APPLYING MULTI-METHODOLOGICAL SYSTEMS THEORY TO PROJECT MANAGEMENT

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Abstract

This paper begins with the proposition that most project managers are dealing with complex systems. Complex systems are defined as systems with numerous stakeholders, nonlinearities, multiple interdependencies and feedback systems. Typical nonlinearities are often unanticipated changes in the scope of the project, the dismissal of project managers, shedding people with critical labour skills or the termination of credit arrangements with banks. The interdependencies are the relationships between project management, the suppliers and contractors, the clients and the other stakeholders. The feedback systems most common to the success and failure of project management are the rework cycles and their impact on both the demand for labour and the final budget and completion date. The paper outlines a methodology for project management that integrates a number of systems thinking tools into the project management process.

Introduction

The project management processes as described constitutes what is commonly known as a "wicked problem". Such problems require a multi-methodological approach because they are often not amenable to solution with a single methodology. Lee and Miller (2004) document a multi-methodology approach combining System Dynamics with Critical Chain Project Management to simulate a multi-project environment where the focus is on interactions between projects. The approach taken in this paper is broader and examines a series of methodologies, primarily from Soft Systems Methodology (SSM), System Dynamics (SD), and Viable Systems Methodology (VSM). Howick et al (2006) reported on a case where a team of modelers designed and implemented modelling guidelines to link semantically rich scenario maps to a formal causal influence diagram of a running simulation model.

To apply this set of Systems Methodologies, the project management process is divided into three traditional stages:

1 The concept and design phase
2 The implementation phase
3 The evaluation phase

Each one of these stages is aligned with a specific and appropriate systems methodology appropriate. The systems methodologies are:

1. Rich pictures
2. Causal Loop Diagrams
3. CATWOE analysis
4. Viable Systems Methodology
5. Process Mapping
6. Action Learning
7. System Dynamics Modelling

The application of the systems methodologies to the three stages of project management is shown below in Figure 1. The application of the methodologies progresses from the general, namely Rich Pictures, to the highly specific, in the form of System Dynamics Modelling. System Dynamics Modelling is used in two phases in the project: implementation and evaluation. It also plays a valuable role in the Action Learning and reflection processes.

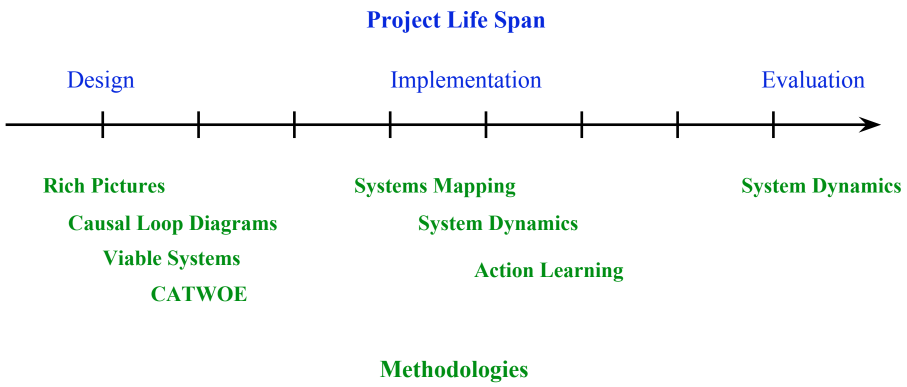

Figure 1: Methodologies from CATWOE and Rich Pictures to the dynamic perspective of SD.

Ishino and Kijima (2005) have applied a more limited application of mixed methodology using soft systems methodology, SWOT analysis and strategy maps of the balanced scorecard for simulating project management. Lane and Oliva (1998) discuss the theoretical case for integration of SD and SSM and the relative strengths of each.

> SSM generates and represents diverse perspectives on a problem situation and addresses the socio-political elements of an intervention. However, it is weak in ensuring dynamic coherence: consistency between the intuitive behavior resulting from proposed changes and behavior deduced from ideas on causal structure. Conversely, SD examines causal structures and dynamic behaviors. However, whilst emphasizing the need for a clear issue focus, it has little theory for generating and representing diverse issues. (214)

The Concept and Design Phases

The concept and Design Phases involve the initial conception of he project, a feasibility study ands the design of the organizational structure responsible for the governance, management and implementation of the project itself. The emphasis here is primarily on SSM. Winter (2006) describes the use of SSM where objectives are often unclear and where different constituencies have conflicting aims at the front-end of a major project within Tesco Stores Ltd.

