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TOWARDS A SYSTEMIC CONSTRUCTION INDUSTRY DEVELOPMENT: A RESEARCH AGENDA FOR A FRAGMENTED INDUSTRY IN AFRICA

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Abstract
In spite of the several attempts by African countries to address their infrastructure needs, and despite the enormous investments injected into infrastructural development, much has not been achieved. The central problem is that researches and development issues in the industry have not taken into consideration its fragmented nature and how this impacts on the efforts being put in place. Relying on the survey of literature review, this paper proposes a research agenda for the construction industries in Africa and other developing countries in which a concerted effort based on systemic approach should be used to address the problem. It is conceived that the research and development objective of the industry in Africa could be better achieved if it is considered as a system of fragmented components. This will provide a framework in which the General Systems Theory which will enable the application of laws and theories from other disciplines in the industry's research and hence its development. The expected results is that improvements and developments programmes shall be focused on individual component parts whose interactions, if properly managed, will result in the development of the whole. In the process better and realistic results of infrastructural developmental agenda will be achieved.

Keywords: Infrastructure, construction, fragmented, system, system thinking.

INTRODUCTION

In spite of the relatively high investment in infrastructure in developing countries, the World Development report (1994) highlights the less corresponding impact these have had on the people in these countries. Hence, the report indicated that the infrastructure's future challenges should be dealt with by tackling inefficiency and waste –both in investment and delivering services. The report indicated that the poor performance of those managing the delivery and maintenance of these infrastructures provides strong reasons for doing things differently.

In the developing countries the problems confronting the construction industry are even bigger, compounded by lack of adequate resource and institutions to address them. Considering the investments levels of the construction industry and the development needs of most developing countries, the time is overdue for these matters to be given prominence. Indeed, Agenda 21 for sustainable construction in developing countries puts construction at the centre of how the future is to be shaped, and the sustainability of this future (Du Plessis, 2002 pi). In particular, developing countries were well advised to avoid the development mistakes of the developed world and to take steps to intervene on behalf of sustainability today than to wait and change things after they have occurred (Du Plessis, 2002 p1). These, together with the threat on the environment, have led to the call by various countries to work towards improvements in, and the development and sustainability of, the construction industry. Where, sustainable development has been defined as the "development that meets the needs of the present without compromising the ability of the future generations to meet their needs" (The Brundtland, 1987). Against this background, several countries at various levels of socio-economic development have recognised the need and importance of taking measures to improve the performance of their construction industry in other to meet the aspirations of its developmental goals (Ofori, 2000). This is in line with the agreements reached and reported by the CIB Task Group 29 (1999). According to Ofori (2000), the report agreed that "construction industry development is a deliberate process to improve the capacity and effectiveness of the construction industry in order to meet the demand for building and civil engineering products, and to support sustained national economic and social development objectives (CIB, 1999)". At that meeting, the report continued, it was agreed that construction industry development promotes: (a) increased value for money to industry clients as well as environmental responsibility in the delivery process (b) the viability and competitiveness of domestic construction enterprises. This has become necessary because of the poor performance of the construction industry due to problems and challenges including those having to do with its structure characterised by fragmentation, institutional weakness and resource shortages (Ofori, 2000; Beatham et al., 2004; Latham, 1994; Egan, 1998).

However, this quest has met with several challenges which have prevented the development of the industry of any country to reach the desired goal. This state of affairs is epitomised in the several performance deficiencies on project execution namely: delays, cost overruns, disputes and poor quality of work among others. Discontent with the state of their construction industries, governments in developed countries are supporting various initiatives for improvements (Ofori, 2000). Following the Latham (1994) and Egan (1998) Reports, for example, the UK construction industry in particular has resorted to using several performance measures to address improvement concerns of the various aspect of the industry (Beatham et al., 2004). According to Ofori (2000) several other countries have also made some deliberate attempts to improve their construction industry. They have formed dedicated agencies to administer the continuous improvement of the industry. Examples of these are: Malaysia (Construction Industry Development Board), Sri Lanka (The Institute of Construction Training and Development), Tanzania (National Construction Council of Tanzania), and Singapore (Building Construction Authority). Ofori added others who have made long-term plans towards this end as: Hong Kong (21st Century Steering Committee), Australia (Australia Construction and Steering Committee, 1997) and Southern African Countries (Formation of construction industry development agencies to co-ordinate efforts and pool resources where necessary).

