Breaking Down Innovation: New Tools for Project Managing Innovative Projects

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Abstract
Project Managers have a reasonably comprehensive toolbox of management techniques to tackle all but the most critical area of the project: That of the idea generation process. The idea generation process is still very much regarded as a 'black-box' from which a concrete solution to a problem will somehow emerge, and from which a Work Breakdown Structure can then be developed. Yet without a methodology to actively monitor and manage this idea generation process which, after all, is the key to the success of the project, how do we ensure that the project manager and the product development team can effectively do their jobs?

The Design Breakdown Structure acts as a precursor to the traditional Work Breakdown Structure, and allows the idea generation process to be graphically mapped and monitored. The Design Breakdown Structure is proposed as the basis of effective project management and communication for collaborative projects.

Key Words: Work Breakdown Structure (WBS), fuzzy front end, project management, new product development, Design Breakdown Structure (DBS), idea generation, mapping innovation, functional fixedness, management and control of innovation, project management tools.

Introduction

Almost all projects undertaken ultimately involve the delivery of a product, be it a physical consumer product, a new road infrastructure, or an improved service to the community. One of the many ways of differentiating these project types is through the level of innovation that will be required to produce an acceptable solution.

Mantel, Meredith, Shafer and Sutton propose a model based on the extent of change required to organization's processes and products, as shown in figure 1. They classify projects based on the extent of innovation as: derivative, breakthrough, platform and R&D projects, and suggest that an organization's success is determined by the organization's portfolio of projects (Mantel et al, 2001).

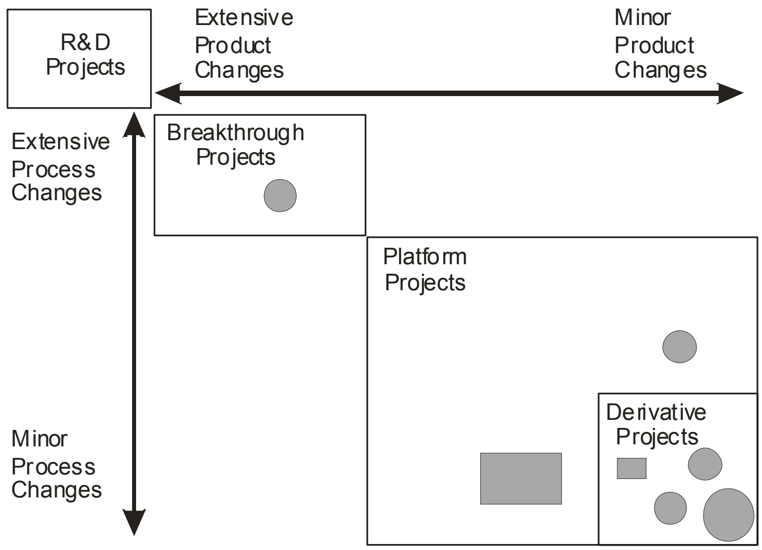

Fig 1: Level of innovation based project typology

Booz, Allen & Hamilton (1982) reported that for every seven projects at the idea stage, only one becomes a success. There are many other studies that reflect this number, and what this tells us is that the energy spent on innovation needs to be tightly focused so that those ideas that have the highest potential are quickly identified to give them a greater likelihood of success.

Within the field of modern project management, a Project is broadly defined as an activity of finite duration with the ultimate delivery of a defined goal (Wideman, 2000). Therefore one should, in theory, be able to apply standard project management practices to any projects, irrespective of the level of innovation they require, and thus be able to effectively manage them and deliver better products that delight the customer and are on time and on budget.

Though current project management practices do undoubtedly help in managing 'run-of-the-mill' type projects (such as many construction projects, for example), they are somewhat lacking in their ability to help manage the factors often required by projects that require 'innovative' outcomes (such as radical new products, or completely new services to the community). This effect is magnified when one examines projects that are constrained by tight deadlines as many often are.

Most project management models contain a number of distinct phases or stages that can be drawn somewhat along the following lines:

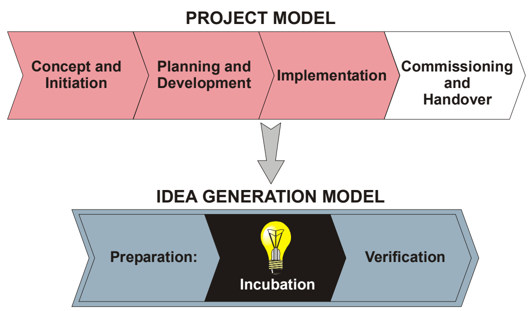

Fig 2: Models for Project, Product and Idea Generation

Each of these phases is further broken down as required and each phase has a reasonably well-defined number of tools, techniques and methods developed to help control it. It is these methods and techniques that allow designers and project managers to control their projects.

