Applying the Lens of Complexity Theory to Project Management

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Abstract

The authors argue that the traditional way of regarding project management is too mechanistic and is rooted in an inappropriate paradigm of command and control thinking. The alternative paradigm is to view projects as complex systems and the outcomes of the project as emergent properties of the system. This alternative paradigm presents a challenge to the organization learning process. Learning happens through the 'double loop' process and the knowledge is held as procedural norms in the organization. This creates a paradox, the procedures are mechanistic structures embodied in the project methodology and because of their inherent nature they cannot accommodate complexity. The authors suggest the use of Interpretive Structural Modelling (ISM) as a means of overcoming the difficulty. Our argument is that through the frequent use of concept modelling tools through the duration of the project as well as the front end, a manager can navigate project to more successful outcomes.

Keywords: Complexity, emergence, project management.

Introduction

Complexity theory is a response to the mechanistic and reductionist approach or paradigm that we use to explain our world (Dann and Barclay, 2006). Management literature has traditionally focused on prediction and control based on an underlying belief that "*interactions can be described in linear terms*" (Lissack, 1999). This paper first argues that the mechanistic paradigm is reflected in the modern approach to project planning and management, particularly at the front end where many critical decisions are made. This position is supported elsewhere in the literature (Cicmil et al., 2006; Smyth and Morris, 2007) The paper then argues that in reality different environmental conditions create different kinds of issues that need to be addressed, and this implies that the project design should be contingent on the conditions it encounters (Shenhar and Dvir, 2004). In addition the design needs to take account of the fact that emergent behavior will arise from the particulars of any specific project (Lissack, 1999).

The typical modern project uses a standardized set of planning and execution processes (Shenhar and Dvir, 2007). The standardized approach takes the view that the project objectives are pre-set, usually being provided as part of a document issued by the project sponsors (PMI, 2013). This approach does however lead to a variety of problems (Thomson, 2011). The approach arises from a belief that claims there is a general pattern to the appropriate way to manage a project (Smyth and Morris, 2007). A problem with this kind of project design is that insufficient time is spent on defining the question the project sets out to address and developing a robust definition of the projects requirements (Morris, 2009). This problem can be attributed to the main focus of the various guides or bodies on knowledge,

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these documents focus on the planning and execution stages of the project with little attention paid to gathering and monitoring requirements (Smyth and Morris, 2007).

Front-End Ambiguity

When the project begins a set of 'success criteria' may be articulated, these usually include budget and schedule constraints and some statement of the expected outcomes (Atkinson, 1999; Ivory and Alderman, 2005). Such statements of requirements inevitably result in conflicting demands leading to compromises being made by project teams (Ivory and Alderman, 2005). The approach at this point of the project is already weakened due to this failure to actually articulate the desired outcomes in a coherent way. Poor quality specifications and misunderstanding by the project team are examples of the kind of problems that may arise (Deane et al., 1997). In some cases the project evaluation criteria omit the production of a successful product, service, or benefits, and simply focus on measures of the execution of the project itself as if this was the sole objective of the undertaking (Cooke-Davies, 2004). The outcomes are effectively left as "*an emergent property of peoples different attitudes and beliefs*" (Atkinson, 1999: 337). The stated outcomes may be inappropriate solutions to the problem being addressed. For example an organization may state a requirement for major systems changes when the appropriate solution involves implementation of a new replacement technology (Deane et al., 1997). Customer uncertainty regarding the appropriate solution gives rise to inappropriate project and contractual requirements that fail to address the long term problems faced by the client organization.

Further deviations from the client's vision of the outcomes arise when the project team fail to translate the requirements into an effective solution and project plan because they have not suitable skills or experience (Deane et al., 1997). Even in situations where planning is of a high standard and shown to be a significant contributor to project success, the planner may make "*significant changes as well as to improve the baseline for future control purposes*" (Zwikael and Globerson, 2004: 1545).

Some suggestions have been made to address these problems. One advocates the application of Value Management techniques to elicit and capture requirements. It then proposes a Programme Management framework to manage the requirements across the life-cycle of the project and between related projects (Thiry, 2002). The requirements problem has been recognized elsewhere and approaches such as Scenario Planning (van der Heijden, 2009) and Soft Systems Methodology (Winter, 2009) have been proposed as potential solutions. Another author proposes the application of a variety of tools at different points during the project front-end (Andersen, 2009).

