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A knowledge based theory of project management

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Abstract
Project management has been successfully applied in environments where planning and control are predictable and enforceable, such as construction and military systems. The apparent benefits of project management have seen its use expand into Knowledge Economy applications and beyond, with varied success.

Estimation, scheduling and control issues multiply on projects that are characterised by activities that are knowledge intensive or novel, where the activities or solutions are unique or creative, or where the environment is complex. During the conceptualisation and planning phases of these projects, subject experts and project managers find it difficult to define accurate scope of work, work breakdown structures, risks or dependencies.

This paper will present a theory for project management based on the knowledge-based theory of projects, a novel concept that describes a project and its quantification in terms of knowledge and knowledge configurations.

It is intended that this new approach will assist project managers in estimating, scheduling and controlling those projects that are predominantly knowledge based.

An introduction to project management
Project management appears to be more pragmatic than theoretical, with theoreticians noting a lack of clear and precise theory. This lack of theory is problematic in the search for solutions for the knowledge economy. Emerging theory needs a consistent understanding to build on, and to compare and contrast against. Emerging methodologies require the clarity and guidance that theory provides. Practice requires theory for consistency and professionalism to develop.

Koskela and Howell (2002) begin their analysis of project management theory by stating that there is "no explicit theory of project management", and feel that a general theory to underpin the discipline could be found in theories of management, planning, control and projects. Turner (2006) feels that there is 'embryonic' theory contained in literature, particularly his books. In response, Sauer and Reich (2007) somewhat agree, but do note that explicit theory is lacking.

Reasons for this situation appear to be deep seated. Koskela and Ballard (2006) feel there is no clear consensus as to whether project management should be based on theories of economics or production. Alleman (2004) notes a lack of theory and consequent practice issues in the field of software engineering, and suggests that solutions could be found in other domains with similar behavioural patterns. Levner (1991) for example built a project management theory on an application of programming theory; a branch of mathematics that finds optimised control solutions to multi-step problems.

A clear concise model that is sufficiently abstract and general to encompass the entire discipline would resolve some of these concerns. Project management arranges elements such as resources, time, risks and activities in such a way as to achieve a result. Normative project management theory therefore cannot be based on a single dimension such as cost, time or

quality. An approach based on configuration and control would appear to be the most universal.

One definition that appears to somewhat meet this criteria for generality is the British Standards' (1996) BS6079 definition: "*Project management is 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.*"

Restated, this leads to a usable abstract definition of *general* project management that will be employed later in devising new theories:

Definition 1: "*Project management is the systematic and optimal arrangement and coordination of resources and actions over a period of time to achieve specific objectives within certain constraints.*"

Knowledge based project management

Turner (2006) noted that information is important in the management of projects. He does not define information, but his use of the term seems to imply that information in may respects could be synonymous with knowledge. Knowledge management literature such as Jasimuddin et al. (2005) concurs, finding tacit and explicit knowledge difficult to differentiate in practice.

Project managers in the Knowledge Economy face inherent 'unknowability' of what has to be done, how it must be done and the risks involved in the initial stages of projects. Knowledge was furthermore identified to be a primary component of certain types of projects in the Knowledge Economy. This led to a theory for knowledge-based projects:

> "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." (Onions, 2007)

Some indication of how to manage such projects was also given:

> "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." (Onions, 2007)

By restating definition 1 above in terms of the knowledge-based project, a hypothetical and normative model of project management is proposed:

Definition 2: *Knowledge-based project management is the systematic and optimal arrangement and coordination of knowledge and knowledge configurations over a period of time to achieve specific objectives within certain constraints.*"

This definition emphasises the stance that project management is essentially a problem of control, coordination and configuration. It is also intended to focus narrowly on a specific type of project – those involving and producing knowledge.

Theoretical implications of this theory

Analysis of the definition 2's variables, particularly time and knowledge, and their relationships, may lead to theoretical implications and validation.

