KNOWLEDGE MANAGEMENT MODELS IN CIVIL ENGINEERING CONSTRUCTION FIRMS IN NIGERIA
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ABSTRACT
Knowledge is scattered in the construction projects through various documents and individuals brains. Knowledge was stored somewhere without retrieving it for re-use and also some were created during construction stage and if not properly capture, stored and utilized it will lost. The aim of this paper is to develop a new KM implementation framework to address the problems of knowledge creation, storage, sharing and utilization for the betterment of the construction organization. The method employed for this study is descriptive research through critical reviews of the existing models developed by researchers and scholars in order to get the in depth of developing the new KM implementation framework. The result obtained from this study is the development of new circular KM implementation framework for Civil Engineering Construction firms. The paper concluded that, the implementation of this KM framework depends on the commitment, attitudinal behaviours, dedication and personal interest of the top management or knowledge expert in the construction organisation. However the paper recommended that CE construction firms in Nigeria should established a standard code of practice for knowledge management to be fully implemented in their organisation.

Keywords: Knowledge management; knowledge Modeling, Construction industry

1. Introduction
Civil engineering (CE) construction firm is one of the sectors that employed large numbers of employees in various professionals, to works jointly in the same construction site and to actualize the set objectives. In spite of the different experts and professionals brought together to actualize the dream of the clients, new problems and solutions emerged in the construction site (such as variation, mistakes during construction, design problems, materials supply delays or shortage and unforeseen circumstances). These problems and solutions are rarely well documented and valuable lesson learned are confined to the minds of those who experienced them. Hence experiences, information and knowledge from past project can be detrimental to the non-resistance of precedent mistakes and the re-uses of good solutions. The re-use of information and knowledge reduce the needs to refer to the past projects, reduces the time and cost of solving problems and improves the quality of solutions during the construction phase of a project. Moreover, when the knowledge is shared, the same or similar problems of that nature and type do not need to be constantly solved. Therefore it is essential for the construction organisation to capture, store and share knowledge with the other employees for effective project delivery.

Knowledge management (KM) in the construction industry has been identified within projects, across temporary, multi-discipline project organisations, and within individual firms. It is believed that there are greater potential of KM within individual organisation. However, Tserng and Lin., (2004) conducted a similar research and discovered that KM in the construction industry is still at the infancy stage. Kamara et al., (2002) added that the main driver of KM in the construction organisation is the need for innovation, improved organisation performance, and client’s satisfactory. Consequently, Carrillo et al., (2004) conducted a study in UK Engineering and construction firms, and discovered the main drivers for KM in construction firms as the need to encourage continuous improvement, to share valuable tacit knowledge, to disseminate best practices, to respond to customers quickly, to reduce construction reworks, and to develop new products and services respectively.

The theoretical frameworks for KM model developed in relation to the implementation of KM in the construction industry were done in different segment and background. Grover &
Davenport (2001) stated that research in KM seems fragmented; therefore there is need for more research work to be done in the form of extending, refining, and empirically validating its models, and developing its theories and concepts across specific background and location for models to be understood. Majority of the KM models developed by the researcher are too complex to be implemented successfully in the construction industry, this is because most of these knowledge were developed based on the nature and operational system of each country.

The management of knowledge in CE construction firms is at four levels: such as management of project knowledge; individual knowledge; organisation knowledge; and environmental knowledge. KM practice in CE construction firms is mostly informal and people centred, although there is a growing trend towards the development of formal KM strategies within CE construction firms (McConalogue, 1999, Kamara et al. 2002). However, other strategies include the development of standard operating procedures, best practice guides, and code of practice. These are mostly used within CE construction firms. However the study of KM in civil engineering (CE) construction firms is still in at infancy stage in Nigeria. The Nigeria CE construction firms lack awareness and understanding of the concept and theory of KM. The aim of this paper is to critically reviews and appraises the existing KM models relating to construction firms. This will provide a platform that clarifies the characteristics of the various models. Based on this platform, the aim of the paper is to develop a theoretical framework of KM models for CE Construction firms in Nigeria. The above aim will be achieved through accomplishment of the following set objectives:

1. To reviews and appraise the existing KM models in construction firms.
2. To develop KM implementation framework that simplify and improve awareness of the concept and theory of KM in CE construction firms.

2. Research Methodology

The method adopted for this paper is descriptive research. The data collected is critical reviews of the existing literature of KM models from journals and conference papers. The KM models were selected for reviews and appraises based on the nature and type of situation their addressed. However, emphasis was placed on thus that related to construction organisation in order to gain ideas and knowledge of develop a simple and easy KM implementation framework that will outline the understanding of concept and theory of KM in CE construction firms.