Project Execution and Emergence

Once the project is under way, a variety of effects come into play which give rise to emergent phenomena, these are not usually reflected in the project plan nor anticipated by the project planners. Emergent phenomena are events or properties of a system that arise because of interactions between system components. Emergent properties range from simple and predictable outcomes of physical systems, through to quite complex and un-predictable outcomes arising from social systems (Halley and Winkler, 2008). To illustrate this point, an aircraft is a complicated system with predictable characteristics, whereas human organizations or groups are complex and their behavior is not easily anticipated (Snowden, 2003). Social systems are regarded in the lexicon of complexity theory as complex adaptive systems (Schneider and Somers, 2006). The effects observed from interaction and reaction between components of these systems, and the system and its environment are not easily predicted.

Internally these effects arise due to the nature of projects which can typically be seen as a rapidly evolving socio-technical network spread over a number of nodes or activity centers (Ivory and Alderman, 2005). In such an environment it is unrealistic to expect planners to have designed procedures and controls for all eventualities. And the conflicts and contradictions that inevitably arise are not prevented by such planning. This reality has resulted in the suggestion that "*project execution may be thought of as a process of constantly adjusting the project system to fit a confounding and emerging reality*" (Ivory and Alderman, 2005: 8). In such circumstances the manager is not able to use command and control methods and is restricted to influencing the situations arising in the project (Lissack, 1999). This can happen due to inadequate project controls, lack of expertise in the team, uncontrolled external interventions, and uncontrolled scope creep (Deane et al., 1997). The project goals may be fixed but the metaphorical terrain being navigated to reach them is always changing.

The practical question is how can we understand this changing landscape, what are the underlying drivers that shape it and change it? One response is to look to the intermediate processes that link the mechanistic plan to the actions of various project actors. These include processes known to us through systems thinking and game theory which explain phenomena that include feedback loops, non-linear responses, and stocks and flows (Boschetti et al., 2011).

Before continuing with the discussion it is worth noting that projects may deal with issues that are purely internal to the organization. However, there is a class of projects that are linked to organization strategy and through that link to the broader environment. Where environments change for the organization, the goals of projects involved in strategy implementation may change or lose relevance. Such changes add a dimension to the complexity faced by project managers. To a certain extent such changes can be addressed through the rigorous application of risk management and also by containing the scope and time frames of projects to manageable levels. This latter approach has been positively linked to project success rates (Cooke-Davies, 2002). Interestingly, empirical research indicates that risk management along with communications is the point of greatest weakness in project plans (Zwikael and Globerson, 2004).

An example of the processes described above is the case of a low-cost housing project in South Africa (Lizarralde and Massyn, 2008). Due to social isolation a community experienced barriers to accessing health and education facilities. The response of the community was to initiate a housing development through the government supported people housing process. This procurement model "*explicitly promotes active participation of the beneficiaries in the development of mutual self-help projects supported by local or international NGOs*" (Lizarralde and Massyn, 2008: 3). An NGO did become involved and it took over the project management as well as the design role for the development. The original functional designs for the housing units were subsequently changed which resulted in poor land use. As a result of the NGO taking over the project the community involvement was substantially reduced. The end result was a housing design with limited ability to expand to meet the growth needs of the family and no provision for home industry use. Due to the pre-existing infrastructure around the site, several high-speed highways, the community remains isolated from its immediate neighbors.

System Effects on Project Execution

The housing development example described above clearly illustrates the problem of inappropriate selection of a solution to the problem. The isolated community remained isolated in their new homes. The process of creating the project diverted attention away from the social issue to the problem of finding suitable space for development (Lizarralde and Massyn, 2008).

Once the location problem was addressed the issue of housing design came up. The original design conceived by the beneficiaries was for 'row-houses' with substantial space for expansion behind the housing unit. The NGO had stated reservations about local practices of shack building and had positioned the eventual designs, detached and semi-detached, to minimize the potential for expansion (Lizarralde and Massyn, 2008).

What this tale relates is a history; the narrative begins with an isolated group in need of basic housing. The required housing units need to be designed to accommodate physical extension at a later date. The tale ends with a community in formal housing located and designed in such a way that future extension is impractical, located in a geographically isolated area.

