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A knowledge based theory of projects

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Abstract
Project management has been successfully applied in wide range of industries where planning and control are predictable and enforceable, such as construction and military systems. These are environments where the solution and activities are known or can be accurately described.

Knowledge Economy projects are characterised by activities that are knowledge intensive or novel, by highly unique or unknown solutions, or where the environment is complex and dynamic. These projects can be more difficult to plan and even more difficult to control.

To resolve this situation this paper proposes a novel and radical new theory of the project. It is suggested that a project may be described in terms of the knowledge required to execute and deliver it. In so doing the focus is shifted from what is unknown to a dimension that can be better planned and is more beneficial to the effective delivery of the project.

It is intended that this theory may be used to underpin new project management theories and new implementation methodologies suited to the knowledge economy.

An introduction to projects and the problem

According to the Project Management Institute (PMI, 2007), a project is "*a temporary endeavour undertaken to create a unique product, service or result*". Kerzner (2001, p2) defines a project as a series of activities and tasks with a specific objective to be completed within certain specifications, between start and end dates, possibly within funding limits, consumes resources and cutting across functional lines. Projects involve coordinated activity to achieve these goals. Turner (2006) regards a project as a temporary organisation, which the owner creates to create value, consuming resources to do non-routine, risky work to deliver an output, and which will be operated to achieve a beneficial outcome.

Project management is an approach used to manage project activities and resources in the most optimum manner. British Standards (1996) define project management as the planning, monitoring and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to a specified cost, quality and performance (BS6079).

The problem facing project managers in the initial stages of most projects is that a great deal of uncertainty exists and will persist throughout the project's duration. Even with the support of experienced technical team members during the planning process, the novelty of technology, environment, requirements and solutions predictably limits a project manager's ability to reliably forecast what has to be done, how long it will take and how much it will cost.

Methodologies have been devised to alleviate the inherent uncertainty of these types of projects. Iterative methodologies for information technology, such as the spiral model (Boehm, 1988), divide a large problem into a series of increasingly complete layers or versions of the final solution. They iterate or repeat the waterfall model a number of times throughout the duration of the project as to reduce risks such as of delivery diverging from requirements or changes in scope throughout the project lifecycle.

Practitioners have also found solutions, albeit it workarounds. Business pressure to 'get on with it' and scarcity of specialists to support planning have led to the common practice of 'building fat' into estimates for activity costs and durations. This practice entails overestimating the parameters of each task so as to allow for as-yet unknown risks. Approaches, such as Critical Chain (Goldratt, 1997) and the Theory of Constraints (Goldratt, 2002; Dettmer, 1998) eliminate risk padding from each activity and include a buffer in the project plan to absorb task overruns.

Failure to adhere to estimates is therefore inevitable when using conventional methodologies. Project failure in knowledge intensive environments is frequently described as high (Goulielmos, 2003). A series of reports published between 1995 and 2001 (IT Cortex, 2006) found that between 40% and 83.8% of all information systems projects are described as failures. To be fair though, it must be noted that definitions of failure differ. Goulielmos (2003) for example appears to test projects according to their ability to meet softer organisation objectives rather than planning criteria.

Solutions are therefore needed to alleviate the fundamental problem; that scope and work are inherently unknown and even unknowable at the beginning of the project. Project managers on knowledge intensive projects are often unable to initially identify tasks or outcomes in sufficient detail, hampering accurate and precise estimation or planning of the time, cost and resources. Project management methodologies based on the breakdown and estimation of activities are therefore impractical in complex environments, where the solution is unknown or novel, or where activities are creative, novel or knowledge intensive. Examples of these types of situations where there is intrinsic uncertainty in the deliverables (scope of work) and activities required to produce them include information systems, high technology, pharmaceuticals, medical research and web site design projects.

A proposed solution

It has been noted that information (and, using the broadest of definitions, knowledge too) is a resource used in projects (Turner, 2006). Focusing on knowledge would appear to be prudent in order to reduce the uncertainty and manage complexity of Knowledge Economy projects.

