THE THEORY OF PROJECT MANAGEMENT: EXPLANATION TO NOVEL METHODS

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ABSTRACT

In a series of prior papers, the authors have explored the theoretical foundation of project management. In this paper, this theoretical foundation is consolidated and used for explaining the novel features of two project management methods, which radically deviate from the conventional doctrine of project management: Last Planner and Scrum. Both methods have emerged since mid-nineties as practical responses to the failure of conventional project management methods, Scrum in the field of software projects, Last Planner in the field of construction projects. It is shown that both methods reject the underlying theoretical foundation of conventional project management and instead subscribe, implicitly or explicitly, to alternative theories, which better match the situation in question.

KEY WORDS

Project management, lean construction, agile programming, theory.

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INTRODUCTION

In a series of prior papers (Howell and Koskela 2000; Koskela and Howell 2001; Koskela and Howell 2002a; Koskela and Howell 2002b) the authors have explored the theoretical foundation of project management. In this paper, the theoretical foundation emerging from this work is summarized and used for explaining the novel features of two project management methods, which radically deviate from the conventional doctrine of project management: Last Planner and Scrum.

THE THEORETICAL FOUNDATION OF PROJECT MANAGEMENT

PRESENT UNDERLYING THEORY

In prior literature, it has been generally seen that there is no explicit theory of project management. We argue that it is possible to precisely point out the underlying theoretical foundation of project management as espoused in the PMBOK by PMI and mostly applied in practice (2002b). This foundation can be divided into a theory of project and a theory of management.

The theory of project[3] is provided by the transformation view on operations. In the transformation view, a project is conceptualized as a transformation of inputs to outputs. There are a number of principles, by means of which a project is managed. These principles suggest, for example, decomposing the total transformation hierarchically into smaller transformations, tasks, and minimizing the cost of each task independently.

We contend that understanding of management is based on three theories: management-as-planning, the dispatching model and the thermostat model. In management-as-planning, management at the operations level is seen to consist of the creation, revision and implementation of plans. This approach to management views a strong causal connection between the actions of management and outcomes of the organization. The dispatching model assumes that planned tasks can be executed by a notification of the start of the task to the executor. The thermostat model is the cybernetic model of management control that consists of the following elements: there is a standard of performance; performance is measured at the output; the possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached.

Table 1: The underlying theory of project management

Subject of theory		*Theory*
Project		Transformation
Management	Planning	Management-as-planning
	Execution	Classical communication theory
	Control	Thermostat model

[3] The theories of project presented in this paper are the same as presented previously as theories of production (Koskela 2000). The reason for this is that projects can be seen as a special type of production. This is evident from the definition of a project according to Project Management Institute (2000): "A project is a temporary endeavor undertaken to create a unique product or service".

This underlying theoretical foundation of project management (Table 1) has been evaluated through four sources of evidence: (1) the plausibility and consistency of the theory in itself; (2) empirical validity; (3) competing theories; and (4) alternative methods based on competing theories (Koskela and Howell 2002b). The evidences from these four sources turn out to be strikingly consonant, indicating that the underlying theoretical foundation of project management is deficient.

Based on the understanding provided by competing theories and on the empirical evidence, the hidden assumptions of the underlying theory of project management can be revealed (Table 2). Unfortunately, many of these assumptions are valid only in exceptional situations. These wrong assumptions lead directly to several kinds of problems in practical project management. Those problems are thus self-inflicted, caused by the very theories and methods we are relying on.

Table 2: The underlying theories and assumptions of project management (Koskela and Howell 2002b).

Theory of project		***Conceptualization*:** Project is a transformation of inputs to outputs ***Principles*:** 1 The total transformation of a project can be decomposed into manageable and well-understood sub-transformations, tasks 2 A project can be realized in a optimal manner by realizing each task in an optimal manner and the tasks in optimal sequence *Corollary:* Project performance can be performed by improving the tasks ***Assumptions:*** 1 Tasks are independent, except sequential relationships 2 Tasks are discrete and bounded 3 Uncertainty as to requirements and tasks is low 4 All work is captured by top-down decomposition of the total transformation 5 Requirements exist at the outset and they can be decomposed along with work
Theory of management	**Theory of planning**	***Conceptualization:*** There is a managerial part and an effector part in the project; the primary function of the managerial part is planning, and the primary function of the effector part is to translate the resultant plan into action. ***Principles:*** 1 Knowing the current state of the world, the desired goal state, and the allowable transformations of state that can be achieved by actions, a series of actions, the plan, can be deduced. 2 The plan is translated into reality by the effector part of the organization. ***Assumptions:*** 1 Translating a plan into action is a simple process, by following directions. 2 The internal planning of a task is a matter of the person to whom the task has been assigned
	Theory of execution	***Conceptualization:*** Managerially, execution is about dispatching tasks to work stations. ***Principle:*** When, according to the plan, the time has arrived to begin task execution, it is authorized to start, in speech or in writing**.** ***Assumptions:*** 1 The inputs to the task and the resources to execute it are ready at the time of authorization. 2 The task is fully understood, started and completed according to the plan once authorized.
	Theory of control	***Conceptualization:*** There is a process to be controlled, a unit for performance measurement, a standard of performance and a controlling unit (thermostat control). ***Principle:*** The possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached ***Assumptions:*** 1 The process is of continuous flow type, the performance of which is measured at aggregate terms 2 The process can easily be corrected by the control available.

