-11-507-3089, FAX (+27) 0-51-507-3254, Email: femuze@cut.ac.za

ABSTRACT

While rapidity in service activities have strengthened the role of urban areas as engines of economic growth, high population density and increased industrialization, has brought needless social and environmental complaints in cities. This phenomenon necessitates a change in societal attitude in favor of the creation of responsible living conditions, which demands requisite skills and knowledge that would shape the cities. Thus, this paper explores the adequacy of current urban engineering education in terms of the knowledge, skills and competencies required to plan and develop future cities. The paper examines how "wicked problems" that marginalize effective sustainable city planning can be addressed through astute understanding of social and environmental challenges, urban governance systems and stakeholder involvement. Based on current education system, initial findings suggest that competencies in urban planning will not necessarily enable students to address challenges related to the development of smart and sustainable cities. Rather, engineering, science and social knowledge, which would engender the ability to predict future social dynamics, should enable graduates to become active drivers of sustainable and livable cities.

Keywords: Education and Training, Environment, Infrastructure planning, Urban regeneration

1. INTRODUCTION

Although advances in sustainable construction practice can be made within existing principles and pacts, du Plessis and Cole (2011) argue that needed substantial gains may not be achieved without a consistent, all-embracing shift in the way that things are currently framed. There is increasing evidence, for example, that crime and other social problems can be designed 'out' of a housing development project (Burrage, 2011). While the idea of the need for a new paradigm is not new and has been emphasized in many disciplines, its consequences for stakeholders in Architectural, Engineering, and Construction (AEC) sector have been fairly unexplored. Major shifts in thinking that influence the model of sustainability in a whole systems paradigm were identified by du Plessis and Cole (2011), who argue for a view of sustainability that moves beyond a simplistic model of achieving balance between economy, society and environment to a model based on resilience and adaptive capacity and regeneration of social–ecological system.

Urbanization is a complex process that has been on the upward trajectory. For instance, the United Nations (UN) estimates that about 1.7 billion dwellers will be added to the urban population in Asia from 2009 to 2050 (UN, 2009). This translates into major increases in dwellings, roads and additional infrastructure to convey potable water and all forms of wastes. This expected growth could leave cities with intense strains on infrastructure and dwellers. As an illustration, roads that were designed for limited cars would be choked with traffic, and the concerns would manifest as increased pollution, reduced economic efficiency and increased global warming. Drainage and sewage systems would also form major sources of worry for municipal workers and urban dwellers because of continuous overloading.

The relevance of this argument to the civil engineer, who is focused on meeting the developmental needs of society without compromising the needs of future generations (Corker, 2011), cannot be over emphasized as civil engineers have to tackle "wicked problems", apart from "tame problems". Tame problems are definable, understandable, consensual challenges that are subject to the general idea of efficiency. The general idea of efficiency is a guiding concept in civil engineering, the natural sciences and operation research (Rittel and Webber, 1973; Hardin, 1998). Tame problems have clear missions, exhaustive formulation and are always aligned with the classical paradigm of science and engineering. The work of Hardin (1968) illustrated the features of a tame problem. In response to "how do we allocate natural resources in an equitable way", Hardin (1968) was able to suggest two solutions: either privatize the commons or change human nature. In essence, a tame problem has a relatively well-defined and stable problem statement; has a definite stopping point; has a solution that can be objectively evaluated; belongs to a class of similar problems that can be solved in the same way; and has solutions that can be tried and abandoned (Ritchey, 2013).

