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Knowledge management in industrial design: A key factor in Metal/Jewellery, ceramics and graphic design

[1] Yohanna Ogbu Egiri, [2] Enoch Gotring Wuritka

[1, 2] Department of Industrial Design, Abubakar Tafawa Balewa University, P.M.B. 0248 Bauchi, Nigeria

Abstract
Knowledge is usually developed by individuals on the basis of day-to-day work and, as such, knowledge is a continuous manifestation of interactions between people, within and outside the organization. This paper discusses some important phenomena of knowledge management in industrial design with the view to bringing it to the designers' domain for its application on product design. To this end, the competitiveness of an organization can be achieved and the knowledge sharing and integration process can generate new knowledge for the effective practice of Industrial Design which is the key factor in Metal/Jewellery design, Ceramics design, Graphic Design and other kinds of Design.

Keywords: Knowledge, knowledge management, Knowledge Management in Collaborative Product Design

Introduction

The ability to manage knowledge is crucial in today's knowledge economy. Knowledge belongs to the family of steadily increasing corporate assets, like management systems, brand identity, customer information and corporate reputation (Pascarella, 1997). Knowledge is a human, highly personal asset and represents the pooled expertise and efforts of networks and alliances. Reportedly, 99% of the work people do is knowledge based (Wah, 1999). Knowledge seems invisible, but it clearly drives the bottom line (Pascarella, 1997). The value of knowledge is increased when it has a key purpose and focuses on mission, core values and strategic priorities. Knowledge assets, like money or equipment, exist and are worth cultivating only in the context of the strategy used to apply them (Stewart, 1997)

The creation and diffusion of knowledge have become increasingly important factors in competitiveness. More and more, knowledge is being thought of as a valuable commodity that is embedded in products (especially high-technology products) and embedded in the tacit knowledge of highly mobile employees. While knowledge is increasingly being viewed as a commodity or intellectual asset, there are some paradoxical characteristics of knowledge that are radically different from other valuable commodities. Knowledge management consists of "leveraging intellectual assets to enhance organizational performance" (Stankosky 2008).

Knowledge management was initially defined as the process of applying a systematic approach in the capturing, structuring, management, and dissemination of knowledge throughout an organization to work faster, reuse best practices, and reduce costly rework from project to project (Nonaka and Takeuchi, 1995; Pasternack and Viscio 1998; Pfeffer and Sutton, 1999; Ruggles and Holtshouse, 1999). A good definition of knowledge management would incorporate both the capturing and storing of knowledge perspective, together with the valuing of intellectual assets. Although there is still a lack of consensus over what constitutes a good definition of knowledge management, there is a general consensus as to the goals of an organization that undertakes knowledge management. Nickols (2000) summarizes this as "the basic aim of knowledge management is to leverage knowledge to the organization's advantage."

Therefore, Knowledge management can simply be defined as the deliberate and systematic coordination of an organization's people, technology, processes, and organizational structure in order to add value through reuse and innovation. This is achieved through the promotion of creating, sharing, and applying knowledge as well as through the feeding of valuable lessons learned and best practices into corporate memory in order to foster a continuous organizational learning.

Knowledge management solutions have proven to be most successful in the capturing, storing, and subsequent dissemination of knowledge that has been rendered explicit particularly lessons learned and best practices.

The focus of intellectual capital management (ICM), on the other hand, is on those pieces of knowledge that are of business value to the organization referred to as intellectual capital or assets. Stewart (1997), defines intellectual capital as "organized knowledge that can be used to produce wealth".

Knowledge management

The words knowledge and management are two very broad concepts when separated. When the two words come together, it speaks of a concept that strives to organize information in a way that produces an advantage for an organization. Knowledge management is the concept under which information is turned into an actionable knowledge and made available effortlessly in a usable form to the people who can apply it. (Information Week, Sept. 1, 2003). Knowledge management is a collaborative and integrated approach to the creation, capture, organization, access and use of an enterprise's intellectual assets. (Grey, 1996)

Wiig (1993) proposed that knowledge management is a group of clearly defined processes or methods used to search

important knowledge among different knowledge management operations. Knowledge management was alternatively used to confirm new product strategies and strengthen human resource management in achieving the enterprise's goals. Because the main objective of knowledge management is knowledge innovation, each organization member can increase his knowledge through the spiral course of socialization, externalization, recombination and internalization. The competitiveness of an organization is thereby achieved and the knowledge sharing and integration process can generate new knowledge. Ler (1999) pointed out that knowledge management involves collecting information and transferring information to demanders. Such activities, including knowledge obtaining, knowledge refining, knowledge storing and knowledge sharing, can effectively increase the value of the knowledge asset in an organization. This is called knowledge management. Knowledge can be understood to emerge from the application, analysis, and productive use of data and/or information (Hislop, 2005).