The 'story' above is about a community that moved into formal housing. However, the term community implies some form of homogenous entity. It has been pointed out that in fact the term has many meanings, and a community is "*seldom, if ever, homogenous*" (Emmett, 2000: 503), this is also true in the case of many construction projects (Thomson, 2011). In addition, when community engagement occurs, the active engaged members are likely to be doing so for personal reasons rather than the overall good of the community (Emmett, 2000). This suggests that when this 'community' is engaged one can expect processes such as feedback loops, games such as prisoner's dilemma, and so on to become active in regard to the project. These are the processes that support emergent phenomena, and it is the emergent phenomena that we observe when looking into a project.

A commonly observed phenomenon with developmental projects is a loss of engagement or interest among the community participants as the project unfolds (Emmett, 2000). In fact the lack of predictability about the emergent nature of participation on these projects is what one would expect when observing a complex non-deterministic system (Johnson, 2006).

Emergence and Emergent Phenomena

Emergence can be described in simple terms as a property of a substance that is not present in the individual components that make up that substance (Corning, 2002). From a project management perspective, emergent phenomena are behaviors exhibited by groups or teams, team work, something that is not and cannot be displayed by a single individual. There are a number of sources that attempt explanations of 'emergence', but in order to understand organizational dynamics, all are needed (Goldstein, 1999). There are four key concepts that together explain emergent phenomena in social systems, they are; Non-linearity, Self-organization, Beyond equilibrium, and Attractors.

Non-linear effects arise when a small change in one aspect of a system results in a disproportionate response from the system. In other words the small effort put into the system is magnified in its impact giving rise to a larger or more energetic response than the effort initially put in to trigger the response. Non-linear effects can be seen in various aspects of project social practices. Examples include the increased competitive and antagonistic behavior exhibited by groups towards other groups, this often exceeds the level of antagonism that each individual in the group may exhibit towards the target prior to joining the group (see Forsyth, 2006: 451). Stress, a common phenomenon in project environments can affect different people in different ways. In some cases change and increased levels of stress give rise to over-reaction or outbursts of anger that are out of proportion to the nature of the change (Verma, 1996; Parumasur and Barkhuizen, 2009).

Self-organization is a process where people spontaneously form a grouping or shared identity. This is distinct from planned groups that are deliberately formed by their members or an outside agency. The unplanned group is known as an emergent group; in a work setting it usually manifests itself as some form of social network usually developing a set of unwritten norms that define their behavior (see Forsyth, 2006: 6). Self-organization often

arise in emergency response situations where the composition of the team, the roles of its members, and how it operates arises from the context of the situation and the participants knowledge and experience (Drabek and McEntire, 2003).

The study of systems originally looked at organizations as stable entities. However, this viewpoint did not provide insight into unpredictable phenomena in the organizational context. Once it was understood that organizations actually exist in a far-from-equilibrium state emergent phenomena could be better understood (Goldstein, 1999). Organizations typically develop mechanisms that resist change and thus preserve their established identity. To overcome this self-correcting mechanism additional information about the environment and about its own varieties of response are needed. These can be shared by members of the organization to enable the synthesis of a new understanding of itself (Goldstein, 1988). Such changes are typically brought about through some form of change project. The resulting solution to the perceived problem then emerges from the response engendered by the new information and understanding. The temporary status of projects is well understood from the very definition of the term. Projects are typically created to deal with environmental or internal situations that the parent or sponsoring organization is not capable of dealing with in its current form (Thomas, 2006). Their goal is often to change the current organization in some respect to enable it to retain its discrete identity.

Attractors are conceptual models of states that a system may tend to move towards. They may represent a stable state under certain conditions, and a system can change from one apparently stable state to another, each state being regarded as the manifestation of an attractor. Because of the different kinds of behavior systems exhibit in relation to attractors, there is a classification of types of attractors (Goldstein, 1999). The consistent application of a particular decision making process in a project when faced with a problem is an example of an attractor in human behavior (De Greene, 1990).

The Dilemma Posed by Complexity

Complexity, once acknowledged, poses a problem for the project manager. On the one hand the manager is obliged to forecast a future state that by convention will include an estimate of the project completion time and costs. This forecast is generated from a planning process that involves a large number of different professions who have engaged in an 'evolutionary' planning process to arrive at a suitable design (Tunstall, 2006). The construction process that follows will also involve numerous people whose precise actions and eventual relations with one another are not knowable in advance.