However, wicked problems are 'human problems' that require solutions derivable from politics, environmental studies, economics, ecology, demography, professional ethics and philosophy, to mention a few (Rittel and Webber, 1973). Wicked problems are ill-defined, ambiguous and associated with strong moral, political and professional issues, apart from the view that they are strongly stakeholder dependent (Ritchey, 2013). In addition, Ritchey (2013) noted that wicked problems do not keep still: they are sets of complex, interacting issues evolving in a dynamic social context. In other words, most wicked problems are often without easy technical solutions as they can become malignant, vicious and tricky to solve. Such problems are exemplified in the range of challenges that are faced by cities (Rittel and Webber, 1973). Increasingly, cities in the developed world experience signs of environmental stress in the form of heat waves, poor air quality, excessive noise, and traffic congestion (Schetke and Haase, 2008). Cities with concerns of environmental pressures and the quality of urban life are driven by a common goal. The goal is about asking for clarification of purposes, redefinition of problems, matching priorities with purposes, and reorientation of professional activities (Rittel and Webber, 1973). As an illustration, most Indian cities are characterized by high densities, intensely mixed land use patterns, short trip distances, and a high share of walking and non-motorized transport that lead to persistent environmental decay, congestion, and poor health conditions (Tiwari, 2002). This situation in India cannot be solved through a technical approach alone. Rather solutions lie with ideas that include long-term social and organizational planning issues.

To begin, a succinct analysis of the related literature indicates current education and its contents as it relate to urban planning and development in terms of providing living cities. The differences between "tame problems" and "wicked problems" were highlighted and used to raise concerns about current urban planning related education. To conclude, the implications of this changed understanding – from tame to wicked problems – were used to compliment knowledge areas in urban engineering education.

2. A NEED FOR A PARADIGM SHIFT IN URBAN ENGINEERING EDUCATION

According to Laws and Loeber (2011), practicing sustainability now amount to managing and participating in a process of learning and negotiation within a network of stakeholders whose risks and relations are dramatized and brought into focus by a particular project or need for action. With the use of a water management scheme in The Netherlands, Laws and Loeber (2011) argue that overcoming common infrastructure development dilemmas in terms of sustainability requires engineers to approach technical projects as arenas for learning and problem-oriented negotiation. Such soft skills are advocated in the engineering education literature as a measure to improve project lifecycle performance. In 'future skill sets for the municipal engineer', Cooper and Ashurst (2011), contend that in order for the municipal engineer to thrive in the future, such individual should:

- Have the ability to absorb and accept change willingly;
- Constantly update the traditional technical skills;
- Match new technical skills sets to new work areas in a timely manner;
- Develop non-technical skill sets that must be nurtured by management, and
- Enhance interpersonal skills to meet new and increased job related demands.

Furthermore, Cooper and Ashurst (2011) observe that as most young engineers enter the profession through a university, there is a critical case to ask universities to look at their curricula and determine how the desirable skills could be included in program modules. The inclusion of this skill sets in the civil engineering education could be enhanced when better links are developed between the industry and the academia for the long term benefit of the profession (Barr, 2008). The importance of competency-based training (CBT) that combine skills, abilities and knowledge needed to perform a specific task in the AEC sector has yet again resonate with this discussion because professional competence is always benchmarked against a particular set of specific competencies (Newton, 2008). When these skill sets are available, green hubs that have been proposed in the literature can become a reality. Burrage (2011) suggests that green hubs as a tool in regeneration, and other forms of sustainability would transform a passive green space to a proactive space. The proactive spaces can be places to nurture and develop social and cultural harmony in a community. The literatures cited by Burrage (2011) show that the topology of urban green space involves cultural, ecological, developmental, agricultural and recreational value. All these can be combined to produce parks and gardens; natural and semi-natural urban green spaces; corridors; and outdoor sports facilities.

The ability to engage project stakeholders and engender the indicators shown in Table 1 evidently requires a pedagogy that is progressive. The sustainable development process for a major infrastructure project discussed by Gilmour et al. (2011) provide a mechanism for assessing sustainability through social, economic and environmental prism. See Gilmour el al. (2011) for the definitions and other attributes of these indicators. It is notable that these indicators should not be viewed as exclusive to major projects as the development of effective local infrastructure now requires a complex blend of different expertise in technical aspects of engineering and management that can modify behaviors of stakeholders (Rogers et al., 2012).