Concept and Design Phases 1: Rich Pictures

Rich pictures were developed by Peter Checkland in his Soft Systems Methodology (Checkland, 1981; Checkland and Scholes, 1990) and are useful in collecting information around complex situations such as the management of a project. The example shown in Figure 2 is a rich picture developed by students in the project management course at the University of Technology Sydney (UTS) who were asked to develop a rich picture for an organization to shift the World Cup cricket from India to another venue.

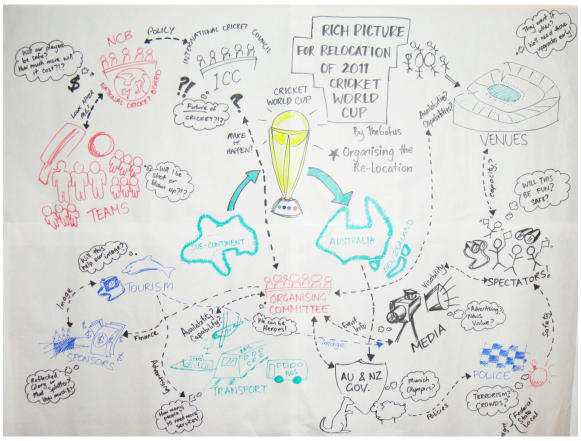

Figure 2: UTS students rich picture of the World Cup cricket organization

The rich picture identifies the issues and related process in the project. It is also useful in exposing mental models and metaphors that are associated with the particular project. Often these metaphors will be indicative of mental models, values and attitudes that are unstated but often extremely influential in the governance and management of the project.

In addition, the goals of stakeholders can often be diverse. Meadows and Robinson (2002) list a number of goals that people may have in projects

1. The stated goals
2. The personal or institutional goals
3. The wild hopes and fears
4. The life goals

Understanding the diversity of these goals at the beginning of the project may be extremely useful particularly if the BOT graphs, identified in the next stage, can identify the fears of people have for the dynamics of project as shown in Figure.

Design Phase 2: Causal Loop Diagrams

The first step in this systems oriented approach is to draw a Causal Loop Diagram (CLD) of the essential success drivers in the project. These success drivers become the policy levers that will ensure the on-time completion of the project. The purpose in designing CLDs is to understand the fundamental dynamics of the project and to develop policy levers to control variation in the system. These CLDs, if well-developed, are an important input into the work of System 5 in the Viable System Model that will be developed later in the project.

Figure 3 shows two CLDs. The left hand one indicates the downward spiral that can develop when rework begins to surface in the project. As completion times blow out, the pressure on staff, particularly the management, increases and turnover (either voluntary or involuntary) increases. Staff turnover erodes the skill base and contributes to increasing rework. There are also delays in the system as the increasing pressure is often not immediately obvious as it is absorbed until a crisis develops. There are also further delays in hiring staff. Both of these factors can to exacerbate the downward spiral. The right-hand causal diagram indicates a possible leverage point where the effect of the emergence of rework is mitigated by hiring as the rework begins to surface. This policy intervention may short-circuit the crisis generated through stuff turnover.

