Decision-making in organizations under uncertainty based on cognitive model: The NU experience.

BY

CHINWI MGBERE

THESIS

Submitted in partial fulfillment of the requirements
for the degree of Executive Master of Business Administration
in the Graduate School of Business
Nazarbayev University, 2016

Astana, Kazakhstan

Advisor: Rick Larrick

Abstract

Professional experience shows top, middle and low-level management must be ready to make decision at their respective levels instead of demonstrating an attitude of avoidance, falling into a reactive mode and losing holistic understanding of the bigger picture. This leads to information and decision-making going up and down the hierarchical ladder resulting in critical loss in duration. It is imperative that sustainable strategy receives paramount attention considering the constraints in financial and human resources, uncertainty and complexity in an organisations' environment. Sustainable decision making is achievable through interaction and influence between decision makers (stakeholders) during project implementation. Projects stand to benefit from this interaction through exchange of knowledge and motivators, given that a competent project manager with high cognitive potential is involved. The goal of this thesis is to develop a decision-making model where decision making leaders create conditions that allow teams to manage themselves effectively and enhance team performance at their best.

Keywords: decision-making, attitude, organization

Table of Contents

Decision-making in organizations under uncertainty based on cognitive model: The NU experience

1. Problem formulation

1.1 Introduction

Project challenges require project teams to make rapid decisions. These decisions interact with the complex, dynamic and sometimes ambiguous project environment and affect the overall project outcome. Nazarbayev University (NU) in Astana was established in 2010 as part of an initiative to create a world class University - a quantum leap of the educational system in Kazakhstan. A collaboration initiative with some of the leading top 100 universities from around the globe has also been initiated. To excel under such conditions, an innovation approach of collaboration, coordination and information sharing and decision making was implemented. This enhanced the decision making process of project team members and stakeholders and the value of their decisions. The NU campus construction project is characterized by an environment of ever changing stakeholders with new stakeholders coming to play during project implementation and exerting diverse influences: cultural - with international General Contractors, workforce from countries across Europe and Asia with their own beliefs and values; changing end-user requirements; governmental; political and technological. To excel under such conditions, an innovative approach that enhance the decision making process of project teams is required. To enhance effective decision-making all levels of the leadership echelon (top, middle and low), the organization has to demonstrate the required level of competence and cognitive readiness in executing their

roles. Situational leadership and self-managed teams is key to successful implementation of this model. This research problem is focused on uncovering factors (barriers) that influence the attitude of project team members and make them shy away from decision making in challenging project situations, perceived as threats and factors (cognitive enablers) that enhance cognitive readiness. Cognitive readiness can be defined as the possession of psychological (mental) and sociological (social) knowledge, skills, and attitudes that individuals and team members need to sustain competent professional performance and mental wellbeing in the dynamic, complex, and unpredictable project environments (Strater et al. 2012). This concept also relates to the "capability to adapt to and quickly address with manageable stress new, unpredictable, unforeseen changes, acting dynamically and proactively with self-efficacy sensations" (Archibald et al., 2013). Such performance may be achieved by a project team after working together for a fairly long period of time. In a highly dynamic environment where the consequences of poor team performance can be detrimental, applying the knowledge of human behaviour provided by the advances in cognitive psychology (Etter et al., 2000; Morrison & Fletcher, 2001; Fletcher, 2004) in a real-world project, like the NU construction project enhance project performance. To expose factors that affect high performance of project teams, we use an interdisciplinary research approach based on facts, methods, theories, and rules of inference discovered in the field of cognitive psychology and tools, crucial for behavioural scientists. This

thesis is also aimed at defining factors that promote coordination and information sharing in project teams for effective decision making by major project stakeholders. A team with adequate level of collaboration and information sharing is the backbone for effective (informed) decision making, which in turn enhances the teams' cognitive readiness that support high performance.

NU campus construction project is implemented by the Private Entity – Facility Construction Directorate (FCD) in the role of project manager and Client representative. FCD Tasks include: pre-project, project and post-project activities such as business case development, feasibility studies, design, construction, and transition to operations. There are at least five stakeholders involved in FCDs' projects. When multiple teams are involved in projects, there is usually a tendency for the teams to work in silos, instead of working cross - functionally, e.g. cohesively. This causes conflicts in the integration of functions and leads to the decreased work and team performance. Team performance depends on factors such as team satisfaction, project efficiency, goal achievement and many other factors. Only some of the stakeholders involved in the project share the same value of cross-functioning. Value difference among the stakeholders lead to job-related tension, lower job involvement, commitment, therefore impairing the overall project efficiency. (Green et al., 2000; Jackson and Schuler, 1985; King and King, 1990).