Table 1: Sustainable development indicators

Economic	**Environment**	**Social**
Demography	Biodiversity	Housing provision
Skills base retention	Green space / public space	Health and wellbeing
Knowledge-based employment	Waste	Community
Investment stimulation capacity	Air	Social inclusion
Tourism	Water	Participation and responsibility
Regeneration	Noise	Active community participation
Job creation	Energy	Confidence
Economic output	travel	Amenity value

Adapted from Gilmour et al. (2011: 21-23)

2.1 Emergent Urban Engineering Education Propositions

An argument in the literature has continued to encourage people to move to places with better governance. The issue is not whether a development will urbanize or not. It is about "where and under what rules", should locations urbanize (Beck et al., 2011). The changes, which are expected or experienced, are with varied challenges. The question is whether the challenges can be addressed by policy making, governance, and the use of technology. These questions point to the fact the recognition of urban problems are wicked, as opposed to tamed problems, raises major concerns about the way urban planning is currently taught in higher institutions. This changed understanding has implications for competencies that urban engineering education appears to address.

The population growth rates, the dynamics of the economy, information technology, climate change and fluidity in social behaviors show that city planning and development problems will be enormous and the conventional urban related education will fail to solve these challenges adequately. Challenges such as "how should we avoid congestion in urban areas" and "what is the ideal environmental policy for a rapidly expanding city", inevitably demonstrate the need to address wicked planning problems. Planning challenges include all public issues. Concerns about the location of a motorway, tax rate adjustment, modification of school curricula, and the elimination of crime, constitute some of the issues that must be addressed. The planning problems may have features that are not limited to (Rittel and Webber, 1973):

- Lack of a definitive formulation for the problem: the process of solving the problem is identical to the process of understanding its nature.
- Lack of a stopping rule: the planner terminates work for considerations that are external to the problem, for example, time and money.
- Solutions to the problems are not true-or-false; rather they are framed along good-or-bad format.
- There is no immediate and ultimate solution test.
- There is no opportunity to learn by trial-and-error as every solution attempts is vital.
- Every planning problem is unique and can be considered to be a symptom of another problem.

In response to the wicked nature of planning problems (Rittel and Webber, 1973; Ritchey, 2013), urban planning related education has evolved to a highly specialized field of study with varying degree of success. While there is no disagreement on the role of urban development education in the urban development process, there is always confusion over the contextualization of the education provided by institutions of higher learning. Suffice to say, it is not certain that the current urban development related education are geared up to face the challenges that cities are facing or are expected to face in the future. The main question is: are urban planners, urban engineers, urban managers and urban development professionals adequately knowledgeable and skilled to make the cities adaptable to the current and future challenges? In other words, there is a need to ascertain if these professionals would be able to address wick planning problems. The intent of the urban planning program should include how to resolve wicked problems. According to Rosenhead (1996), certain criteria for dealing with complex social planning problems include:

- Accommodate multiple alternative perspectives rather than prescribe single solutions.
- Function through group interaction and iteration rather than back office calculations.
- Generate ownership of the problem formulation through transparency.
- Facilitate a graphical (visual) representation for the systematic, group exploration of a solution space.
- Focus on relationships between discrete alternatives rather than continuous variables.
- Concentrate on possibility rather than probability.

These criteria invariably suggest a change from the dominant engineering and science paradigm of planning problem solving to a pragmatic approach. For example, group facilitated and computer aided general morphological analysis (GMA) is attuned to these criteria and offers a way to address wicked problems (Ritchey, 2013).

3. A CONCEPTUAL DESCRIPTION FOR FUTURE CITIES

The authors look at the future cities in terms of cities where people would desire to live, instead of a city in which people would be forced to live. May be this sounds utopian; however, this is what the future challenges for city development process would entail. If the notion that cities are engines of economic growth is accepted, cities need to adapt to changes in technology, governance, and the environment. Such adaptations should be economically efficient, socially beneficial, and environmentally benign (Marcotullio and Solecki, 2013). To make the adaptations function properly, it demands robust theoretical understanding of the urban forms and processes concerning how to address identified challenges. The theoretical understanding and application would require appropriate knowledge and skills among the persons involved in the urban development process.