Based on this evidence, it is argued that the present underlying foundation is obsolete and has to be substituted by a wider and more powerful theoretical foundation: a paradigmatic transformation of the discipline of project management is needed.

TOWARDS A NEW THEORETICAL FOUNDATION OF PROJECT MANAGEMENT

What then would be the wider and more powerful theoretical foundation for project management? Based on analysis of the weaknesses of the present foundation and consideration of competing theories and methods (Koskela and Howell 2002b), we propose – as a starting point - to include the theories indicated in Table 3 into the new foundation.

Table 3: Ingredients of a new theoretical foundation of project management

Subject of theory		*Relevant theories*
Project		Transformation Flow Value generation
Management	Planning	Management-as-planning Management-as-organizing
	Execution	Classical communication theory Language/action perspective
	Control	Thermostat model Scientific experimentation model

Regarding the theory of project, the (partial) models of operations as flow and value generation add the consideration of time, variability and customer to the conceptualization provided by the transformation model (Koskela 2000). Similarly, the theoretical foundation of management has to be extended. Regarding planning, the approach of management-as-organizing adds the idea of human activity as inherently situated (Johnston and Brennan 1996). Thus, planning should also focus on structuring the environment to contribute to purposeful acting. Concerning managerial execution, the language/action perspective, originated by Winograd and Flores (1986), conceptualizes two-way communication and commitment, instead of the mere one-way communication of the classical communication theory. The scientific experimentation model of control of Shewhart (Shewhart and Deming 1939) focuses on finding causes of deviations and acting on those causes, instead of only changing the performance level for achieving a predetermined goal in case of a deviation. The scientific experimentation model adds thus the aspect of learning to control.

It is clear that what has been presented does not yet provide a unified and complete theoretical foundation for project management. However, this foundation shows manifestly that a better theoretical foundation can be created for project management. Future research will extend and unify the ingredients found until now.

In the following, we show that the ingredients of the new foundation are being used in two novel project management methods, which radically deviate from the conventional doctrine of project management: Last Planner and Scrum[4]. Both methods have emerged since mid-nineties as practical responses to the failure of conventional project

[4] In this presentation, the new foundation is used for explaining these two novel project management methods. This - with minor reservations - also corresponds to the logic of the underlying research process. Even if we knew the Last Planner method already at the start of the research, we tried to systematically explain it only after the formulation of the new foundation - however, the Last Planner method has probably implicitly influenced our search. We learned about Scrum only after the formulation of the new foundation.

management methods, Scrum in the field of software projects, Last Planner in the field of construction projects.

LAST PLANNER

A new method, often called Last Planner, to cope with the situation met in construction production control, has been developed by Ballard (2000) since 1992. The method has emerged in an inductive manner from a series of industrial experiments (Ballard and Howell 1998).

At first sight, Last Planner deviates from the conventional project management doctrine in terms of planning, execution and control. These differences are described in the following detailed analysis.

Industrial experiments have shown that the introduction of Last Planner leads to clear benefits. A productivity increase of 10 % is reported by an American (Teston 1998) and a Danish (Baadsgaard 2001) company. Ballard (2000) has measured productivity increases from 10 % to 40 %, with 30 % as a median. In addition, benefits regarding lead time reduction and safety are reported (Baadsgaard 2001).

Let us analyze Last Planner from the point of view of its theoretical foundation, especially on the management side.

THEORY OF PLANNING

The term Last Planner refers to the hierarchical chain of planners, where the last planner acts at the interface to execution. Thus, this method concentrates on the detailed planning just before execution, rather than the whole planning process.

The method of Last Planner distinguishes planned tasks according to Can, Should and Will modalities. The tasks pushed from the higher planning levels belong to the Should category.