Within the models, one area that is invariably under-defined in terms of methods and techniques for control is that of the Idea Generation stage, which is usually described as a "black-box" process (Incubation, germination and Illumination are other words often used to describe this process) in which various inputs are entered, and over an undefined period of time, something magically occurs and a good, workable idea is generated as an output. (Amabile, 1989, Kmetovicz, 1992, Rosenthal, 1992, Reilly, 1999, etc.)

What this means from a project management point of view, is that the manager has an extremely comprehensive toolbox of methods and techniques to deal with all but the most vital area of his project, that of generating the ideas that will make his project a success, and tell him what the very project he is working on actually involves.

This paper proposes the concept of the Design Breakdown Structure (Diegel, 2003) as the basis of a project management tool to help manage projects requiring high levels of innovation.

Before one can begin to truly manage innovation, one must first gain an understanding of the cognitive processes involved in innovation

A Perspective View of Innovation

Though the end product of innovation is about the new, the process of innovation is about the old. In the words of Gerald F Smith, "We cannot imagine anything whatsoever, only things constructed out of existing knowledge. I cannot imagine a color beyond my visual experience" (Smith, 1998).

Innovation is about finding new uses for things we already know. We cannot think of anything, new or old, that is not already stored in the knowledge banks of our minds. If we recall something from long-term memory without attempting to alter it, then it is just that: a memory. But if we take that data we have in memory, and use it for a different purpose than it was originally intended or if we take two bits of data and combine them to form something new and useful, then that is innovation. The process of innovation is therefore about taking existing knowledge and data and converting it into something novel and useful. (Barnett, 1953, Amabile, 1983).

So, if innovation is about using and adapting things we already know, then why is it so difficult to control? Is it completely random, or do we have some amount of mental control over the process? To try and understand these questions, we need to look at some background cognitive theory on how our brain thinks and resolves problems.

Mainstream cognitive theory behind how we think is relatively straightforward: We receive environmental inputs that are stored and processed in short-term memory. We are limited to around seven simultaneous external stimuli, and only a very limited amount of data can be stored in short-term memory for very a limited time (around 7 items for between 5 and 20 seconds). Short-term memory includes a scanning process that continuously scans the data stored in this buffer and determines its usefulness, and then either refreshes it or discards it. The results of working memory can be used to recall other data from long-term memory as, and when, required. (Blumenthal, 1977, Ellis, 1978).

Long-term memory could be compared to a hierarchical semantic database in which extra time is required (approximately 0.75msec) for each extra level of the database you descend to (Collins & Quillian, 1969). The links that join the nodes of data in long-term memory can weaken or get corrupted or broken with time, thus explaining memory loss or incorrect memory retrieval. Each data node can be stored as a mental representation of a single bit of data, as an image or, in the case of often used bits of data, as 'chunks' of data in which an entire concept is retrievable in a single operation (Collins & Quillian, 1969, Birch & Clegg, 1996).

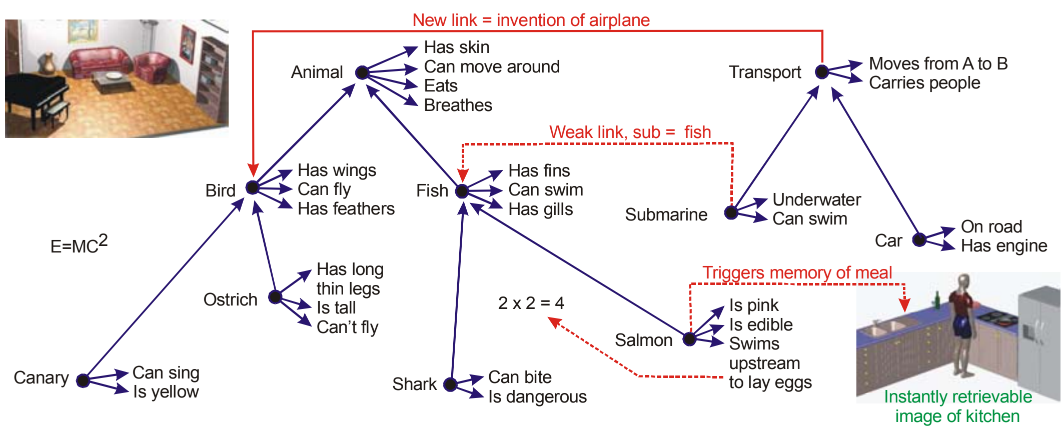

Fig 3: Long term memory hierarchical semantic database

When short-term memory attempts to retrieve data from long-term memory, it can follow any of a great number of data link paths to reach the data it wants to retrieve. It is our ability to create new links and choose which existing links to follow through our long-term memory database which allows us to be innovative.