In recent times, a movement is taking shape for the development of sustainable future cities through a smart combination as indicated Figure 1. The smart cities recognize six major parameters. These include the economy (related to competitiveness), mobility (related to accessibility and connectivity), environment (related to natural resources), human capital (related to people), living (related to the quality of life) and governance (related to participation) (Giffinger et al., 2007; Komminos, 2002; Lombardi 2011; Shapiro, 2008; Van Soom, 2009). Smart economy refers to parameters around economic competitiveness related to innovation, entrepreneurship, trademarks, productivity and flexibility of the labor market as well as integration in the national and international market. Smart people are essentially described by the level of qualification or education as well as by the quality of social interactions and integration, participation in public life and the receptive attitude, and openness towards the outer world. Smart governance encompasses facets of political participation, services for citizens and the functioning of the administration. Local and international accessibility in the form of sustainable physical transportation system, and, Information and Communication Technologies (ICT) is referred to as smart mobility. Smart environment is expressed by attractive natural conditions in terms of the climate, green open space, level of pollution, resource management and efforts towards environmental protection. Smart living includes various indicators of quality of life in the form of culture, health, safety, housing, and tourism, among others (Giffinger et al., 2007).

Thus, a future city will essentially be a relatively complex combination of these smart elements and should be sustainable if it will demonstrate forward-looking development in these six important characteristics on the basis of their coordinated interactions. The interactions are dependent on local circumstances and activities carried out by the inhabitants of a place through politics and business (Lombardi, 2011; Komminos, 2002; Giffinger et al., 2007; Shapiro, 2008; Van Soom, 2009). In brief, the ability to see planning problems as wicked problems that should be addressed with a methodology that is different from the approach that is applied to tame problems would significant affect the dynamics and nature of future cities, especially if the cities have to be smart and sustainable.

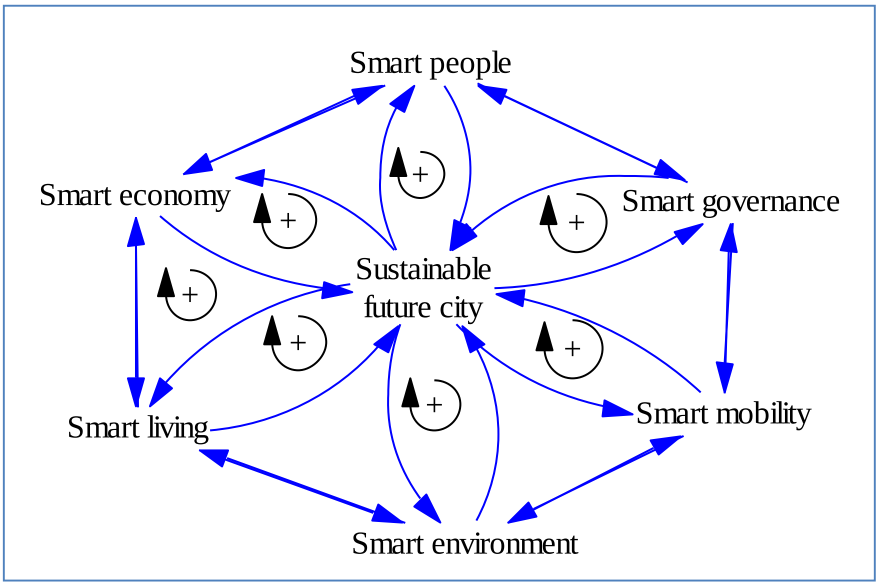

Figure 1: An illustration of a sustainable future city

4. CURRENT URBAN DEVELOPMENT EDUCATIONAL APPROACH

If the approach of urban development education is analyzed, it can be observed that it varies from highly diversified field to highly narrow and specialized ones (see the Association of Collegiate of Schools of Planning (ACSP) 2011/2012 guide).

To mention a few fields, it involves Geography, Economics, Sociology, Civil Engineering, Architecture, and Urban Design.