3. Knowledge Modeling

Davenport and Prusak,(2000) described KM model as techniques that use graphical and word-based presentations to explained the actual system of KM, in order to describe the features, constituent, inputs, output tools, procedures, practices and other factors that can impact the organisational knowledge and /or the knowledge management system (KMS). KM models are used for applying and implementing KM in an organisation and provide a procedural and structural strategy that guides KM efforts through the stages of designing, building, evaluating and improving the KMS in organisations. KM models can help to decide and achieve required improvement and used to evaluate the success of existing KMS in organisations (Robinson et al, 2004; Axelsson and Landelius, 2002).
Fig 1.1: Demerest’s KM model (McAdam and McCreedy, 1999)
Demerest’s KM model highlights knowledge in construction projects within an organisation. The construction projects are not limited to scientific inputs but are seen as including the knowledge of social construction. McAdam and McCreedy, (1999) argued with Demerest KM model that construction knowledge is embodied within the organisation, not just through explicit programs but through a process of social interchange. Demerest KM model does not give a clear definition of knowledge but presents a more holistic approach. However, the flow of knowledge transfer can be very rapid and circulatory, as in form of action learning. Fig 1.1 illustrates the Demerest KM model that shows the process of dissemination of the espoused knowledge throughout the organisation and its surrounding.

Fig 1.2: Demerest’s KM Model (modified) McAdam and McCreedy (1999)
Fig 1.2 shows two different types of arrow, this means that a solid (double) arrow shows the primary flow of direction while the plain (single) arrow shows more recursive flows. Fig 1.2 has been slightly modified to address limitations in fig 1.1, by explicitly showing the influence of both social and scientific paradigms of knowledge in construction. Both business and employee benefits are covered by elements used in the model. For the KM to have stakeholder support and commitment, employee emancipation must be addressed along with the benefits in the organisation.
Nonaka and Takeuchi (1995) advocated that knowledge is created through continuous interaction between tacit and explicit knowledge to form four modes as presented in Fig 1.3 of SECI (socialization, externalization, combination and internalization) model above. Nonaka (1991) argued that in creating new knowledge there should be a non-stop process to re-create the company and everyone in it by making the creation of new knowledge a non-specialized activity where everyone in the organisation acts as a knowledge worker.

The spiral represents continuous movement between different models of knowledge creation, and the increase in the spiral radius shows the movement and diffusion of knowledge through organisational levels.

Socialization is to share or acquire other experiences or tacit knowledge through meetings, direct conversation, observation, practice, training etc. through socialization. An engineer can learn from an expert or senior engineer the tacit secrets of solving a problem in the construction projects (tacit to tacit).

Externalization is a transforming tacit knowledge that explicit knowledge to enable its communication. Through externalization, a senior engineer can translate his tacit knowledge such as experiences, ideas, know-how and perceptions into explicit knowledge in the form of reports, specifications, articles, procedures, descriptions etc, that is easy to be understood, captured, shared and reapplied (tacit to explicit).

Combination of several linked element of explicit knowledge that will form new explicit knowledge in the third form of knowledge creation. Through combination, a report can combine explicit knowledge with other related knowledge to provide more analysis and understanding of valuable explicit knowledge available for employees (explicit and explicit).

Internalization shows the process of developing new experiences by learning from, reusing and re-applying the existing explicit knowledge to produce new tacit knowledge. Successfully externalization can enhance the update and revalidate explicit knowledge to be reapplied by employees to learn and produce new know-how and tacit knowledge (explicit to
tacit). This new tacit knowledge can be shared among individuals through direct contacts (socialization) to re-start a new repetition of the continuous twisting.

McInerney (2002) argued that knowledge can also be a disadvantage for organisations, if it is false and misleading, discouraging or does not satisfy organisational set objectives/mission and strategy. Knowledge is dynamic in nature because it changes individual’s mentality through experiences, and learning in an organisation by sharing and transfer of knowledge among the employees to enhance performance and competitive advantages. The requirements for organisational system to be flexible on dealing with continuous updates and changing requirements from all sectors of the organisation, indicates the need to store knowledge in the knowledge repositories (database).