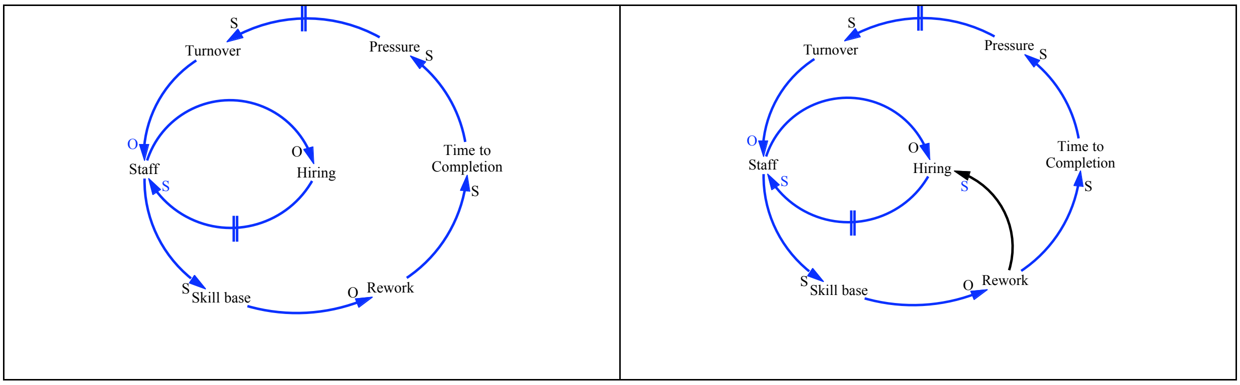

Figure 3: Two CLDs with a policy lever included on the right hand side.

The CLD will be accompanied by a series of Behaviour over Time (BOT) graphs. These graphs can serve a number of functions. The left hand graph in Figure 4 shows the freehand BOT with the planned staffing for the project, the one that is feared if the project deadlines blow out and the actual behaviour. Lyneis et al (2002) make the point that project management needs to have a learning structure included so that this projected and actual behaviour can be understood and the learning from the past built into future projects. He also observes that staff productivity declines during the first part of the project as a result of the

"Rookies and Pros" effect. In the example below it would be expected that productivity would decline slightly when new staff are taken on.

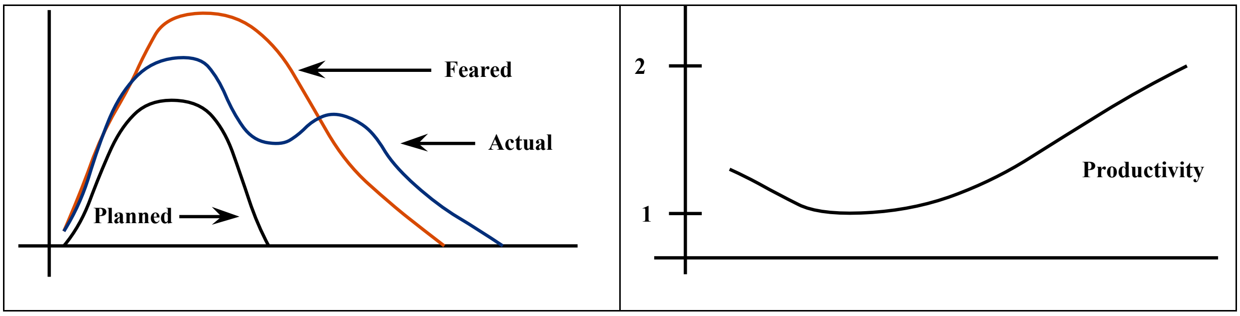

Figure 4: Behaviour over Time graphs for Staffing levels and Productivity after Lyneis et al (2002)

Design Phase 3: CATWOE

- Clients - those who benefit (or suffer) from the operations of the organization e.g. customers
- Actors - the individuals, groups, institutions and agencies who perform the functions of the organization
- Transformations – the processes that transform inputs to outputs
- Weltanschauung or world-view is the bigger picture into which the situation fits and incorporates the way the organization views the world
- Owners – these are the people who have ultimate say over the project who provide the resources and who can pull the plug
- Environment - The broader constraints that act on the situation. These may be ethical limits, the laws, financial constraints or limited resources

CATWOE is a simple descriptive framework that requires little explanation apart from the fact that it normally helps to do the Weltanschauung or worldview first. This is useful as a framing exercise and provides a useful perspective for the rest of the analysis. The next stage of the CATWOE analysis is the formulation of the Root Definition, which is the best possible and most encompassing definition of the organization that can be drawn from the CATWOE analysis. The Root Definition provides useful input to Design Phase 4. Examples of Root Definitions from the UTS program included:

The final stage of the CATWOE analysis is to establish the Value Propositions that constitute the two-way exchange of value between the organization on one hand and the clients and owners on the other. Figure 5 shows the value propositions between a football club and two of its clients, the fans and the players.