In lookahead planning (with a time horizon of 3-4 weeks), the prerequisites of upcoming assignments are actively made ready, in other words, they are transferred to the Can category. This, in fact, is a pull system (Ballard 1999) that is instrumental in ensuring that all the prerequisites are available for the assignments. In conventional project management, the plan pushes tasks to execution; only the Should category is recognized.

Another principle is to maintain a buffer of tasks, which are sound for each crew. Thus, if the assigned task turns out to be impossible to carry out, the crew can switch to another task. This principle is instrumental in avoiding lost production (due to starving or suboptimal conditions).

Theoretically interpreted, lookahead planning aims at alignment of plan and situation. “Should” represents the tasks in the plan, and “Can” represents those tasks that realistically will be possible to start in the situation. Thus, lookahead planning subscribes to the view of human action as situated - a foundational assumption of managing-as-organizing, while also acknowledging the significance of plans for action - as advocated by managing-as-planning.

THEORY OF EXECUTION

There is a structured weekly dispatching procedure, where the site manager together with subcontractors and crews decides about the tasks to be carried out in the next week. Here the principle is that the assignments should be sound regarding their prerequisites. This

means that work should not start until all the items required for its completion are available. Only tasks in the Can category are transferred to the Will category. After the week in question has gone, the crews inform whether they have realized the assigned tasks or not.

This procedure contrasts to the conventional project management, where execution just consists of task authorization: the site manager notifies the subcontractor or the crew that the task should be started.

Theoretically interpreting, the execution phase in Last Planner is similar to the language/action perspective model in that communication is a two-way process, and commitment is created for the realization of the tasks within the planning conversation where plans prepared by one crew are understood as promises to others and through the obligation to report on the completion of the task.

THEORY OF CONTROL

Control consists of measurement of the realization rate of assignments, investigation of causes for non-realization and elimination of those causes. Here a metrics called Percent Plan Complete (PPC) is used. In conventional project management, main control consists of comparing progress with the performance baseline, expressed in money or hours.

Theoretically interpreting, Last Planner is using the scientific experimentation model of control.

THEORY OF PROJECT

Tasks are the central unit of analysis in Last Planner. Even though flows are not directly represented in Last Planner, the principles used contribute to the generic principles of flow management. Last Planner facilitates avoiding both variability propagation and unnecessary penalties of variability. The focus on plan realization diminishes the risk of variability propagation to downstream flows and tasks reducing the need for large material buffers on site. Last Planner effectively combines control and improvement to fight back against variability and the waste caused by it. Thus, Last Planner combines the flow and the transformation view in short term planning, execution and control[5].

CONCLUSIONS

An overview of the underlying theories of Last Planner is given in Table 4. Regarding management theories, Last Planner is based on the alternative theories of planning, execution and control, as identified above. For planning, the conventional approach of management-as-planning is also used. Regarding project theories, flow and transformation models are used, but not the value generation model[6].

Note that Last Planner can be used besides a conventional project management system, and thus control through the thermostat model can be realized concurrently, if required.

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[5] This has been analyzed at more length in Koskela (1999).

[6] However, it can be argued that Last Planner indirectly supports value generation by increasing production system capability, which can be broadly defined as the capability of the production system to produce products as and when required by customers.

The success of Last Planner provides added support for the view that the competing theories make up a better foundation for project management than the conventional theory.

Table 4: The underlying theoretical foundation of Last Planner

Subject of theory		Theories
Project		Transformation Flow
Management	Planning	Management-as-planning Management-as-organizing
	Execution	Language/action perspective
	Control	Scientific experimentation model

SCRUM

Scrum has emerged in the last half of the 1990's as an alternative project management methodology for software projects where unpredictability accentuates due to uncertainties in both requirements and technology (Schwaber and Beedle 2002). It is a result of evolution rather than of a deliberate design based on a new theoretical foundation[7]. The use of Scrum has turned out to lead to clear benefits in terms of productivity, duration and customer satisfaction (Schwaber and Beedle 2002).

Scrum deviates starkly from the conventional project management doctrine. Two outstanding differences are that there is no Work Breakdown Structure, and that dispatching decisions have been totally decentralized.

Let us analyze Scrum from the point of view of its theoretical foundation, especially on the management side. An overview on Scrum is presented in Figure 1. The analysis is based on the description of Scrum in (Schwaber and Beedle 2002).