Organization knowledge is typically held in the form taken for processes and procedures. In the case of a project driven or mature user of project management that knowledge is held collectively by a methodology and the supporting procedures and experience of its users. This model sits within the deterministic paradigm that started this particular argument. The dilemma posed is how to capture and learn as an organization whilst retaining a fluid ability to respond to the challenges posed by complexity in the project environment.

The dilemma rests between the need to adopt a deterministic or mechanistic view to prepare the project plan and the understanding of the complex reality the future represents. This dilemma is often missed in practice when deterministic approaches are often coded in the methodology used.

A Tool to Manage Complexity

The traditional approach to problem solving has been reliant on mechanistic and predictive approaches (Rosenhead and Mingers, 2001). Such approaches aim to provide an optimal solution. An alternative view has placed the focus on the identification of the real problem, 'what the problem is'! The approaches developed from the latter viewpoint use models to

provide decision makers with enough information to make coherent decisions and be confident about the commitments they make (Rosenhead and Mingers, 2001).

Interpretive Structural Modelling (ISM) is a means of constructing a model of relationships between issues. The process of building the model creates a dialog between participants which facilitates learning and sharing of viewpoints in a congenial atmosphere. The use of software ensures that the logic of the model is consistent and the use of the tool supports a process that makes efficient use of time. The output from the tool is a map or diagram of the relationships between the various issues identified.

Three applications of ISM are mentioned here which should resonate with project managers. The first involved the development of a balanced scorecard for a food company (Thakkar et al., 2006); the second was the development of a risk model for a logistics supply chain (Pfohl et al., 2011). Finally the application has been applied to vendor selection in a procurement setting (Mandal and Deshmukh, 1994).

In the case of the balanced scorecard model(Thakkar et al., 2006) ISM was used to obtain a balance between strategic objectives and operational measures. The tool enabled decision makers to visualize and evaluate the overall objectives of the business unit. It also gave them faith in modifications and changes arising due to realities arising in the context of the planning exercise.

The application of ISM to risk analysis facilitated pairwise analysis of risks by a group of experts from different functional areas (Pfohl et al., 2011). ISM thus enabled a more complete understanding of the total risk exposure faced by the organization in addition to the specific risks perceived by individual experts.

In the third example, ISM was applied to a vendor selection problem (Mandal and Deshmukh, 1994). The approach was used to create a hierarchy of selection criteria to be applied to a ranking process, one of the steps in a procurement exercise. The surveys show that ISM is a versatile approach which can be employed in various projects. Figure 1 portrays the ISM process and how it can be used to absorb and iron out complexity in different project phases.

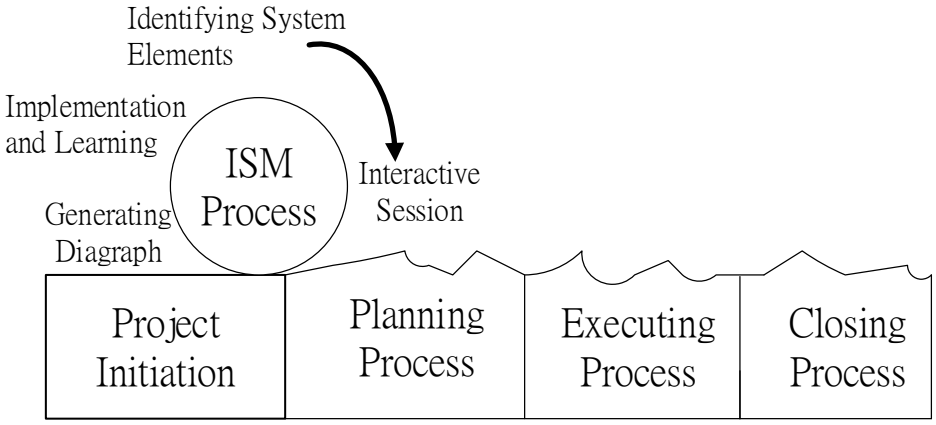

Figure 1. ISM in Project Management

Conclusion

This paper has argued that the modern project environment is characterized by numerous processes that do not readily conform to command and control management approaches. Because of the variety and unpredictability of these processes it is suggested that a dynamic steering mechanism is needed to establish project goals and to keep it on track once it is under-way.

In this paper we have proposed that the frequent use of Interactive Management software tools enables project teams to better understand the fundamental issues they are facing and thus arrive at superior project solutions for delivery to the project client.

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