At present, there are several broad disciplines that are related to urban development. These disciplines include Urban / City / Town Planning with or without Regional / Rural planning, Urban design, Urban Management, Urban Engineering and in some places, it is known simply as Civil and Urban Engineering. The programs vary from social sciences to highly technical designs of built forms and structures. The idea behind urban planning related courses is the development of appropriate strategies for sustainable urban development, which cover aesthetic and psychological concerns. Furthermore, the courses aim to create environmentally sustainable, socially inclusive, economically prosperous, architecturally pleasing, and culturally vibrant cities.

However, despite the evolution of several courses relating to urban development over the years, the challenges in tackling the aspects of urban development remain. The argument here is that urban development education has not evolved the way it should have when compared with other structured applied field of sciences. A debate still remains whether it is an applied science and highly technological or it belong to social sciences. The key question that comes from this argument is that if urban development challenges need technological solutions, why does the status quo remains, despite recent advancements in technology.

4.1 Enhancing Capacity to Overcome Challenges Envisaged for Future Cities

With the contention that the current urban development education could be inadequate to meet present and future challenges, the next question is: what should the education be? Before what urban development education should encompass is discussed, there is a need to understand what the challenges are at present and what could be the scenario in the future. Using rapid urbanization as an example, there is a tendency for increased social pressures in cities and urban area. The increased infrastructure requirements, dwindling natural resources, and worrisome sanitation issues, leads to interventions that is broad-based in terms of knowledge and skills. Similarly, the demographic, economic, sociological and political aspects of city development are becoming more complex. The assimilation of different cultures, races, and generations make the city development process complex. Thus, while technological aspects can be considered as ingenuity to the development process, the socio-economic and environmental aspects cannot be undermined. There is therefore a need for structural union between subject areas important to urban development so as to engender a contextualized education in urban planning and engineering.

What should a contextualized education in urban planning and design entail? The response to the question should bring about new ideas in developing new courses and new curricula or may reconfigure the existing ones. The point is that current education in the related fields of urban development needs revision. Figure 2 is an illustration of the current state and the desirable state of urban planning and engineering education. The illustrated states were derived based on the review of several courses at different level of higher learning.

In particular, Figure 2 suggests that forecasting competency through a scientific process, should be enhanced with appropriate learning courses. Further, while technology related competencies may form the core of urban development education; imbibing soft skills in the area of governance, and policy formulation and management decision making is also vital. The urban development education in a sense is now highly diversified. However, does it need to be? Is different level of urban education and different specializations at various levels, which sometimes look mutually exclusive despite being aimed at the same goal needed? For example, environmental planning looks for providing knowledge and skill for development of a healthy environment in a city; however, they work separately from the people related to transportation planning, who in a sense play the role that provides efficient transportation facilities for people and goods. This is despite the widely held view that transportation or more specifically, vehicles are the main source of pollution in the cities. Similarly, several programs feature the same modules at both undergraduate and post graduate levels, thus creating repetition. This trend marginalize the inclusion of modules that are essential for developing tools for forecasting, space management, environmental impact mitigation, and optimal land use. Desirable modules are not limited to mathematical simulation and modeling, systems analysis, geographic information system (GIS), governance and conflict resolutions, to name a few.

Thus, it is herein argued that urban development related education, in whatever form, should be streamlined and structured as a specific applied science discipline with the incorporation of relevant social science modules. The modules should be offered in a hierarchical way that is relevant and contextualized to both local and global needs. The illustration in Figure 2 is indicative of the areas of knowledge and the skill sets that would be needed. Figure 2 also show how the modules can complement the current curricula. In particular, when governance and conflict resolution related modules are taught in urban planning programs, it should deepen the political, psychological and sociological knowledge and capacity of students and graduates alike. The augmentation of the current environmental impact assessment modules with mathematical modeling and simulation content should also be considered. In a nutshell, increased prioritization of the modules in role 2 as indicated in Figure 2 should assist urban planners to address wick problems.