TOWARDS A BALANCED DEVELOPMENT

Discussing the concept of revaluing construction, Kumaraswany et al. (2007) focus on the need for a “balanced development” of the construction industry. Balanced development, they explained, refers to the need for striking an appropriate balance both within and between the development of the various “stakeholders, construction personnel, public institutions and private companies, the construction industry and the country itself”. Among the benefits to be achieved relate to “accelerating knowledge flows, which include one-way transfers and two-way exchanges of both ‘hard’ and ‘soft’ knowledge components between or among joint venture partners, consultants, contractors and sub-contractors, and other participants in construction projects. In their submission, Kumaraswamy et al. (2007) note the following difficulties:

- There are difficulties in identifying desirable developmental goals, agreeing on them among the stakeholders, and then achieving the right balance.

- There are also difficulties in agreeing on the appropriate courses of action for achieving the developmental goals as well as the assignment of responsibilities for them.
- The fragmentation of the industry also makes it difficult for companies to share information and knowledge (Robert et al, 2006).
- The construction industries generally comprise small and medium companies that cannot easily invest in research and development (R&D) or in sophisticated information management systems (Robert et al, 2006).

In particular, they conclude that "smoother knowledge flows would help to accelerate the mutual understanding of the diverse stakeholders and thereby facilitate the required holistic perspective for better management of the construction industry towards balanced development along all the fronts highlighted above (Kumaraswamy, 2006). This would contribute towards the revaluing of the construction industry in developing countries." However, coupled with it "one-of-a-kind production, site production and temporary product organisation (Koskela, 2002)", we see an industry which has complex problems to overcome to achieve these objectives for development.

THE PROBLEM STATEMENT

An industry with the foregoing difficulties and challenges needs to redefine its approaches towards research and development. The acknowledgement of the underpinning peculiar features appears to have been overemphasised to the detriment of what really needs to be done with this knowledge as we attempt to bring about improvements and development.

In the main, researches and efforts aimed at developing the industry have not considered it as a system –a complex system for that matter –with variety of interrelated and interacting parts. Hence most of the interventions aimed at improving the industry and addressing the developmental problems have attempted to address it either en bloc or dealt with the parts in isolation. This limits our understanding of the construction industry. With regard to the quest by nations to develop their construction industry, this could explain why efforts have not yielded the desired results so far.

AIM AND SPECIFIC OBJECTIVES

The aim of this paper is to propose a conceptual framework by which construction industries of developing countries could be developed holistically using a systemic approach. It is the position of this paper that the objective of improvements and developments in a typical construction industry would be better achieved if the industry is considered as a system and to address its problems using System Thinking. To this end the specific objective of the paper is to achieve the following:

- To discuss the need to consider the construction industry of a country as a system of identifiable components
- To show that it is possible for research in the construction industry could be done within the domain of system thinking for holistic
- To suggest this paradigm as a major research agenda for the construction industry everywhere

It is the contention of this paper that a critical study and monitoring of the interactions between these parts and their attributes will provide the basis of identifying improvement areas which will in turn shape development goals of the industry of a country. Consequently, the performance of the construction industry of any country will be the aggregation of the performance of its components. Thus, the improvements in the construction industry of any country as measured by its performance at any time should be represented by the aggregation of the improvement of its components; and finally, the overall development of the construction industry of any country at any time should be represented by the aggregation of the developments of its components.

THE CONSTRUCTION INDUSTRY AS A SYSTEM

Hall and Fagen (1956 pp. 18-28) define a system as: “a set of objects together with relationships between the objects and between their attributes”. Objects are parts or components of a system and they are unlimited in variety. Attributes are properties of objects. In the construction industry for example, clients, practitioners, contractors, projects and so on constitutes the objects of a components; whiles such attributes as can be used to describe the “objects” in the industry as success factors, indicators, growth.

The last key word in the definition is “relationships”. This is what “ties the system together”. It is in fact these relationships that make the notion of the “system” useful. The relationships that exist in the components parts of a construction system are indispensable for its success and growth.