If we follow a path of existing links, a memory is recalled. If we create a new link between one bit of data and another that was previously unrelated, or if we follow a link that would not, under normal circumstances, be associated with the current data in short-term memory, then that is a new thought.

One of the principles of Gestalt theory (in which human beings are viewed as open systems in active interaction with their environment) is the law of Prägnanz, which states that psychological organization will take the route requiring the least effort or energy in the achievement of the spatial and temporal stability of experience (Wertheimer, 1938). To put it crudely, it implies that the mind is lazy and will look for the simplest and most obvious links in long-term memory first. What this also implies is that thinking innovatively requires directed effort and a conscious decision to expend the extra energy required (Blumenthal, 1977).

The Mathematics of Innovation

It is of interest to do some simple mathematical calculations in order to try and grasp the level of innovation that our minds are capable of. Based on the basic numbers suggested by mainstream cognitive theory we know that short term memory is capable of containing seven items at any one moment in time, and that scanning long-term memory requires approximately 0.75msecs per node traversed (Blumenthal, 1977, Ellis, 1978, Collins & Quillian, 1969, Birch & Clegg, 1996, Duncker, 1945).

Based on the assumption that innovation is in fact based on our ability to recombine or find new uses for knowledge we already possess, one can do a calculation of possible combinations.

A combination of ***n*** taken ***m*** at a time is defined as a selection of ***m*** out of the ***n*** items without regard to the order. The total number of all the possible combinations is denoted as:

$$C_m^n = \frac{n!}{m!(n-m)!} = \binom{n}{m} = \binom{n}{n-m} \quad \text{where } n \geq m$$

Repeating and summing this equation for the seven items in short-term memory in groups ranging from one to seven tells us that at any one instant we have the potential for 127 new combinations in memory, which also means that at any one moment in time we have the potential for 127 innovations.

This assumes however that we think in combinations only, and not permutations, which is not necessarily the case. In other words, is our innovative outcome identical if we consider the concept of an apple combined with an orange, as opposed to an orange and an apple? If one considers that we may have different innovative outcomes based on permutations of the data in short term memory, then the total potential for innovations can once again be calculated:

A permutation of ***n*** taken ***m*** at a time is defined as an ordered selection of ***m*** out of the ***n*** items. The total number of all the possible permutations is denoted as:

$$P_m^n = n(n-1)(n-2)\cdots(n-m+1) \quad \text{where } n \geq m$$

Once again using the seven items in short-term memory, this calculation suddenly expands the number of innovative outcomes from 127 to 5913.

Taking these numbers a step further to calculate our innovative potential over a period of one second we find that over a period of 1 second, we have the potential to traverse 1333 data items in long-term memory (based on 0.75msecs per node) and process them in short-term memory. Repeating the combination and permutation calculations based on this number, we can now calculate that, over a period of one second, we have the potential for 16,291 innovations based on combinations, or 7,882,209 based on permutations.

Now, whether we take the lower or the higher of these two numbers, we can see that we have a tremendous potential for innovation at any one time. This then raises the question as to why we therefore have so much difficulty in thinking innovatively.

Functional Fixedness: A Roadblock to Innovation

One of the main mental barriers that prevent us from easily forming new ideas with existing data is functional fixedness (Duncker, 1945). Functional fixedness is the effect of only being able to see something for what we have traditionally been taught it is by our education, environment, culture, etc.

A commonly used example of functional fixedness is Maier's two-string problem (Maier, 1931). In this problem, the subject is in a room with two strings tied to the ceiling. Both strings are of equal length. The objective is to tie the ends of the two strings together. The problem is that while the strings are long enough to be tied together they are short enough that one is unable to just take hold of one string, walk over to the other string, and tie them together. In Maier’s worst-case example, the only object in the room is a pair of pliers.

About 60% of the participants in Maier's study failed to find a solution within a 10-minute time limit. These participants saw the pliers only as the traditional tool they are, not recognizing that the pliers could be used as a pendulum bob, swinging at the end of one of the two strings, allowing one to hold the first string and wait until the other, weighted by the pendulum, swings to within reach.

Most of us have difficulty in seeing the pair of pliers in the above example, as anything other than a tool as that is what we have always been taught they are. Through force of habit, we are fixated by the fact that the objects function is that of a pair of pliers. If we can overcome this fixedness, then we can see that they could have many other uses. The pair of pliers could be used as a weight (paper-weight, pendulum weight, weapon, fishing sinker, etc.), an electricity conductor (emergency fuse, car jump start kit, etc.), and so on.

The reason that overcoming functional fixedness is so important is that, as innovation consists of finding new uses for knowledge we already have, we need to get past the barrier that a particular bit of knowledge only has the use it was originally intended for.

The Creativity Breakdown Structure and Design Breakdown Structure techniques proposed in this paper helps to overcome functional fixedness by breaking the object or concept one is looking at into its fundamental problem areas.