The NU project Stakeholders include (see Figure 1.1):

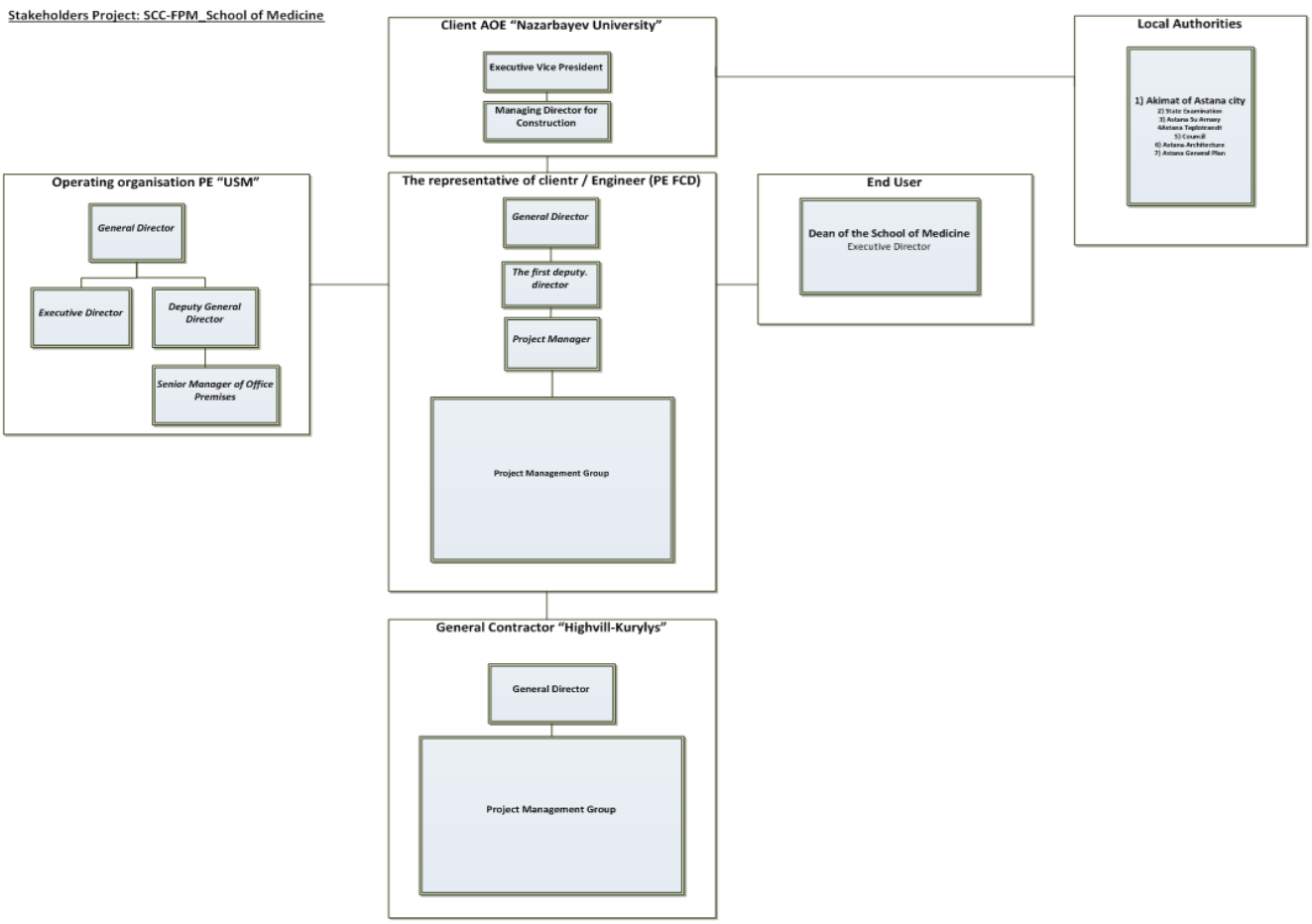
The internal stakeholders:

- FIDIC engineer (Project manager company) – FCD, with roles like: project director; project committee; planning and control unit; project manager; cost account managers.

The external project stakeholders:

- General contractor team, with roles like: Project director, Project manager, design team, construction team, subcontractor teams, and supplier teams.
- NU (Client) - Project sponsor, Managing council,
- End user teams, depending on the project have roles like: (Students Affairs, Graduate School of Business, Graduate School of Public Policy, School of Engineering, School of Science and Technology, NU Research Innovation Systems, Centre for Life Sciences, NU School of Medicine, etc.)
- Facility Management team ("PE University Service Management")
- Regulatory bodies and Special Interest Groups.

Figure 1.1 Project stakeholders



The main goal of FCD is to organize the initiation, planning and implementation and hand over of NU projects, which is always associated with the following questions:

- How long will it take to implement the project?
- How much will it cost?
- Will the built facility be fit for purpose?
- Will the end result meet the major stakeholders' expectation?