The essence of a system is that it is a “complex whole” (the concise oxford dictionary, 1976, p.1174) “of a group of interrelated, interdependent, or interacting elements forming a collective unity” (Collins English dictionary, 1979, P.1475). It is this idea of complex wholeness and collective unity that makes system thinking a relevant philosophy for the construction industry –existing as fragments and aiming to develop as a whole. Using contrasts to explain further, Fuenmayor (1991) identifies two possible types of nonsystems by way of inference from the definitions above:

1. Indivisible entities (e.g. sub-atomic particles which are not constituted by a plurality of elements). These are atomic concepts without a direct phenomenal correlate.
2. Sets of elements that do not form a “collective unity”.
3. Using system thinking, the construction industry of any country as a system can be represented at three levels as shown below:

- **System Level**: the system itself i.e. the construction industry as a social system.
- **Subsystem level (objects)**: all that belong to the system, each component and assembly e.g. projects, firms, personnel etc.
- **Super-system level:** everything that does not belong to the system but interacts with the system, or produce influence upon functioning of the system e.g. the natural, social, economic, political and competitive environment. Hence, using the “systems approach” to address the needs of the construction industry is simply to see the industry as a system.

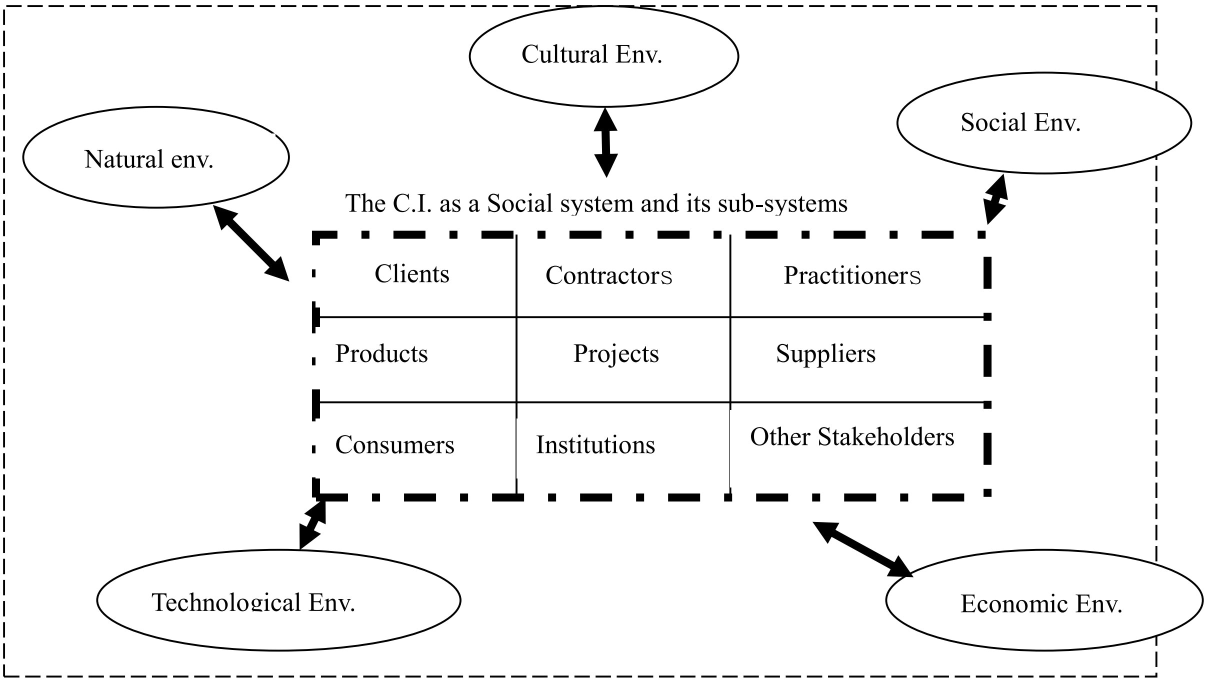
In this regard, the construction industry is a composite (social) system of distinguishable parts in that it deals with the society (people and shelter) and the environment (economic, technological, and natural). It is characterised as one which comprises many interacting parts such that a change affecting any one part usually, has the potential of affecting the other in an unpredictable manner. It is also a pluralistic (Jackson and Keys, 1984) industry because groups (components or constituents) within the system have diverging interests and aspirations. It is therefore important that studies into the mechanisms within the industry should be carried out with this system concept in mind.

According to Capra (1982; 2003), systems thinking is the most appropriate paradigm for rethinking socio-economic development, arguing that it will help us avoid the shortcomings of tackling environmental challenges at the global level.