The Creativity Breakdown Structure

The Creativity Breakdown Structure (CBS) technique revolves around the following: Developing an innovative idea always consists in finding a novel use for an existing object or concept. As an example, if one were looking for novel uses for a brick, one might come up with several initial ideas (door-stop, paper weight, etc). Our functional fixedness about what a brick is will have a tendency to limit the alternative uses we can find for the brick. However, if one breaks the brick down into the fundamental properties that make it up (such as weight, rectangular, heavy, porous, does not conduct electricity, rough, small enough to be picked up in one hand, holds heat, etc.), one can usually come up with many more ideas for its use, than when one is thinking of just the brick as a whole.

When problem solving, which is a large component of the product development process, one is in effect attempting to use the above technique, but in reverse. One has already identified the properties that one requires, and one is looking for the “brick” or other solution that will fulfill those properties in a novel way.

The Creativity Breakdown Structure helps us to graphically break down each problem to overcome into its fundamental problem areas (such as theory, knowledge, energy source, timing, cost, equipment, materials, components, mechanical, etc.), so that we can identify what the properties that the potential solution will have to possess, and thus reverse-engineer it.

It should be noted that breaking things down into sub-units, or decomposition as it is often referred to in product development, is nothing new. However, though of some help, just breaking a product down into subassemblies is of limited use, particularly if done in a non-graphical format such as a list. It is the graphical and structural nature of the Work Breakdown Structure (WBS), Design Breakdown Structure (DBS) and Creativity Breakdown Structure (CBS) that make them powerful tools, as one can almost instantly see the relationships and hierarchy between the various elements that make them up. They also act as a common communication tool so that, when talking about the idea generation process, all team members are talking the same language.

The Work Breakdown Structure

The project management toolbox does include a tool that is vital to the management of the project called the Work Breakdown Structure (WBS) that gives details of the product or deliverable to be made. What is lacking is a tool to allow us to effectively manage and control the construction of the Work breakdown Structure.

As defined in the Guide to the Project Management Body of Knowledge (PMI, 2002), A Work Breakdown Structure is a task-oriented 'family tree' of activities that organizes, defines and graphically displays the total work to be accomplished in order to achieve the final objectives of a project. Each descending level represents an increasingly detailed definition of the project objective. It is a system for subdividing a project into manageable work packages, components or elements to provide a common framework for scope/cost/schedule communications, allocation of responsibility, monitoring and management.

The WBS consists in breaking down the project into the various work packages that make it up. From these work packages, schedules, task lists, resource allocations, etc. can be derived, allowing the project manager to manage and control the project.

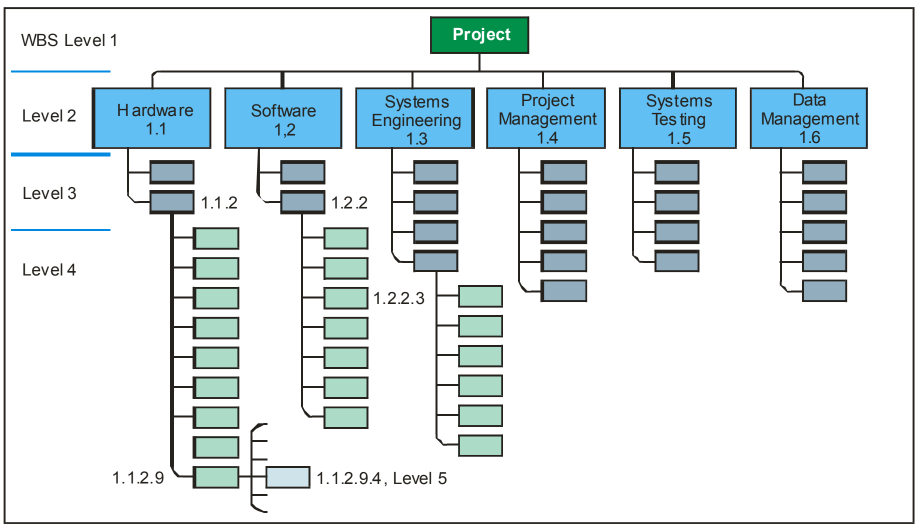

Fig 4: Sample of traditional Work Breakdown Structure

Though the WBS is invaluable for helping to manage projects that are relatively well defined it does not cater well for areas of unknown. How do you break down something that you do not yet know the shape of, or how you are going to achieve? The catch with the WBS is that it can only be generated once we know details of the product that will be produced from it. It cannot easily be generated during the fuzzy front-end of the project, as one does not have enough information to build it.

A better set of tools is therefore required to help manage the early conceptual stages of innovative projects before a meaningful WBS can be generated. By adding a further refinement to the WBS, which we will call a Design Breakdown Structure (DBS), we will