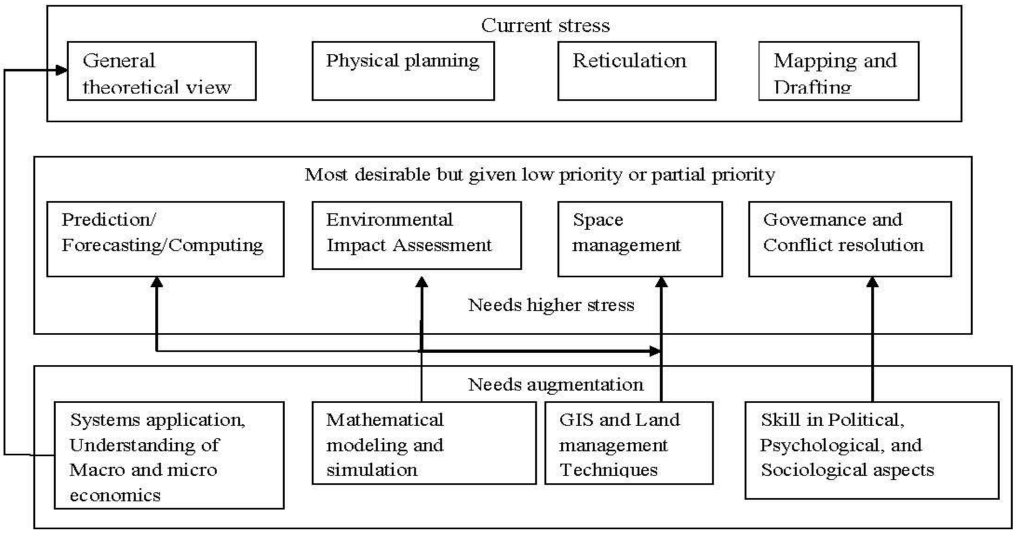

Figure 2: Current and desirable state of courses in urban engineering education

5. CONCLUSION AND RECOMMENDATION

The literature reviewed explored the adequacy of current urban engineering education in relation to the provision of future cities that should uplift the living conditions of urban dwellers. The discourse noted that pedagogy that pertains to urbanization should be revisited. The revision should recognize and address the dynamics of wicked problems that urban planners must solve in order to plan and develop cities.

The authors have argued that urban planning, as currently taught in higher institutions, assumes that the challenges that are to be addressed are “tame problems” instead of “wicked problems”. Evidences in the literature have shown that urban planning problems are societal problems that are inherently different from problems, which are definable and separable and could have solutions that are identifiable. In other words, planning problems tend to be ill-defined and always rely on political judgments for resolution; hence these problems can be malignant, vicious, tricky and aggressive. Thus, the education and training of urban engineers need to take cognizance of the features of “wicked problems”, for it to have meaningful impact on city development.

The paper contends that knowledge and skills required for handling complexities have implications for how to address challenges pertaining to society, environment, and urban governance. Although the key learning outcomes within civil engineering programs that address urban planning do not have to be repudiated, the modules have to be complemented and modified to reflect the knowledge areas that are not currently inside the curricula.

City planners and engineer should therefore endeavor to go beyond technical competencies if they are to remain relevant in a future city context. Civil engineers that are tasked with urban development related projects need to jettison the out-dated outlook of problem resolution in order to produce development that support the 'living cities' concept.

The urban development process constitutes and demands a variety of specializations and skills. Among the specialists, there is a need for a leader that would move the team towards the common goal. The team leader should ideally be an urban engineer with essential knowledge and competencies to understand the inherent nature of urban planning problems. The requirement for a competent urban engineer brings to the fore the need for the reinvigoration of related educational programs.

6. REFERENCES

Association of Collegiate of Schools of Planning (2011). Guide to undergraduate and graduate education in urban and regional planning. 17th edition. ACSP, Tallahassee, Florida, United States of America.

Barr, B. (2008). UK civil engineering education in the twenty-first century. Proceedings of the Institution of Civil Engineers – Management, Procurement and Law 161(1): 17-23.