The learning curve

Project knowledge and project knowledge configurations (hereafter simply referred to as knowledge) change and evolve over time. If it is assumed that knowledge is cumulative over time, this may be represented as an increase of project knowledge over the duration of the project as per Figure 1 below (where K_x is cumulative knowledge and t_x is cumulative time:

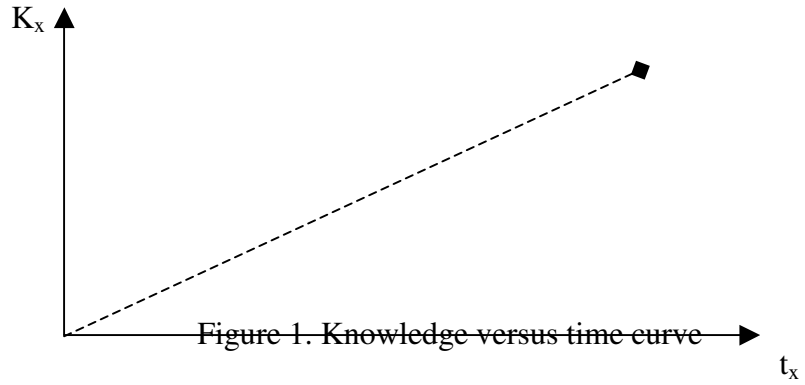

Figure 1. Knowledge versus time curve

This linear plot is simplistic and ignores two issues. Firstly, projects may lose staff and people forget, thereby reducing the cumulative project knowledge. Such events would plot as a negative slope at a point in time on the curve. Secondly, and more importantly, knowledge-based project theory stipulates there is a relationship between knowledge configurations over time. As solutions are found to one problem, or as knowledge of the environment or eventual solution grows, this knowledge becomes an element of future knowledge configurations – it is applied to other problems.

Kerzner (2001, p951-974) describes this effect of experience on cost of production as 'economies of scale', where cost of production decreases as experience (knowledge) increases. He refers to the resulting curve as a 'learning curve' and implies a logarithmic relationship between cost of production and experience. It proposed that the cumulative knowledge-time curve would be more likely to plot as follows:

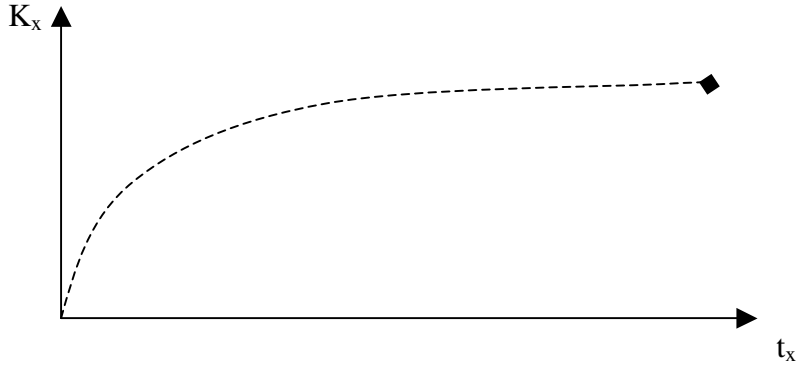

Figure 2. The effect of 'learning' on knowledge versus time

Mathematically precise expression of this curve would be speculative due to project and even environment specific factors. Generalising data from a number of projects may be more useful, and lead to identification of learning profiles typical to particular types of projects, domains or industries.

Project risk

Project risk according to Kerzner (2001) is probability and consequences of not achieving a defined goal. A situation where the factors are completely unknown is described as

uncertainty, and where there are calculable probabilities there is *risk* (Anderson, 2003). Risk and uncertainty may therefore be regarded as knowledge-deficient situations.

If risk and uncertainty are regarded as 'what is not known' about the outcomes or how to achieve them, then risk (r_x) at any point in time (t_x) in the project is represented by the gradient of the tangent to the curve plotting project knowledge against time (figure 3 below).