Completion and success is strongly dependent on the knowledge used in the execution of the project. For example, selection of skilled individuals has been seen to be critical to project success (Kerzner, 2001, p161-216). Knowledge loss is detrimental, and Burke et al. (2005) show that knowledge retention and reuse on similar projects has a positive correlation with project performance. On this basis, it is proposed that a solution may be found in managing Knowledge Economy projects and their risks through quantification of the knowledge needed, applied and generated during the course of the project.

No theory was found to describe project management in terms of its knowledge, so the first step in this novel strategy will be to model projects according to knowledge. Theories and methodologies for project management may then be developed on the basis of this theory.

A knowledge based theory of projects

A project P may be described as a finite collection (or set) of planned and unplanned activities A with specific objectives, and constrained by limits usually measured in terms of time, cost and quality:

$$P = \{A\} \qquad 1.$$

This does not imply that projects are merely a collection of activities. Project activities are interrelated by working towards the same project objective, and are interdependent, with many if not all activities having an optimum sequence. This sequence may be termed a configuration.

It is possible to consider each activity in the project from a knowledge perspective. Knowledge has tacit and explicit characteristics (Polanyi, 1966), where tacit knowledge remains in the mind of the knower and can seldom be written down, and explicit knowledge is knowledge that has been written down. Others regard knowledge an object or as a process, or both (Styhre, 2003). The products of knowledge work and the embedding of knowledge into deliverables should also be taken into account. In discussing knowledge as an integral element of project activities, this paper will make no distinction between the type and nature of knowledge. Knowledge in this paper will refer to an entity or 'piece' of knowledge, the process of knowing or applying knowledge, and the configuration or arrangement of knowledge. For theoretical purposes, knowledge may simply be regarded as what people know. Examples from an actual project may illustrate:

> A software developer needs to know how many users the customer anticipates the system will need to accommodate. In this context this requirement is a 'piece' of knowledge, or *knowledge object/entity*. The customer knowing this, combined with the knowledge the software developer already has of the solution and the technology, constitutes a *knowledge configuration*. The software developer acts on that knowledge over a definite period of time and produces a piece of code. On completion there is a different knowledge configuration; there is knowledge embedded in a deliverable (the software code), revised knowledge the developer has of the solution (he knows how it was done, rather than thinks how it should be done - as he did at the start of the activity), and the project manager knows that the deliverable has been produced. This change in configuration occurs over a finite period of time, and, if comprehensively defined, may even be treated as a closed system.

From this example it may be seen that knowledge is required to commence an activity, it evolves during each activity and, assuming that nothing is forgotten or lost[1], there is a nett gain in project-relevant knowledge by the project team (and even in the deliverable) if that knowledge is embedded in the product by the conclusion of the activity. Furthermore, at the end of an activity and provided the activity is signed off or the project completed, no further knowledge is involved in or required by that activity.

The knowledge component of any activity A_x may therefore be described as the finite set of all knowledge K_{Ax} used, gained, created and lost during the duration of any activity A_x and expressed as follows:

$$K_{Ax} = \{K_1, K_2, \ldots K_n\} \qquad 2.$$

If that activity is regarded solely from a knowledge perspective, this becomes:

$$A_x = \{K_1, K_2, \ldots K_n\} \qquad 3.$$

[1] Knowledge losses on a project could include the departure of a team member.

Likewise, if a project is regarded from a knowledge perspective, the project P may be regarded as a finite set of knowledge K_n involved in all project activities A_n:

$$P = \{K_{A1}, K_{A2}, \ldots K_{An}\} \qquad 4.$$

Taking into consideration the configuration of activities, a knowledge-centric definition can be derived for the term 'project':

Definition 1: *A knowledge-based project may be defined as a finite and unique set of interrelated and interdependent knowledge and knowledge configurations that change over a finite period of time in order to achieve specific objectives within certain constraints.*

Quantification for estimating, planning and control

Project managers will no doubt see complications since, as a pragmatic construct, projects require quantification to facilitate planning and control. A set-based theory may be useful in identifying boundaries, elements or requirements, but it does little to assist quantification. And tacit knowledge is unfortunately notoriously difficult to quantify in its own right.