Knowledge management in industrial design is imperative because of the increasing nature of competitive market and the design needs of consumers. When this knowledge is at the disposal of industrial designers, specialist in Metal/Jewellery, Ceramics, Graphic design, etc would be able to come up with innovative design that would address the design needs of consumers; thereby making life more meaningful to humanity.

Knowledge Management in Collaborative Product Design

With the development of research on collaborative product design, it was found that collaborative product design was essentially knowledge-intensive work, and knowledge management was of significance to collaborative product design. Knowledge management which utilizes collective intelligence to enhance the adaptability and innovation capability of an enterprise is a method for sharing explicit knowledge and tacit knowledge. Knowledge management includes several aspects: building knowledge base; promoting knowledge sharing between employees; constructing cultural climate in internal environment; managing knowledge as enterprise assets. Many big companies, such as IBM and HP, have been implementing knowledge management strategy.

Collaborative product design task involves decision-making processes that require evaluation, comparison and selection of design alternatives as well as eventual optimization from a systematic perspective (Xuan, 2008). Due to its significance in commercial value and application perspective in the area of knowledge economy, collaborative product design is attached great importance to knowledge management. Balasubramaniam and Amrit, (1999) focused on providing support for a collaborative task with emphasis on capturing process knowledge in collaborative systems which include functions for representing context with informal components, accessing the processed knowledge, reviewing past knowledge, and managing the dependencies of tasks. Vincent, Bertrand and Philippe (2007) are particularly interested in knowledge exchange and share during collaborations of product design. They proposed a model of design context to support design process and knowledge exchanges, and further studied the particular case of conflict resolution during collaborative design by using software which formalise designers' exchanges in a real industrial conflict.

Types of Knowledge

- Tacit knowledge
- Explicit knowledge

Tacit knowledge: Tacit knowledge is personal; it is stored in the brains of human beings. It is accumulated through study and experience. It is developed through the process of interaction with other people. Tacit knowledge grows through the practice of trial and error and the experience of success and failure. Tacit knowledge does not always lead directly to a useful application or a marketable product. Often it has only an indirect impact on the organization's effectiveness through the creation of better approaches or more effective work responses. Nonaka (1991) popularized the concept of tacit knowledge by highlighting the problems of the previously narrow approach to knowledge, and suggesting a more holistic approach of capturing tacit and often subjective insight, experiences and intuitions of personnel. Tacit knowledge is necessary to create new value in a product. It is generally gained over a long period of time with learning and experience, it is difficult to express, and can only be transferred by the willingness of people to share their experiences. Unfortunately, this knowledge is lost with the loss of the person.

Explicit knowledge: Explicit knowledge is codified; it is stored in documents, databases, websites, emails and the likes. It is a knowledge that can be readily made available to others and transmitted or shared in the form of systematic and formal languages. Explicit knowledge is embedded in product documents, repositories, product function and structural description, problem solving routines, technical and management systems.

Knowledge in Industrial Design

Knowledge is not directly available but is obtained by interpretation of information deduced from analysis of data. It can be said that the primary function of industrial design research is to transform empirical or rational knowledge into a form that can be used for practical purposes. Sainter *et al* (2000) describe knowledge as the "experience, concepts, values, beliefs and ways of working that can be shared and communicated". Sriram (1997) describes knowledge in the context of intelligent engineering systems as "something that an intelligent being possesses and utilizes for problem solving". Sunnersjo (2010) uses the word 'knowledge' in terms of design as an understanding of a given information, its content, its origins, and its applicability. He argues that "the knowledge should include not only the rules that designers should adhere to, but also the background knowledge that makes the design rules possible to review and understand".