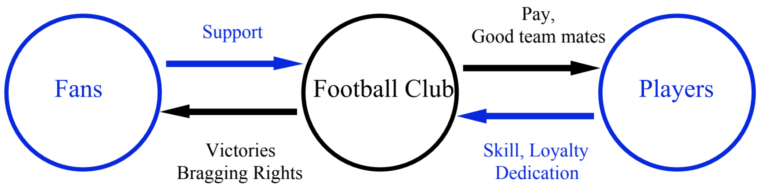

Figure 5: Value proposition between a Football club, its fans and players

The fans provide support for the club and in return they expect the club to be successful. The players expect that the club will pay them well and will be able to build a team that will be successful. In return, the club expects high levels of skill, dedication and loyalty from the team members.

Design Phase 4: The Viable System Model

The Viable Systems Model was developed by Stafford Beer (1972) in his book *Brain of the Firm.* The model to be developed in this phase is a structure that is the basis for an organization that will remain viable in the face of a changing environment. The viable systems model provides a structure for the governance of the project.

The five systems of the VSM are shown in Figure 6

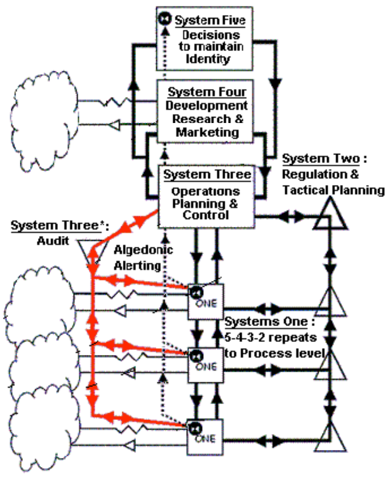

Figure 6: Stafford Beer's Viable Systems Model (*wikimedia.org/wikipedia/commons*)

1. System 1 is the operating system that implements the key transformations of the organization.
2. System 2 is the management and coordination system for System 1 providing information channels for system 1 to communicate with System 3.
3. System 3 is the control and audit system that establishes rules, allocates resources and provides a communication link to Systems 4 and 5.

4. System 4 is the intelligence system that scans the environment and provides information on how the organization can remain viable.
5. System 5 provides policy decisions, balances the minds from the other systems and serves as the government system for the whole organization.

In this phase of project management the establishment of the governance, intelligence, audit and operational functions for the project can be designed using the VSM template. Examples of the work of the UTS students are shown in Figure 7.

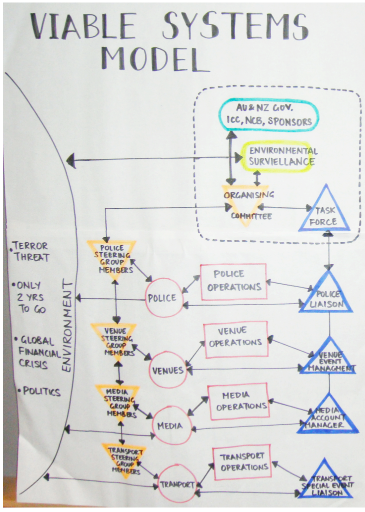

Figure 7: Example of Beer's VSM

System 4 has an important function to play in the management of projects. The environmental scanning role should cover frequent communication with such stakeholders as banks, suppliers, contractors, customers and other members of the project team. The information gathered from these stakeholders is sent to the modelling team and then fed into the project model. The updated model becomes an important input into learning cycles of System 1. This enables the people in System 1 to be aware of possible delays and lags in the supplier of finance or materials.

In placing an emphasis on governance and the application of the VSM, we endeavour to broaden the focus of the governance process beyond what Beer would term System 1 (the operating system). Using the VSM ensures that there are formal structures for policymaking, intelligence gathering, audit and resource allocation rather than rolling these functions into the operating system whose primary function is delivering on the project. It provides a structure where the requirements of the Clients, Actors and Owners identified in the CATWOE can be accommodated. It also provides a framework where the critical elements of the value propositions can be included in the activities SYSTEM 1.