To circumvent this problem, indirect quantification of the knowledge component must be found in ways that are tangible and relevant to projects and project management – particularly the dimensions of time, cost and quality. Experience suggests it is possible to estimate and measure the cost or time required or taken to acquire, create, apply, transfer or reuse knowledge. An example illustrates:

> An Internet website development project needed a new name for the site that was not offensive if translated into other languages. It took time to find suitable experts, for them to evaluate the problem, and for their report to be delivered. It cost money in the form of salaries for external experts to consider the issue. Knowledge required was quantified in terms of its time and cost to acquire.

If each piece of knowledge can be quantified, it follows from equations 2 and 3 above that the cumulative value of any activity A_x in a particular dimension or unit (such as time or cost) may be computed by the summing the individual values of members of the set of knowledge required to undertake and complete that activity (in the same units):

$$A_x = \sum K_{Ax} \qquad 5.$$

Consequently the value or cost of a knowledge-based project in any particular unit or dimension such as time or cost may be computed as the sum of all knowledge and knowledge activities:

$$P = \sum K \qquad 6.$$

The impact of time

By nature and by definition, projects and activities are time dependent. As this characteristic would be inherited by the knowledge-based approach, it should be possible and beneficial to model the effect of time on the theory.

The configuration or state of knowledge at the start of an activity is different to that at the end. At the start of each activity (A_x), what is known about that activity and how to complete

it is notionally at its lowest (K_{start}). On completion of that activity, what is known about that activity is notionally at its greatest ($K_{completion}$). Each activity may therefore be seen as a nett change in knowledge over the course of that activity:

$$A_x = K_{completion} - K_{start} \qquad 7.$$

If the complexity of knowledge loss is ignored, a knowledge-based project may then be conceived of as a nett change in knowledge,:

$$P = \sum K_{completion} - \sum K_{start} \qquad 8.$$

Since project activities are time dependent, any knowledge-based activity A_x may also be described as a change in knowledge ΔK_x over activity duration (t_x):

$$A_x = \frac{\Delta K_x}{t_x} \qquad 9.$$

Since a knowledge-based project P may be regarded from a knowledge perspective as the nett sum of all knowledge K at completion of all of its constituent activities, and since projects are conducted within a finite time frame, a project P may therefore be regarded as a change in knowledge ΔK that occurs over the duration *t* of that project:

$$P = \frac{\Delta K}{t} \qquad 10.$$

As knowledge can be measured in terms of time, cost or other quantifiable interval or ratio measure, a project can be quantified accordingly:

Definition 2: *A knowledge-based project may be quantified though the measuring of resources and activities involved in making changes to knowledge and knowledge configurations over the finite duration of the project.*

Conclusion

This paper presents a novel theory that describes a project in terms of its knowledge, together with two new definitions that describe a project and how it may be measured.

In order to describe a project in terms of its knowledge, this theory assumes that a project can be described completely and accurately when the following hypothetical conditions are met:

- The project is not externally constrained.
- Knowledge is the only input.
- Knowledge configuration is the only form of activity.
- Project knowledge can be described as entities and as processes.
- The deliverables are knowledge based.
- The role of project managers is to plan, schedule and control (facilitate) changes in knowledge configurations.

This theory is therefore specifically intended for Knowledge Economy projects. It is intentionally abstract and generalised, to provide a communicable and stable foundation for future work and to avoid concerns about specificity that have been levelled at other theory (Sauer and Reich, 2007). Furthermore this theory is normative (prescriptive, or how projects

'ought-to-be), rather than descriptive (explaining the 'as-is' of projects) (Sauer and Reich, 2007).

Further research has used this theory to underpin a complementary project management theory and implementation methodology. Future work could include strengthening the theoretical argument, empirical testing, and identifying real world effectiveness.

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