Industrial design is a field that blends together art and engineering with the general goal of creating an object for production. This discipline focuses around objects of industry. Industrial design is a multi-disciplinary field that involves many other aspects of design including graphic design, packaging, furniture, ceramics, metal/jeewelry design and many more. Industrial design basically combines applied art and applied science with solid business acumen to create and design a product that is functional, useable and aesthetically pleasing to the eyes. But this cannot be realised without the proper management of knowledge. The understanding of knowledge

management within the context of industrial design is necessary for product innovation which can be shared and applied on product design.

Knowledge Innovation and Creation Process

Knowledge innovation is tacit in nature but it can be converted to explicit knowledge. Before innovation can take place, there must be pool of knowledge to derive the innovation process. Innovation is the practical application of knowledge. An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (Oslo Manual, 2005). The minimum requirement for an innovation is that the product, process, marketing method or organizational method must be new (or significantly improved) to the firm.

Knowledge creation always begins with the individual. An industrial designer has an intuition about market trends that becomes the catalyst for an important new product concept. In the above scenario, an individual's personal, private knowledge (predominately tacit in nature) is translated into valuable, public, organizational knowledge. Making personal knowledge available to others in the organisation is at the core of this knowledge management model. This type of knowledge creation process takes place continuously and occurs at all levels of the organization. In many cases, the creation of knowledge happens in an unexpected or unplanned way. Knowledge creation consists of a social process between individuals in which knowledge transformation is not simply a unidirectional process but it is inter- active and spiral (Nonaka and Takeuchi 1995).

Knowledge is one of the most important assets of any organization. Unfortunately, very few are able to harness this asset in a meaningful way. Even fewer are organizations that are able to optimize the use of this important asset.

Collaborative Design management

With the increase in globalization, the amount of information about the product that needs to be managed and shared across various developmental waves is quite enormous. Rapid advances in information technology have provided the platform for the distribution of CAD system to support collaborative design, which allows the designers to view and modify the product model to their satisfaction.

The organizational structure of collaborative design is fashioned in such a way that it allows interaction and knowledge sharing among the team of designers whose features are dynamic. In such structure, a designer may involve in several projects, and a project is composed of designers from different design departments and units of various enterprises who would work in synergy towards the actualization of the project at hand. Collaborative design is a process that consists of a series of distinct events that occupy discrete and measurable periods. This mean, collaborative design can be seen as a series of discrete activities and that the level of expertise affects the way work is done, being discernible in the temporal pattern of their work of time. Kvan and Vera (1998) suggested that designers act as individual experts addressing design issues from their perspectives. Their expertise may change during a design session as their understanding is supplemented and they earn from their involvement.

In the process of collaborative design, task is accomplished through serial interactive activities which are performed by collaborative designers. Designers working on a same project often appear to be temporally and spatially distributed. Thus, quite a lot of time is spent on planning, tracking, and coordinating in the process of collaborative product design (John 1996). During the process of design, the designers should communicate and share knowledge with each other on collaborative product design, and share modification of the product. Based on the outcomes of activities accomplished by A and B, designer C performs serial actions to achieve the goal of task. Similarly, C should communicate and share knowledge with A and B. With the increase of task complexity and the number of collaborative designers, efforts concentrated on commutation and knowledge sharing would build up and the scenarios of interaction and would become much more sophisticated. This reflects the urgency of knowledge management in collaborative product design.

Application of CAD on Industrial Design

Computer Aided Design (CAD) defines the use of information technology (IT) in the Industrial Design process. A CAD system consists of IT hardware, specialised software (depending on the particular area of application) and peripherals, which in certain applications are quite special. The core of a CAD system is the software, which makes use of graphics for product representation, database for storing the product model and drives the peripherals for product presentation. Its use does not change the nature of the design process but as the name suggests, it aids the Industrial designers to make their designs. The designer is the main actor in the process, in all phases from problem identification to the implementation phase. CAD can aid a designer in the following ways:

- Accurate generation and easy modification of graphical representation of the product. The designer can nearly view the actual product on screen, make any modifications to it, and present his/her ideas on screen without any ambiguity, especially during the early stages of the design process.
- Perform complex design analysis in short time.