McInerney (2002) added that, instead of capitalizing efforts in the creativities of extracting knowledge from the employees, it is relatively more productive for organisations to capitalize efforts in creating a knowledge culture. This include encouraging learning and sharing of knowledge such as establishing small group meeting rooms, rewards to those who continuously practice learning and who teach others what they know, offering informal “water cooler” type meeting places throughout the work place, encourage trust, dialogue and collaboration among employees. Fig 1.4 below shows how tacit and explicit knowledge interact through internal and external processes within and among employees in an organisation using a graphical representation of a KM model. The static collection of knowledge is not enough, but continuous knowledge creation is essential to manage knowledge more effectively and to keep organisations healthy and innovative (McInerney, 2002).
Fig 1.5: The Activity-Based and Map-Based KM Models (Tserng and Lin., 2004)

Tserng and Lin (2004) conducted a research on the application of KM in construction projects and proposed a construction activity-based KM model for contractors. “Activities-based” can be defined as information and knowledge from all projects, classified and stored as activity units similar to project scheduling. This model was developed with the aim of simplifying the collection and re-using knowledge in construction projects. It represents activities and processes that is necessary for a successful implementation and use of KM systems.

The research used the Integrated Definition function (IDEF) modeling method to provide a prototype used for KMS in the construction projects. IDEF is a series of techniques developed during the 1970s by the U.S Air force in a programme to increase manufacturing productivity through the application of computer technology (IDEF0, 1993). The method adopted composed of techniques including IDEF0 that is used to provide a structured representation of the functions, activities and processes within a system; IDEF1 represents the structure and semantics of information within a system; and IDEF2 represents the time varying behavioural characteristics of a system (IDEF0, 1993).
IDEF0 is divided into more detailed lowered level programmes and consists of a hierarchical series of diagrams and text that includes a top-level diagram. Tseng and Lin (2004) used the above modeling method to achieved successful implementation and uses of KMS to represent activities and processes to inputs, controls, outputs and relationships among the various activities. Fig 1.5 above presents the top-level IDEF0 context diagram that represents five main activities of KM. Each one of these main activities is sub-divided into more detailed subdivisions and presented by using lower levels of IDEF0.

![Fig 1.5: KM process model (Alavi, 1997, KPMG, 1998)](image)

This model explains the KM process in a consulting firm, and described KM as the creation, leveraging, sharing of know-how and intellectual assets by all participants in the firm for the betterment of the output of their product and client’s satisfaction (KPMG,1998 and Alavi,1997). The model developed by KPMG consists of a sequence of six phases such as acquisition, indexing, filtering, linking, distribution, and application. Acquisition refers to knowledge creation and content development. This is accomplished by distilling experiences and lesson learned from experts, engineers and client commitment in the projects, by collecting, synthesizing, and understanding the multiplicity of information. The next three phases are referred to as the library management activities that include screening, classification, cataloguing, integrating, and interconnection of content from both internal and external sources. The distribution phase includes packaging and delivery of knowledge in the form of web pages such as designing knowledge displays, templates, graphics and creation of multimedia formats. And the application phase refers to uses of the knowledge that has been collected, captured and delivered to produce products and services.

![Fig 1.8: IMPaKT Model (Robinson et al, 2004)](image)
Fig 1.8 above highlights three stages strategies approach for improving management performance through knowledge transformation. The first stage targets the strategic context of business problems and their KM implications and also formulating a business improvement plan. The second stage elucidates the knowledge problems identified in the first stage and focuses on the implementation of KM strategy to address these business problems or the business set objectives. The last stage evaluates the significant impact of KM on business performance.

Fig 1.9: Diamond organisational model (Leavitt, 1965)

The diamond organisation model in fig 1.9 above has been generally accepted and adopted by many researchers as basis for understanding KM in organisation. Organisations are regarded as a complex system with four important variables: task, structure, technology and humans that interact to effect changes in the organisation (Leavitt, 1965). Fig 1.9 shows the four groups of variables that are highly interdependent on one another; any change in one usually results in compensatory or retaliatory changes in others. Based on fig 1.9 task are the goods and services that organisations produced or performed (such as construction, procurement, demolition and alteration, etc). Structure is the system of communication, authority and work flow within the organisation such as distribution of power and shape in organisational forms. People are the workers or personnel (professional, experts engineers and others skilled works) in CE organisation firms with intelligence, competence and good behaviours. Technology, sometimes referred to as information technology (groupware, internet, intranet, mobile phone and databank) is considered as a separate component due to its strategic importance in supporting the process of knowledge creation, sharing, application and storage, as well as to improve the communication between individuals, group, organisational and inter organisational knowledge (Kanapeciene, Kaklauskas et al. 2010).