Characteristics of project teams:

• Distinctive roles and duties;

• Standard procedures;

• Knowledge and skills;

• Team building;

• Team members come together in their numbers to deliver on a complex project without prior experience of working together

Standardized procedures have a down side –

• It is slow in reacting to change and adapting to new conditions. Because all procedures are specified in detail, changes in operation require reengineering the workflow, rewriting procedures.

• Underutilization of members' intelligence, initiative, and ingenuity.

The objective of a high performance project team is Stakeholder satisfaction that generates repeat business, even if that meant occasional deviation from standard routines (vary normal procedures and allocated duties).

There is no "one best way" to implement a project. Project teams (through the project charter) receive a common understanding of the project objectives, the direction for their work and a diverse set of tools to use in pursuing the projects objectives. Beyond that, project teams are on their own.

Sometimes team members may not know exactly how long it is going to complete a task. Even so, stakeholders want to be told the truth, and the whole truth,

about the status of the project. It is a key part of the work of the project manager/team members to decide to do just that. If they themselves do not have the information, then it is their job to decide to seek it out and pass it along. When there is a problem, decide to explain to stakeholders honestly what the problem is and what they are doing to take care of it. This approach is underlined by the IPMA Individual Competence Baseline (ICB4) with its methods, tools and techniques - the application of Knowledge, Skills and Abilities in order to achieve the desired attitude that support right decisions for project results.

By the existing practice (business as usual), organizations operate as silos with strict boundaries that only allow for one point of contact at the very top of the chain of command. This creates a profound bottleneck in the decision making process of the project team.

To excel under such conditions - enhance the decision making process of project teams, an innovative approach that promote collaboration, coordination and information sharing is required. The premise of this thesis is a study of the factors that support and enhance competence development of decision makers through positive influencing that is based on collaboration, coordination and information sharing among a network of teams. Leaders of organizational silos are the key points of responsibility in project implementation. They are charged with the responsibility of delivering value to major project stakeholders. In the process of implementing leadership roles, leaders do not

have direct influence on schedule, time and cost. What a leader controls is his project manager. The problem is that key encounters between project managers (team members) and uncertainty occur during the process of project implementation during the day to day project situations. Worse, project leaders are not available on the ground to address these situation as they arise due to the fact that they have other administrative responsibility. So there is no realistic way a responsible project leader can monitor and manage what really counts – for example team members' encounters with project situations.

It is time to rethink the design, manning and management of complex project teams. This thesis problem is focused on uncovering factors:

- Barriers and enablers that promote Collaboration and Information Sharing in Project Teams and how this impact team performance.
- That influences the attitude of project team members and makes them shy away from decision making in challenging project situations, perceived as threats.
- How cognitive learning and influencing can enhance stakeholder decision making competence and behavior in projects

2. Analysis

2.1 Competence-based approach to managing projects

With increasing complexity and scope of knowledge about deliverables (products and services) created in projects, of importance is not only the value of knowledge and experience, but also the competence aspect of managers of projects. As a result, there is a growing demand for competence in all areas of knowledge. The labour market is gradually becoming a market of competence, and competence management will play an increasingly important role in personnel management within the organization. This is particularly true for innovative projects.

Competence approach is based on two concepts:

- authority - the area of activity or function, performed by employee;
- competence - the characteristic of potential capabilities of employee to successfully work within the specific competences.

At the NU project with all its challenges and uncertainty, FCD is faced with the task of unlocking the potential competence of individuals engaged in the projects to the fullest, which is key for quick and appropriate decision-making through all phases of project implementation. Coupled with this challenge is the availability of project manager in the labour market of Kazakhstan. Competence management is an important component of the FCD organizational management system.

- Its development and implementation is based on the following principles: competences are clearly delineated (the principle of independence of the components of an effective model);

- all competences related FCD's core business are completely covered (the principle of completeness);
- authority is clearly defined, regularly reviewed to reflect the current challenges facing FCD (the principle of realism);
- all competences are decomposed to the desired level of detail (the principle of differentiation);
- all competences have indicators that enable the assessment of competence of managers (the principle of measurability).
- These principles are achievable following the implementation of FCD's organizational management system based on global best practice - the IPMA Individual Competence Baseline ICB4.

2.2 Competence areas

ICB4 contains three areas of competence. These areas apply equally to all three domains (project, programme and portfolio management). The three competence areas cover (IPMA"Individual Competence Baseline for Project, Programme & Portfolio Management" Version 4.0):

- People competences: these consist of the personal and interpersonal competences required to successfully participate in or lead a project, programme or portfolio

- Practice competences: these are the specific methods, tools and techniques used in projects, programmes or portfolios to realise their success
- Perspective competences: under this heading come the methods, tools and techniques through which individuals interact with the environment, as well as the rationale that leads people, organisations and societies to start and support projects, programmes and portfolios.