CAD systems have the ability to provide a digital prototype of the product at early stages of the design process, which can be used, for testing and evaluation. Many people from various departments can share it; they can express their opinion for the product at early stage, in order to complete the design in less time and with the least mistakes. Most researchers accept that having the digital prototype in early stage allows more effort to be spent on the definition stage (early stage) of the design process and not in redesigning an already completed design.

Computer Aided Industrial Design systems are applied to many industrial products, ranging from every day consumer products, sports-ware, computers, equipment, and complex parts such as automobile.

Graphic Design

CAD aids graphic designers to Create a compelling visual effects for films, games, or television shows. Maya 3-D animation software and 3-D modelling and animation software enable one to create sophisticated effects, design innovative experiences, and improve production efficiency.

Metal/Jewellery Design

CAD design software is used throughout the product development cycle. From concept to manufacturing, Autodesk software is used to create consumer products such as (jewelleries, seats, etc), industrial machinery, building product and equipment. The Digital Prototyping tools such as Inventor and Product Design Suite help designers and engineers design, visualize, and simulate complete products, before they are built. Digital Prototyping helps reduce reliance on physical prototypes and get more innovative products to enhance marketing.

Ceramics Design

CAD helps in creating geometric shapes of intended ceramics design before they are produced. CAD systems in 2-D and 3-D are used to visually draft curves and figures of ceramics designs. Digital Prototyping tools such as Inventor help to create, document, and share designs, while CAD helps in creating and managing modelling and instrumentation diagrams.

Stages of Industrial Design process

Knowledge management is key in these stages of industrial design process. Because the process cannot take place without the knowledge of what the designer intends to do. The industrial design process runs through a number of stages to bring a product from concept to full market production, these stages include:

- **Design Brief Stage:** this is the stage where Designers meet with a client or company's manager that has an idea for a new product. They will basically look to find out the basic requirements of the client's design brief and gain an understanding of what the product is meant for, before they bring their creative tacit knowledge to bear.
- **Market Research Stage:** Once they have gained an understanding of the brief, the industrial design process will enter the market research stage. During this process the designers will conduct surveys, meet with target customers and take in trade shows covering similar products. The aim of the market design stage is to establish that there is a viable market for the product being developed. Market research also involves the initial stages in the design of the product, where the designer will try to establish the basic characteristics of the product. This can include details such as the basic size and shape of the product, materials to use, estimated cost of production and the safety of the product. Without gathering this information from the target consumers, the designers would not have the knowledge of what to design that would meet the consumers' needs.
- **Design concept Stage**: At this stage of the industrial design process, designers will try to produce a basic design of the product. This can be done by hand in the initial stages, although most designs these days are done using Computer Aided Design (CAD) tools. These make it easier to amend designs as they develop and the final information can be used by automated industrial machines during manufacturing. But for one to use CAD he/she must have the knowledge of CAD. Therefore a proper knowledge management of the information gathered during market research and the designer's tacit knowledge in conjunction with the explicit knowledge will aid during the design concept stage.
- **Design Refinements Stage**: Once the concept design has been completed, input from the client, engineers, accountants and others will generally result in the design being refined for a variety of reasons. This can include improved appearance, better functionality or more cost effective production. Industrial designers typically liaise with a number of other professionals in the course of their work to ensure that any product brought to market has been tested and refined to make it the best it can possibly be. Prototypes may also be produced at this stage to let consumers use the product and feedback from this can result in design refinements.
- **Production Stage**: Once the final design has been approved, the industrial design process enters the production stage. Designers will generally have an input in the initial stages of this to ensure that the product can be manufactured in a cost effective manner. After production of the product, the product is then ready to be marketed to the consumers.

The various knowledge at different stages of industrial design process, are coordinated and controlled by the designers who are the architects of the product design.

Conclusion

With the increase in evolution of knowledge owing to availability of information technology, knowledge management has become a crucial phenomenon in the practice of industrial design. Designers all over the world have embraced this technology as a medium of information dissemination and knowledge sharing platform. Once this knowledge is acquired, it requires careful management in the course of its application on product design. This knowledge management is a key factor in the execution of all aspect of design such as metal jewellery design, graphic design, architectural design, ceramics design and so on. Preponderance of relevant knowledge makes innovative design easier, as all the necessary information is at the disposal of the designers. Innovation is spurred by careful coordination of both the tacit and explicit knowledge which are necessary resources for every meaningful innovation.

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