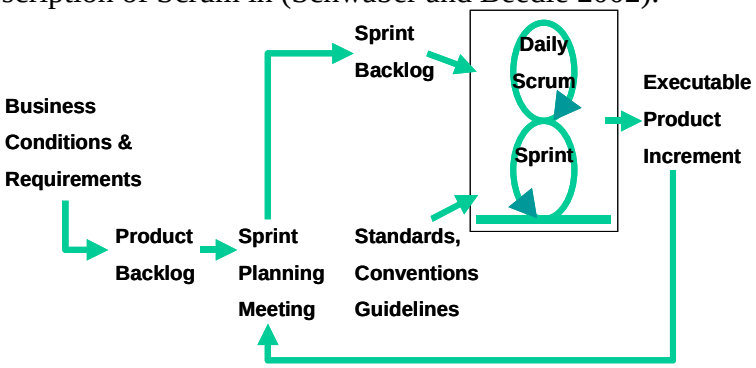

Figure 1: Overview on Scrum (Schwaber and Beedle 2002).

THEORY OF PLANNING

The starting point in Scrum is a list of software functionalities required by the customer, called Product Backlog. Due to technological uncertainties, it is not possible to prepare an accurate work breakdown structure based on this. Rather, performance baselines (called

[7] Schwaber and Beedle (2002) present a number of theoretical perspectives on Scrum, but they do not present a perspective related to basic concepts of operations management.

forecasts) in terms of costs and time are estimated directly based on the functionalities required.

Without an overall WBS, it is not possible to carry out planning and scheduling as prescribed by the doctrine of project management. However, the conditions of project work have been standardized, and certain planning takes place in this framework. Two work cycles have been defined. One, with duration of one month, is called Sprint. The other has duration of one day.

The project is started with the first Sprint Planning Meeting, where the functionalities to be achieved during the first Sprint are determined.

From a theoretical point of view, the question is clearly about management-as-organizing. Management is addressing the structuring of the setting of action, in terms of predetermined work cycles and associated, routinized conversations. There is no central representation of action. Instead, action follows essentially from the situation, created through prior action. Coordination takes place directly among team members, rather than directed centrally. The world acts as its own representation in the sense that all team members announce their daily tasks, which creates visibility on action on short term.

THEORY OF EXECUTION

In the daily Scrum meetings, standardized regarding their agenda, time and place, each person in the project team tells what he intends to do next (obviously based on negotiations with the rest of the team). In case of impediments, he announces them in the following day's meeting.

In the classical dispatching model, a controller decides an assignment for a work station (here: team member) and communicates the assignment to the work station. Here, the roles of controllers and work stations have been merged. Every team member decides his task, however in interaction with the rest of the team. Of course, in this kind of self-dispatching, there is no need to communicate with oneself about the task one has decided to realize. However, the whole team is the direct customer of each task. Thus, it matches with the language/action perspective that there is a public declaration of the daily task each team member has interpreted to be appropriate and is committed to realize. There is no formal declaration of completed tasks, but it is assumed that impediments to any task are announced in a daily Scrum. Without such an announcement, it is implicitly understood that the task is completed. Thus, a two-way discussion, as prescribed by the language/action perspective, is carried out (even if all aspects are not explicit or well-developed).

THEORY OF CONTROL

There are three levels of control. At the lowest level, each team member reports on impediments to progress in daily Scrum meetings. It is then the management's task to eliminate those impediments.

At the next level, there is control after each Sprint period. The team presents its achievements to the management and the client. The progress is compared to planned achievements. Also the executable code is demonstrated, and the customer can get a better insight into the functionalities desired.

The uppermost level concerns the whole project. After each Sprint, the Product Backlog is revised, as well as the performance baseline, that is, the estimation of project cost and duration.

Theoretically interpreted, the uppermost level of control is based on the thermostat model, whereas the two lower levels are based on the scientific experimentation model. These two lower levels are geared towards learning and knowledge-creation, whereas the uppermost level takes care of the time-cost issues of the whole project.

THEORY OF PROJECT

The transformation model is used very little in Scrum. Tasks are never defined in writing, but are described only orally just before they will be realized. Through the daily Scrum meetings, the daily tasks are visible to all stakeholders.

Instead, the principles of the flow model are supported in many ways. Feedback cycles are created both on the daily level and the monthly level for tackling with the associated uncertainty and variability. The organizational solution, a self-organizing team, allows for dense information flows among the tasks or specialists as needed.

Also the principles of the value generation model are applied in many ways. Firstly, value is explicitly modeled through the Product Backlog, consisting of prioritized items. Secondly, it is acknowledged that the customer has difficulties in the determination of requirements – rather it can be characterized as a constant process of sense-making. The inclusion of the customer to the process ensures that such sense-making can effectively take place and is directly influencing the work in the project. Thirdly, through the daily and monthly feedback cycles, the customer can readily ensure that the requirements are correctly understood by the team.