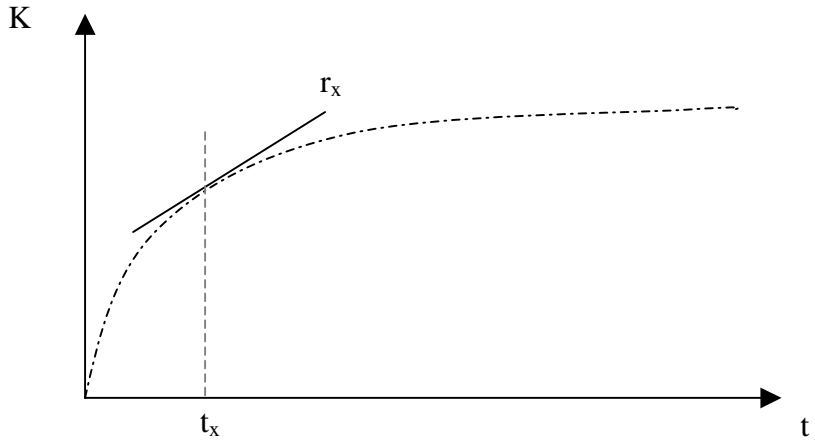

Figure 3. Knowledge versus time graph

At the beginning of the project (t_0) the 'risk gradient' is steepest (r_{max}) and, notionally, on completion of the project (t_c) the gradient of the tangent to the knowledge-time curve is flat and hence risk to the project (r_{min}) is zero. This is curve could be termed a *risk profile* and depicted as in figure 4 below.

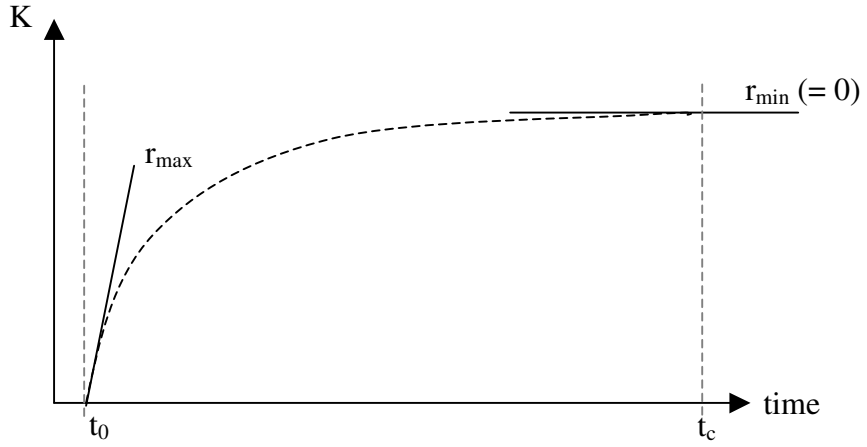

Figure 4. Project risk profile

This plot would verify empirical and anecdotal evidence (such as Kerzner, 2001) that suggests a project is less likely to overrun when more time is spent on project definition early in the project lifecycle. This tendency may be explained through considering the rate of change in the slope of the risk profile curve combined with the cumulative network effects of knowledge discussed previously. The area above the curve that is bounded by the limit imposed by total project knowledge is greater when knowledge is acquired late (area A_1 below) that when acquired early (area A_2 in figure 5 below).

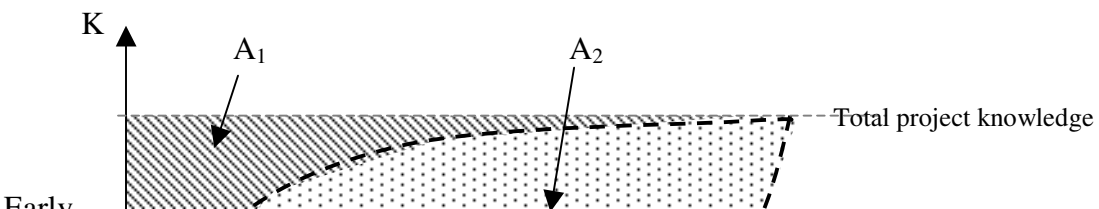

Figure 5. Risk profile for early and late project definition

The nature of work and delivery

Work may be broadly classified as batch, process or project. The knowledge-based theory of project management may explain the difference between a project and work executed in a process or as a batch.

The solution begins with a premise that all work involves applying three types of knowledge:

- Knowledge of what must be done – requirements and scope (solution)
- Knowledge of tools and technology to be applied (skills)
- Knowledge of team members, schedule and the workplace (environment)

This may be described as

$$K_{work} = K_{scope} + K_{skills} + K_{environment} \qquad 1.$$

Using this equation, the differences between the types of work may be expressed theoretically.