Delineating the Key Components of a Construction Industry

The primary action to undertake towards a systemic approach to develop the construction industry will be to identify the key components. Following from Kumaraswamy et al. (2007), thus, the quest for a balanced and sustainable development should be rooted in the delineating and the analysis of such identifiable entities as the stakeholders, construction personnel, public institutions and private companies,(the identifiable components –the sub-system) the construction industry (the system) and the country itself (talking about the super-system) all benefiting from Knowledge flow –both external (among components), and internal (within the same organisation), emanating from the study of their attributes as well as the relationships that ties them together. Figure 1 is the author's view of a representation of the construction industry and some of its key components identifying them as systems and subsystems within a super-system.

The global, regional and related country environment as the super-system



THE GENERAL SYSTEMS THEORY

Fig. 1 The Construction Industry as a social system with its key components with its sub-systems; the super-system comprises the social, economic, natural, technological and cultural environments and the interactions of these system components.

Properties and Characteristics of Systems

Forrester (1971) posits that a thorough understanding of a social system is absolutely necessary for its improvements and development through realistic changes. Lack of this understanding has been the cause of consistent failure on the part of policy makers to achieve their aims of trying to effect changes. This paper uses Jenkins's (1969) six properties of a system and Forrester's (1971) three characteristics of a social system to relate to the construction industry.

Properties of Systems

Using a chemical plant as a basis of analysis, Jenkins (1969) outlines six properties of a system in general:

1. "A system is a complex grouping of human beings and machines." This is also for the construction industry as a system and each of the components as sub-systems.
2. "Systems may be broken down into sub-systems, the amount of sub-system detail depending on the problem to be studied." As illustrated in Figure 2, the construction industry as system can be broken down to as many sub-systems as are identifiable. However, this property of a system informs researchers that the number of sub-systems should be limited by the problem and scope of the research. For example, a research on project execution efficiency in the construction industry will limit the sub-systems principally to projects, consultants and clients and to a smaller extent, the other closely related stakeholders.
3. 'The outputs from a given sub-system provide the inputs for other sub-systems. Thus the performance of a given sub-system interacts with the performance of other sub-systems and hence cannot be studied in isolation." The reality of this in the construction industry is the essence of calling for a systemic approach to research and developments in the industry.

How can one study the performance of projects without thinking about its interaction and hence its relationship with the performance and inputs from consultants, clients, suppliers, and also those of the external environments?

4. "The system being studied will usually form part of a hierarchy of such systems. The systems at the top are very important and exert considerable influence on the system lower down." A typical system within the construction industry must always be seen as forming part of hierarchy defined by which of them have the power to initiate activities and control it, etc. In other considerations, the construction industry within a country (considering it external environments) should be seen as part of a hierarchy of systems comprising manufacturing, agricultural, mining, oil etc. as other related and interacting industries.
5. "To function at all, a system must have an objective, but this is influenced by the wider systems of which it forms part. Usually, systems have multiple objectives which are in conflict with one another, so that an overall objective is required which effects a compromise between these conflicting objectives." All industries as systems must have objectives. All sub-systems within each industry must also have their objectives. At the national level, the objective of the construction industry in a country must be set. The relationship of this objective and that of other industries within the country needs to be considered. How do the overall results of this conflicting objectives impact on the overall objective of a country as the master system? What is the objective of a typical project being executed? What is the level of agreement and conflict between the project as sub-systems and those of other sub-system during its life cycle? How do these conflicting objectives impact on the objective of the industry over time "t".
6. "To function at maximum efficiency, a system must be designed in such a way that it is capable of achieving its overall objective in the best way possible." This brings to the fore the need for identification of the industry's objective to improve performance, to grow, to develop and be sustainable. This will result, expectedly, in the need to re-engineer the construction industry as a system in the country to ensure that it achieves its developmental goals. This is the thesis of this paper.

Characteristics of a Social System

Forrester (1971) also identified three characteristics of a social system which, in applying to the construction industry development agenda, challenges researchers and policy makers to be extremely critical in providing intervention for developments.

1. "Social systems are inherently insensitive to most policy changes that people select in an effort to alter the behaviour of the system". He posits that "a social system tends to draw our attention to the very points to which an attempt to intervene will fail".
2. "Social systems seem to have a few sensitive influence points through which the behaviour of the system can be changed. These influence points are not in the location where most people expect.
3. As a Social system there is usually a fundamental conflict between the short-term and the long-term consequences of a policy change. "A policy which produces improvement in the short-term, within five to ten years, is usually one which degrades the system in the long run, beyond ten years". Likewise those policies which produce improvements in the long-run may initially depress the behaviour of the system. The visible and more compelling nature of the short-term as against the long-term makes this very treacherous. It speaks loudly for immediate attention; however such short-term improvement measures "can eventually burden a system with long-run depressants so severe that even heroic short-term measures no longer suffice".