CONCLUSIONS

An overview of the underlying theories of Scrum is given in Table 5. Regarding management theories, Scrum is based on the alternative theories of planning, execution and control, as identified above. Regarding project theories, flow and value generation models are used, but not the transformation model.

Table 5: The underlying theoretical foundation of Scrum

Subject of theory		Theories
Project		Flow Value generation
Management	Planning	Management-as-organizing Management-as-planning
	Execution	Language/action perspective
	Control	Scientific experimentation model Thermostat model

Scrum is a comprehensive project management method that totally substitutes the prescription derived from the conventional doctrine. The success of Scrum provides added support for the view that the competing theories make up a better foundation for project management than the conventional theory. It also makes evident that the central starting point of the conventional doctrine, the WBS, must be totally rejected in certain project situations.

CONCLUSIONS

We have argued that the present underlying foundation is obsolete and has to be substituted by a wider and more powerful theoretical foundation. We have proposed such a new foundation and we have shown that two novel, demonstratedly successful project management methods can be explained by means of it. Based on the arguments and evidences forwarded, we conclude that a paradigmatic transformation of the discipline of project management is needed. Such a transformation requires that a more intimate relation between theory and practice is created in project management.

REFERENCES

Baadsgaard, Jesper (2001). Byggeproduktion og materiale-logistik optimeres via interaktive styringsværktøjer. *Logistik Horisont*, Vol. 27, No. 6, Oktober. (Construction production and materials logistics are optimized by means of interactive controlling tools).

Ballard, G. and Howell, G. (1998). Shielding production: essential step in production control. *Journal of Construction Engineering and Management* 124 (1) 11-17.

Ballard, Glenn (1999). Can Pull Techniques be Used in Design Management? Concurrent Engineering in Construction: Challenges for the New Millennium. *CIB Publication 236*. VTT, Espoo. Pp. 149-160.

Ballard, Glenn (2000). *The Last Planner System of Production Control*. A thesis submitted to the Faculty of Engineering of The University of Birmingham for the degree of Doctor of Philosophy. School of Civil Engineering, Faculty of Engineering, The University of Birmingham.

Howell, Greg and Koskela, Lauri. (2000). *Reforming project management: the role of lean construction*. 8th Annual Conference of the International Group for Lean Construction IGLC-8). Brighton, 17 - 19 July 2000.

Johnston, R.B. and Brennan, M. (1996). Planning or Organizing: the Implications of Theories of Activity for Management of Operations. *Omega, Int. J. Mgmt. Sc*., Vol. 24, No. 4, pp. 367-384.

Koskela, Lauri and Howell, Greg (2001). Reforming project management: The role of planning, execution and controlling. - *Proceedings of the 9th International Group for Lean Construction Conference*. Kent Ridge Crescent, Singapore, 6 - 8 August 2001. Chua, David and Ballard, Glenn (eds.). National University of Singapore (2001), pp. 185 - 198.

Koskela, Lauri and Howell, Greg (2002a). *The underlying theory of project management is obsolete.* Paper to be presented at the PMI Research Conference, August 2002, Seattle.

Koskela, Lauri and Howell, Gregory A. (2002b). *The theory of project management - problem and opportunity*. Working paper. VTT Technical Research Centre of Finland & Lean Construction Insitute.

Koskela, Lauri (1999). Management of production in construction: a theoretical view. *7th Conference of the International Group for Lean Construction*, IGLC-7. Berkeley, 26 - 28 July 1999. University of California , pp. 241 - 252.

Koskela, Lauri (2000). An exploration towards a production theory and its application to construction. Espoo, VTT Building Technology. 296 p. *VTT Publications*; 408. WWW: http://www.inf.vtt.fi/pdf/publications/2000/P408.pdf

Project Management Institute (2000). *A Guide to the Project Management Body of Knowledge*. Newton Square. 216 p.

Schwaber, Ken and Beedle, Mike (2002). *Agile Software Development with Scrum.* Prentice Hall, Upper Saddle River. 158 p.

Shewhart, Walter A. and Deming, W. Edwards (1939). *Statistical Method from the Viewpoint of Quality Control*. The Graduate School, The Department of Agriculture, Washington. 155 p.

Teston, Jim (1998). *Evaluating the Benefits of Lean Construction on Productivity.* A Thesis Presented to the Graduate School of Clemson University. 97 p.

Winograd, T. and Flores, F. (1986). Understanding Computers and Cognition: A New Foundation for Design. Ablex, Norwood. 207 p.