- *Processes* are repetitive, producing the same item over again. Scope, skills and environment remain constant between one work completion and another. Therefore the overall difference in knowledge between one job and another (ΔK_{work}) is zero.
- *Batches* involve the production of similar items in perhaps different environments ($\Delta K_{environment} <> 0$). Skills and scope would remain the same across completions ($\Delta K_{skills} = 0$ and $\Delta K_{scope} = 0$). For batches the overall knowledge would differ from one job to another ($\Delta K_{work} <> 0$).
- *Projects* are unique, so skills, scope and the environment all change between one project and another ($\Delta K_{skills} <> 0$; $\Delta K_{scope} <> 0$; $\Delta K_{environment} <> 0$; so $\Delta K_{work} <> 0$).

Practical implications

This theory is intended to be normative, but project management has evolved as a practical solution to a type of problem. Any theory would be careless if it did not at least consider the many techniques used by the profession or pay attention to its implementation. Project lifecycles and project management activities will be investigated to determine whether this theory could be compatible with current practice.

Project lifecycle

Many projects follow a lifecycle that can be generalised into five main phases; conceptualisation, design, development, implementation and closeout (Kerzner, 2001; PMI, 2005). This lifecycle has been empirically demonstrated to be functional, efficient and natural. Any normative project management theory should therefore predict such a lifecycle, or lead to a suitable alternative.

The relationship between knowledge, work and delivery has been discussed in literature in the fields of sense-making (Choo), work (Bohn, 1994), learning organisations (Senge, 1990), the knowledge lifecycle (Nickols, 2000; Davenport and Prusak, 1998), decision making (Frishammar, 2003; Hendry, 2000; March and Simon, 1958), the control cycle (Shewhart, 1939) and single loop learning models (Senge, 1990). It may therefore be surmised that:

- Knowledge and people are inseparable.
- Knowledge is a prerequisite for work and decisions; people must know both what must be done and how it must be done.

The knowledge-based projects theory therefore implies that:

- All work can be described in terms of knowledge.
- There is direct and evident coupling between particular knowledge and specific work.
- Knowledge at a point in time can be described as a configuration.
- Knowledge can usually be quantified, at least indirectly in terms of cost and time to acquire, create, apply or transfer it. This is not unlike work, because work itself can only be represented in similar terms and usually not described directly.

This theory can therefore predict that the overall knowledge configuration of a project will change and that certain phases are to be expected; from a focus on knowing what to do (*conceptualise*), to knowing how to do it (*design*), to acquiring that knowledge and applying it (*development*).

The knowledge-based theory of project management calls for achieving specific objectives within certain constraints. This theory therefore predicts that any project is not a closed system, that there are external entities with a stake in the project imposing direction and constraints on it. From this it is possible to predict acceptance and transfer of the project (*implementation*).

The knowledge-based theory of projects defines a project as being finite in duration. There is accordingly some specific point in time at which activity ends and when knowledge is transferred or embedded. Therefore the *closeout* of a project is also loosely predicted, and consistent with conventional project management understanding.

Project management techniques and activities

Project managers apply a range of techniques in managing a project throughout its lifecycle. Techniques are based on activities that include scoping of work, estimation, work breakdown and organisation breakdown structures, scheduling, delegation, communication and coordination of activities, monitoring and close out. Whilst these are not explicitly provided for in the knowledge based project management theory, the need for an optimum configuration of knowledge, and external requirements imposed on the projects suggest that knowledge projects would have corresponding equivalents.

Conclusion

This paper proposes a theory that departs from the conventional understanding of project management that revolves around the work breakdown structure. This theory's knowledge focus suggests that:

- Projects that involve a high proportion of knowledge in inputs, work and outputs may be managed and quantified solely in terms of their knowledge.
- Project management is an exercise in the optimisation of the arrangements (or configurations) of the various elements, objectives and activities of the project.
- The relationship between knowledge and time leads to hypothetical applications of the theory in the areas of risk management, learning and the nature of work.

Such a theory would have several benefits:

- Project management theory is sparse, and this theory may contribute to the general body of knowledge.
- The does not appear to be any theory dealing specifically with managing projects from a knowledge perspective.
- Projects in the Knowledge Economy have exhibited high failure rates. In focusing on knowledge, this theory may deliver a solution to this problem.

Subsequent research by the author focuses on developing a practical methodology for this theory and empirical testing.

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