GENERAL SYSTEMS THEORY AND ITS RELEVANCE TO CONSTRUCTION INDUSTRY RESEARCH

The Need for a General Systems Theory

At the outset, by formulating a research aim to uncover the fundamental characteristics of systems of various kinds, we were making the unquestioned assumption that the world contained such systems (Checkland, 2000). And, generally, a concept is as good as its theoretical base. The manifesto for a systems approach to analysing the construction industry should, thus, be rooted in the general systems theory. According to Boulding (1956) General Systems Theory is a name which has come to describe a level of theoretical model-building which lies somewhere between highly generalised construction of pure mathematics and the specific theories of the specialised disciplines.

Boulding (1956) notes that each discipline corresponds to a certain segment of the empirical world with theories that are developed to have particular applicability to its own empirical segment. The quest for a General Systems Theory is, thus, instigated by the fact that modern science, characterised by specialisation, has become so fragmented that there appears to be a perception which has encapsulated scientist of different fields in their "private universe" and "it is difficult to get a word from one cocoon to the other (Bertallanffy, 1956)". A deeper analysis, however, points to the contrary.

According to Bertallanffy (1956), "similar viewpoints and conceptions have appeared in very diverse fields" and that similar problems are predominant in other scientific fields. For example, problems of organisation, of wholeness, of dynamic interactions, are topical in "physics, chemistry, physical chemistry, and technology". It has become necessary, thus, that a body of systematic theoretical construct which will discuss the general relationships of the empirical world be established. Collins Cobuild Advanced Learner's Dictionary (2006 P.1470) defines a system as "a network of things that are linked together so that people or things can travel from one place to another or communicate". This is the quest for a General Systems Theory. Betallanffy (1956) summarised the aim of General Systems Theory as:

1. There is general tendency towards integration in the various sciences, natural and social
2. Such integration seems to be centred in a general theory of systems
3. Such theory may be an important means for aiming at exact theory in the non-physical fields of science
4. Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of science
5. This can lead to a much-needed integration in scientific education."

According to Boulding (1956) such a theory does not seek to establish a single, self-contained "general theory of practically everything" which will replace all the theories of particular disciplines. The vision is about the development of a "spectrum" of theories –a system of systems which may perform the function of a "gestalt" in theoretical construction.

Such a theory will accommodate the existing models, principles, and laws that apply to generalised systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations of "forces" between them. It is a quest for universal principles applying to systems in general (Bertallanffy, 1956).

A Lesson from the Concept of Sustainability

To illustrate the feasibility of the General Systems Theory as per its applicability, the concept of sustainable development comes to mind. With its definition hinging on the three pillars of economic, social and environmental considerations, this concept has gained wider application across several disciplines. Several developed countries have made it a requirement for approval of most research and developmental projects in all disciplines. These three pillars have become pillars in all disciplines. Such is the expectation of the proponents of General Systems Theory.

SYSTEMS APPROACH TO CONSTRUCTION INDUSTRY RESEARCH AND DEVELOPMENT

Checkland (1989) defines systems approach as 'an approach to a problem, which takes a broad view, which tries to take all the aspects into account, which concentrates on interactions between the different parts of the problem'. Figure 2 shows the author's view on how the various components should be perceived within a typical industry of a country. This arrangement shows how the various types of components are identified according to their levels within the system and visualising the components as standing in interaction within the industry as a system, figure attempts to illustrate the author's view of what encapsulates the research agenda for a fragmented industry which functions as a system. This is represented along the lines of the 'solar' system. Conceptually, however, there is an expected difference in that it is a distortable system of systems because the forces of interaction are not expected to be equal or constant. The changes that occur in society will constantly affect it. However, in the same way that social theories are identified and perceived as existing over time, it is also expected that these impacts are determinable.