4. Summary of the models

The summary of the above models developed by many researchers in different locations and perceptions are as following. Demerest KM models is seem very important because it does not give a precise meaning of knowledge but only present a more holistic approach. However Mc Adam and McCreedy modified Demerest model by including the influence of social and scientific paradigms that actual show the rapid flow of knowledge transfer and circulatory and the makes the people look knowledge as being of economic use in regard to organisation outputs. The lapse in the two models is lack of outline the knowledge creation, capture, storage in the organisation. Nonaka and Takeuchi model explained the interaction of explicit and tacit knowledge through socialisation, externalization, internalization and combination. The model outline how knowledge can be created, captured, and acquired through interactions, but the main lapses with this model is that knowledge storage and sharing for re-use were not explained in the model. However Meclnerney argued that emphasis should be placed on creating knowledge culture that would certainly address issues of creating trust, facilitation of collaboration and
knowledge sharing. Since all the information is linked together and integrated into model that increase the profitability, improve processes, product and customer relations.

The activity based and map –based KM model was developed for the contractors to classified and stored all information and knowledge activity unit similar to the project scheduling for easy retrieving and utilizing, but the ways and procedure to retrieve, share such information was not shows in the model, this implies the need for more research work to validating the model by including the procedure to retrieve and sharing of knowledge.

KM process model seem to be simple and easily to understanding because of it nature of arrangement, it start with Acquisition of knowledge to indexing, and end in distribution (sharing) of knowledge for re-use. This model can be applied to any business organisation.

IMPaKT model was developed to address the business objectives and organisation knowledge based and management performance. The strategy were map out for the three stages involved to make it easy for implementation such as business strategy, KM strategy, and evaluation KM strategy.

Leavitt’s diamond organisation model has been accepted by many researcher and scholars in knowledge based organisation. The model outlines four significant variables that are essential for a model to be implemented in any construction firms such as structures, technology, task and people. These are four variables used for the development of KM model with followings purposes: knowledge creation, capture, acquiring, updating, transferring, storage and sharing. However the new KM implementation framework is developed based on these four variables, since these variables encompass all lapses mentioned in the above models. Conclusively the new KM implementation framework is developed by considering all the sectors of KM in the CE construction firms such as knowledge creating, capturing, structure, map, storage, sharing, acquiring update and utilization.
The summary of above models (from the above models the steps involve in implementation of were outline in different ways such as knowledge creating, storage, transfer, sharing, and updating. However leavitt’s diamond organisation model outline the four important variable for model to be developed.

The New KM implementation framework of model will be developed in circular form combined the ideas of the above models. In order to address the challenges face in term of managing knowledge in Road Construction Company.

The aim of the New KM implementation framework of model was to create understanding on how to manage knowledge in Road Construction Company in Nigeria in order to avoid time and cost overrun, poor planning and designing, achieved quality project delivery.

Fig 1.10 outlines the link to development of new circular KM implementation framework.
5.0 New KM implementation framework developed for CE Construction Firms

Fig 1.10: The circular KM implementation framework for CE Construction firms.

6.0. Discussion of the model

The circular KM implementation framework for CE Construction firms shown above was developed to simplify and improved awareness of the concept and theory of KM in CE Construction firms and it start by identifying the types of knowledge need in CE Construction firms such as knowledge in construction domain like domain knowledge, organization knowledge, project knowledge and environmental knowledge. However the steps involved are explained as follows: Knowledge creation in the above KM implementation framework means exploring the knowledge in the organisation and this process lead to focus on individual, group and department knowledge. Hence the construction projects knowledge are created when reviews the lesson learned during the construction stage, by examine the problems and their solutions encountered during the construction stage. These signify with the arrow lead from likely problems of construction projects box to knowledge creation box. Two form of knowledge
appear while creating knowledge. These are tacit and explicit knowledge that embedded in the CE construction firms. Tacit means individual knowledge or experiences while explicit means technical or academic data or information that is described in formal language, like manuals, mathematical expression, Bill of Quantities, specification, article of agreement and condition of contract etc. However knowledge capturing is the second most important in the above new KM implementation framework, hence the construction projects knowledge are generated on daily basis and if not capture and stored the bulk of knowledge generated will lost. Therefore knowledge capture is a way of collecting the knowledge created and stored in the database for re-use. Example during the construction stage of projects most project-related problems, solutions, experience and know-how are in the minds of individual engineers and experts. Tacit knowledge is not normally documented or stored in a system database. Capturing tacit knowledge and make it available as explicit knowledge is essential in the construction firms. The main driver for KM in construction is need to encourage continuous improvement, to share valuable tacit knowledge, to disseminate best practices, to respond to customers quickly, to reduce rework and to develop new products and services respectively (Kivrak et al., 2008).