Implementation

Phase 1: System Dynamics

Lyneis et al. (2001) cite a review by Morris and Hough that found that in 3500 projects overruns were typically between 40% and 200%. They also comment that recent developments in project management techniques do not seem to improve the situation significantly. They provide an example of the typical BOT graphs that indicate staffing build-up through a project. Ideally staffing builds up and falls away as work is completed. Lyneis observes that project staffing is

> Often slower to build up than planned and exceeds planned levels for an extended period. Often there is a second peak once rework is discovered and needs to be corrected (274).

They also observe that productivity does not remain constant for the duration of the project. In reality, productivity typically falls from the beginning through the middle of the project before rising at the end. Lyneis believes that

> Projects continue to perform poorly because projects are fundamentally complex dynamic systems and most project management concepts and tools either (1) view the project statically or (2) take a partial, narrow view in order to allow managers to cope mentally with complexity. These tools lead each manager to believe that each project is unique which makes systemic learning across projects difficult. (239)

Lyneis notes the success of SD applications in litigation related to project management (Cooper and Mullen, 1993; Reichard and Lyneis 1999) and also its success in project management (Abdel Hamid and Madnick, 1991; Homer at al, 1993; Ford and Sterman, 1998). Rodrigues and Williams (1998) discussed the use of SD to model the impact of client behavior including schedule restrictions on milestones, high demand on progress reports, delays in approving documents, and changes to workscope throughout the life-cycle on a project.

Lyneis outlines the case for using system dynamics in strategic project management that involves:

- Designing the project
- Determining what indicators to measure and monitor and exert pressure on
- Risk management
- Incorporating learning from past projects
- Making mid-course corrections

The use of SD at the beginning of the Implementation Phase lays out the workflow for the project. There are two main advantages in doing this. The first is that the resource requirements for the project can be identified, and second the effects of feedback systems such as those created by lags and delays, rework can be modelled. The inclusion of co-flows of staff can help determine the time required for the project and an estimation of likely delays as a result of resource constraints. Figure 8 is a simple example of such a structure. With very little modification this model can be adapted to change the staffing co-flows to finance or material co-flows.

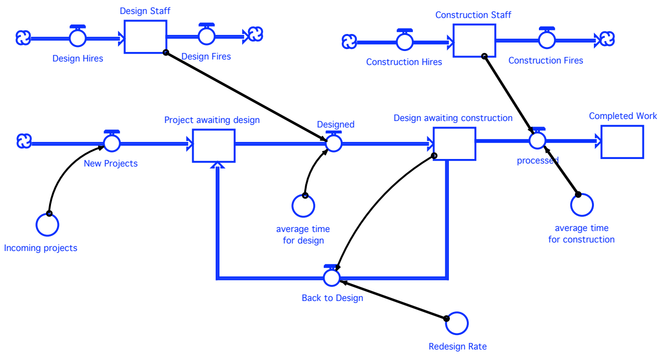

Figure 8: Work and staffing co-flows

The main flow is incoming work to the design department and from the design department to the construction department. There is a re-work loop where work must be redesigned. The co-flows are two stocks of staff for each department. The work progresses through the main chain at a rate that the number of staff can complete their respective tasks. The numbers of staff in turn are dependent on the respect of hiring and quit rates. This model enables managers to understand workflow rights and potential delays based on the number of staff available and the amount of rework that is generated.

Figure 9 is a development of the staffing model known as the "Rookies and Pros" model. This model allows managers to understand the negative effects of experienced staff leaving the project, particularly when the workforce is being expanded either a result of increased work or increased rework.

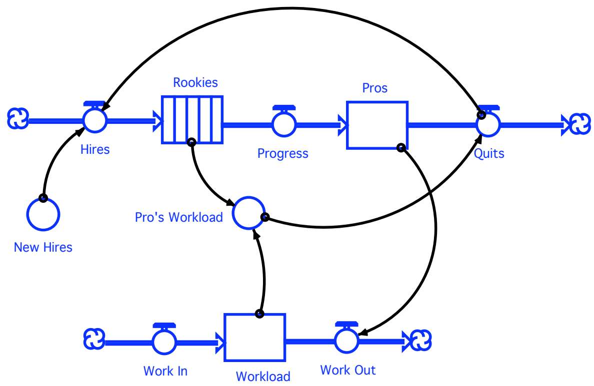

Figure 9: The Rookies and Pros model

The critical dynamic here is the Pros' workload, made up, not only of the workload itself, but by the number of rookies they need to train. As the number of rookies increases, the Pros' workload increases with the lagged effect that Pros begin leaving. This increases the average workload for each Pro as well as increasing the number of rookies as result of new hires. This situation can be exacerbated when there are extra hires as result of project changes or rework.