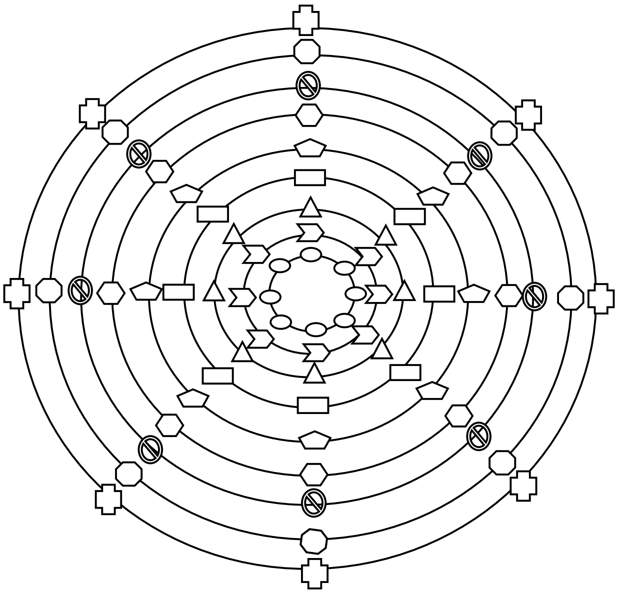


Fig. 2 Components in the construction Industry of a country.

(Note similar components rotating along their 'orbit' in the 'solar' system", as it were, and standing in determinable interaction and relationships within themselves as similar components, and those of other components. Projects are at the centre of the system).

It is conceived as a matter of course that, research in the industry, if it is pursued based on Figure 2, provides the following objectives:

1. The identification of the nature, impact and direction of the interactions (forces) and relationships of similar components along the same "orbit" close or remote; and between those of other components close and remote as the need may be, within a well defined period.
2. The identification of the nature, impact and direction of the external environmental interactions and relationships (the super-system) on each of the components (as well as a group of similar or different components) and vice versa, within a geographical location and within a well defined time frame.
3. The prediction of these interactions and relationships as identified above based on prevailing circumstances and available data.
4. The application of all the above to the sub-systems (each of the components) as a system of systems.

The aim of accomplishing the above research objectives is what brings about the ultimate need of employing all the relevant existing models, principles, and laws that apply to generalised systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations of "forces" between them as proposed by Bertallanfy (1956) and supported by Boulding (1956). In addition, it is envisioned that existing and applicable models, principles and laws from other disciplines into a related system could instigate the discovery of new forces or impacts that has hitherto not been discovered. That is the way forward. This is the agenda for research in the construction industry. The orbits are not limiting and will follow the theory of the 'expanding universe' as and when new "planets" are discovered (new project related disciplines are brought to bear).

METHODOLOGIES FOR SYSTEMS RESEARCH IN THE CONSTRUCTION INDUSTRY

Applying System Thinking to construction industry research and dvelopment, it is paramount that we fall on the existing methodologies that are capable of addressing the research objectives and questions in systems. Researches using the General System Theory embrace methodologies applicable in other fields –which are themselves linked up as a system. Particularly, methodologies in Management Science dominate these methodologies; examples are Soft System Methodology (SSM) (Checkland, 2000), System of Systems Methodologies (SOSM) (Jackson and Keys, 1984; Jackson, 1987), Total System Intervention (Flood and Jackson, 1991), Diversity Management and Triple-Loop Learning (Flood and Romm ,1996). Other methodologies include: Decision Tree and Influence Diagrammes, Strategic Choice Approach, Scenario planning, Robustness Analysis, Metagaming, Hypergames, Cognitive Mapping , Repertory Grid Technique, Delphi Methods etc., as well as Such organizational Research Methods as Linear Programming, Queuing Theory, Game Theory, Simulation and Markov Process .

In all these, Mingers and Brocklesby (1996), acknowledge the growing interest in utilizing more than one methodology and method possibly from different paradigms within the same inquiry.

Such combinations are required in researches in the system domain, which are characterized with high complexity and multidimensional problems. The overall purpose is to maximize flexibility and responsiveness during interventions (Heyer, 2004).

CONCLUSION

This paper purports to instigate paradigm shift in the way researchers in the construction industry in Africa have understood the industry's research question. It proposes a higher level consideration where the interrelationship and interactions between the fragmented components of the industry will be used as a basis of understanding the industry behaviour. It joins the numerous researchers' acknowledgement that the industry is a fragmented one and goes further to ask the question: 'and so what do we do to grow it together?' Approaching research and development within the construction industry with System Thinking will yield the desired realistic and holistic improvements in its performance and its sustainable development. The real problems militating against the development of the industry will be identified through multi-lenses and clarified at its elemental or component levels; identifying how each component impacts on the nearest or remotest components within the industry. A better understanding and knowledge of the construction industry situation will be achieved. Such knowledge of the industry is crucial for addressing its multi-faceted problems including those of inefficiencies, ineffectiveness and wastes.

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