Beck, M.B., Thompson, M., Ney, S., Gyawali, D. & Jeffrey, P (2011). On governance for re-engineering city infrastructure. Proceedings of the Institution of Civil Engineers – Engineering Sustainability 164(2): 129–142.

Burrage, H. (2011). Green hubs, social inclusion and community engagement. Proceedings of the Institution of Civil Engineers - Municipal Engineer 164(3): 167-174.

Cooper, M.W. & Ashurst, J. (2011). Future skill sets for the municipal engineer. Proceedings of the Institution of Civil Engineers - Municipal Engineer 164(4): 241-250.

Corker, N. (2011). Historical paper: 'The tragedy of the commons'. Proceedings of the Institution of Civil Engineers - Engineering Sustainability 164(2): 105-117.

du Plessis, C. & Cole, R.J. (2011). Motivating change: shifting the paradigm. Building Research & Information 39(5): 436-449.

Gilmour, D., Blackwood, D., Banks, L. & Wilson, F. (2011). Sustainable development indicators for major infrastructure projects. Proceedings of the Institution of Civil Engineers - Municipal Engineer 164(1): 15-24.

Giffinger, R., Fertne, C., Kramar, H., Kalasek, R., Pichler, M.N. & Evert, M. (2007). Smart cities – ranking of European medium-sized cities, Final project report, pp. 1-25.

Hardin, G. (1968). The tragedy of the commons. Science 162(3859): 1243-1248.

Komninos, N. (2002). Intelligent cities: innovation, knowledge systems and digital spaces. Spon Press, London, United Kingdom.

Laws, D. & Loeber, A. (2011). Sustainable development and professional practice. Proceedings of the Institution of Civil Engineers - Engineering Sustainability 164(1): 25-33.

Lombardi, P. (2011). New challenges in the evaluation of Smart Cities. Network Industries Quarterly 13(3): 8-10.

Marcotullio, J.P. & Solecki, D.W. (2013). Sustainability and cities - meeting the grand challenges of the twenty first century. In Approaching Environment for Human Transformative approaches to research, policy and actions (L Sygna, K O'Brien & J Wolf (eds.)). Earthscan from Routledge, Oxford, United Kingdom, pp. 375-391.

Newton, S. (2008). A change in perspective for construction management education. Proceedings of the International Conference on Building Education and Research (BEAR), 11-15 February, 2008, Salford, UK, pp. 300-310.

Ritchey, T. (2013). Wicked problems: modelling social messes with morphological analysis. Acta Morphologica Generalis, 2(1): 1-8.

Rittel, H.W.J. & Webber, M.M. (1973). Dilemmas in a general theory of planning. Policy Sciences, 4: 155-169.

Rogers, C.D.F., Bouch, C.J., Williams, S., Barber, A.R.G., Baker, C.J., Bryson, J.R., Chapman, D.N., Chapman, L., Coaffee, J., Jefferson, I. & Quinn, A.D. (2012). Resistance and resilience – paradigms for critical local infrastructure. Proceedings of the Institution of Civil Engineers - Municipal Engineer 165(2): 73-84.

Rosenhead, J. (1996). What's the problem? An introduction to problem structuring methods. Interfaces, 26(6):117-131.

Shapiro, J.M. (2008). Smart cities: quality of life, productivity, and the growth effects of human capital. Review of Economics and Statistics 88(2): 324-335.

Schetke, S. & Haase, D. (2008). Multi-criteria assessment of socio-environmental aspects in shrinking cities: experiences from eastern Germany. Environmental Impact Assessment Review 28(7): 483-503.

Tiwari, G. (2002). Urban transport priorities: meeting the challenge of socio-economic diversity in cities-a case of Delhi, India. Cities 19(2): 95-103.

United Nations (2009). World urbanization prospects. The 2009 revision – highlights. United Nations Department of Economic and Social Affairs/Population Division, New York, United States of America.

Van Soom, E. (2009). Measuring levels of supply and demand for e-services and e-government: a toolkit for cities. Smart Cities Research Brief, N. 3. Available on: http://www.smartcities.info/research-briefs> [accessed 17 August 2013]