Consequently knowledge structures in the above new KM implementation framework of model is based on sorting, organizing, codifying, analyzing, and reporting information that provides information retrieval which organisation needs in the future. Awad and Ghaziri (2004) described dynamic processed by which technical communication infrastructure which includes structuring database, organizing data for analyzing, taxonomy of data, clustering/ managing databases. Knowledge structures categorize data and information through certain types of classification tools and enables for retrieving this information timely. This implies that mapping, storing are the main two significant components of the knowledge structures. Knowledge sharing is the process that involves creating knowledge by individuals and groups with their interaction and relationship of the employees in the organisation, and usually takes place in social and technical channels (Al-Ghassani et al, 2002). Jieh-Haur (2008) highlighted the ways and tools used for effective knowledge sharing such as: Formal social communication network, Informal social communication network, Teamwork, Communities of practices, Organisational learning, Rumors and, Formal structured technology communication networks (e-mail, mobile communications, teleconferences, video conferences, etc.). Knowledge acquisition in the above new KM implementation framework is connected with all construction project life cycle activities. Knowledge is acquired through the interaction and relationship with the knowledge experts in the construction industry such as clients, designers, consultants, stakeholders, contractors and inspectors. The commonest practice in the construction industry is that a senior Engineer will collect related information/documents and converts it into digital format. After the information/document has been digitized, the senior Engineer writes descriptions/notes enclosing that digitalized information and packages as knowledge for submission (Tserng, 2004; Egbu & Botterill, 2002). Knowledge update in the above new KM implementation framework means a process where the existing knowledge can be improved to meet the organisational desire. Tserng, (2004) described knowledge update as the feedback from various users which has put back to the KM system and update the knowledge for re-use. Knowledge utilization means ways in which construction workers utilized the knowledge such as to determine the organisation’s work processes, and making strategies for sustainable competitive advantage. Knowledge is exploited for designing and quality product to meet market competitive advantage and lastly knowledge are also used to play crucial role in the organisation for making good quality services delivery.
The last stage in the new implementation framework is the knowledge gained from the new experiences, know-how, and problem solving solutions from the construction projects.

Conclusion

This study has extensively reviewed the previous knowledge models developed by many researchers to gained views and concept of developed new KM implementation framework. The reviews of the works of past scholars and researchers played a predominately role in the development of the new knowledge new KM implementation framework. It was observed from the previous models developed were mostly focusing on defining knowledge, knowledge processes, knowledge management and business solving problems.

The new circular KM implementation framework was developed to simplify the way of KM implementation in CE Construction firms. The model identifies KM as a tool for delivering competitive advantage, and improved the customer’s satisfaction. This model was developed in circular form for easy understanding and implementation such as when knowledge is created, capture and structure, if is not share properly it return to problems areas to create new knowledge and if share accordingly easy to acquire, update the existing one, and utilized. However if it has been acquired, update and utilized, simple to implemented in CE construction firms to face the challenges of competitive advantages and achieved client’s satisfaction. The paper concluded that, the implementation of this KM framework depends on the commitment, attitudinal behaviours, dedication and personal interest of the top management and employees in CE construction firms. Therefore the paper recommended that CE construction firms in Nigeria should established a standard code of practice for KM to be fully implemented in their organisation.
References


Egbu C.O and Botterill C (2002) Information technologies for knowledge management; their usage and effectiveness, ITCON Vol 7 special issues ICT for knowledge management in construction Pg125-137.


Kivrak S; Arslan G; Dikmen I; and Birgonul M.T (2008) capturing knowledge in construction projects: Knowledge platform for contractors. Journal of Management in Engineering @ASCE VOL24.87-95

Leavitt, H (1965) Applied organizational change in industry: structural, technological and humanistic Approaches, in March (ed). Handbook of organizations, Chicago rand McNally &co

Lin, Y; Wang, L and Tserng, P (2006) Enhancing knowledge exchange through web map-based Knowledge management system in construction: Lessons learned in Taiwan, Automation in construction, 15 (6), 693-703


Robinson, H; Carrillo, P; Anumba, C; and Al-Ghassani, A (2004) Developing a business case for Knowledge Management: the IMPaKT approach; construction management and Economics, Vol.12, No 1, pp733-743