Even these simple models can involve as many as 20 simultaneous difference equations being calculated for each day of the project, a task well beyond the human brain even using a spreadsheet. The impact of such complex interactions and feedback systems can only be understood through simulation modelling. Building this model before the planning and contract negotiation stages of the project provides insights into resource requirements and the impact of delays as a result of rework cycles.

Howick and Eden (2004) discuss the nature of discontinuities in SD models of project overruns and the importance of modelling them. These included change in project managers, scapegoating, customer pressure: discontinuities from ‘settling-in’ following a change of project manager, substantial changes in the production or manufacturing system, renegotiation of project milestones and managerial labour policies. Nasirzadeh et al (2008) outline a system dynamics (SD) approach to construction project risk management including risk analysis and response process. Fuzzy logic is integrated into system dynamics modelling structure to model imprecise and uncertain nature of risks.

Action Learning

Lyneis et al discuss the use of their SD model in the Peace Shield Project to update the model as data about project progress and external conditions became available. Such an approach allowed managers to compare actual progress with desired progress and anticipate the effects of down stream delays. He cites two examples of learning in the Peace Shield Project

1. Implementation of different staffing strategies for software engineering and coding
2. Implementation of a “teaming” for the project

He makes the point that the explicit use of learning structures based on the updated model allows learning to be transferred for one project to another. Frequent iteration of this process creates a learning cycle similar to that of Action Learning.

Both the Action Learning cycles and the Andersen and Richardson model have provision for learning structures and the SD model is an important input into that process.

Project Evaluation

Vennix, Richardson and Andersen (1997) developed the SD enquiry model. The emphasis at this final stage is on he evaluation inherent in Policy Analysis. Figure 10 shows the model.

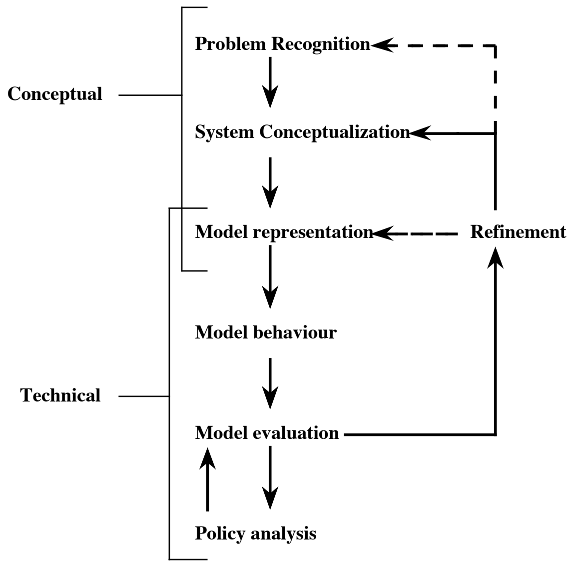

Figure 10: Richardson and Andersen's Enquiry Model

The SD model can be used in evaluation two ways. Firstly, it can be used to compare the baseline projections for the project with the actual performance and to evaluate different stages of the model and to assess their impact on later stages. Secondly, the learning stages, inherent in the development of the model, can be aggregated into a comprehensive report on the learning and development of the project and provide input into the learning cycles of the next project.

In the conclusions we can say that current project management methodologies use a normative and reductionist approach based on models derived form hard systems thinking and systems engineering. However such approaches are insufficient when projects become more comple3 due to uncertainty and ambiguity; Systems methodologies could be very useful to extend the capability of project managers to deal with the complex aspects of a project. Conventional project management methodologies often deal with implications of short-term focused management actions that could actually have a detrimental effect over a longer time.

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