Competence structure of the ICB4 in the project environment is broken down into 29 competence elements with one to many key competence indicators each.

- Perspective competences (5 elements)
- People competences (10 elements)
- Practice competences (14 elements)

The framework of the ICB4 is the bases of the FCD corporate project management control system and Human Resource competence development system. The success of the competence-based approach in FCD largely depends on the ability of managers adapt it to FCDs' processes, strategies and culture. In accordance with the scope of competences for a manager FCD constructed a path for career development with the following roles:

- IPMA-D - Assistant project manager/ project management associate
- IPMA-C – Project Manager

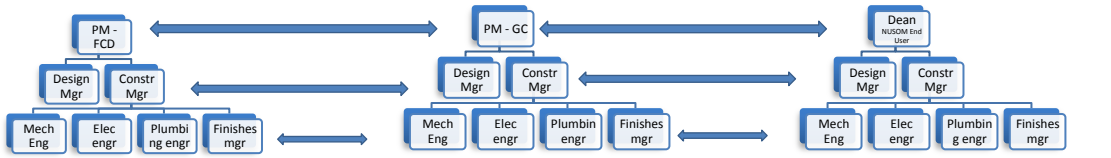
- IPMA-B - Senior Project Manager
- IPMA-A – Project director

2.3 Factors that affect the quality and speed of decision making

“Recent trends (such as the push for sustainability, the increased desire for stakeholder engagement, and the globalization development) have influenced the environment under which decision makers work. Consequently, the models of how decisions are formed and made should adapt to that change. Decision-making problems are studied in terms of three major components: decision makers, decision tools, and techniques for selecting the best alternative. In terms of decision makers, a shift was detected from an assumption of individual decision makers to a hierarchical structure, and, more recently, to a network of decision makers Fig 3.1. Decision criteria have evolved from focusing on the technical and objective to soft and subjective aspects of projects. A general migration from models with pure deterministic nature to (fundamentally) probabilistic models with stochastic approaches is detected. The complexity of engineering problems has resulted in a shift from judgmental to rational selection techniques. Interest in softer and subjective issues (such as sustainability) and the increasing number of (diversified) stakeholders have promoted the application of emergent-based selection methods, particularly in infrastructure projects.”(“Synthesis of Decision-Making Research in

Construction”http://www.academia.edu/Documents/in/Decision_Making_Analysis_and_Modeling?)

Fig 2.1 Network of decision makers



FCD General contractor Maintenance Co. …

2.5 Identifying the need and constraints.

The main objective of Theory of constraints (TOC) is infinite profit, and everything that prevents the system from achieving that goal is defined as a constraint (Goldratt and Cox 1984 Goldratt, EM and Cox, J. 1984. The goal: A process of ongoing improvement, Great Barrington, MA: North River Press.). TOC states that any manageable organization always faces either internal or external constraints that prevent it from infinite throughput. It is critical to identify and supervise only one constraint at a time. In our case the lack of the organizational skills, such as fear of the timely mannered decision making is defined as the constraint.

Steps for implementation of TOC:

1. Constraint identification (Organizational in our case)
2. Supervise the constraints

3. Evaluate the performance

My practice in the NU projects proved that such organizational constraint can be eliminated by working towards cognitive readiness and enhancing the level of competences of these decision making individuals through knowledge and influence instilled by the a competent project management team

2.6 Managerial Constraints

Poor management policies often make it impossible to use physical resources fully or to use non-constraint resources properly to create throughput. An example is the tendency of late cost plan delivery by the General contractor (GC) Organization with the hope it will capitalize on inflation. Another is this silo-type behavior and avoidance of team decision-making. Such policy in fact, led to serious reworks and missed delivery dates of work packages and subsequently decline in profitability. An example is Lean management concept in some GC organizations. Another managerial constraint is the organizational structure the GC organization that is not projectized despite being a project oriented organization.

3 Solutions and implementation

Hypothesis

Since people, so do project decision makers and stakeholders, learn by observing and imitating, self-efficacy in decision making can be enhanced by influencing stakeholders through positive reinforcement, given that the agent of change (the project manager) has

a positive cognitive potential. The resulting network of decision makers is more likely to make fast and effective decisions in project situations

3.1 Social Cognitive Theory

Social Cognitive Theory (SCT) (Bandura, A. Social Cognitive Theory. In: Vasta, R., editor. Annals of Child Development. Vol. 6. 1989. p. 1-60.) "is a learning theory stating that people learn by observing and imitating others and by positive reinforcement. SCT posits that behavioural change is affected not only by personal factors and internal dispositions but also by environmental influences. Therefore, behavioural change is a complex process influenced by internal and external factors. According to the social cognitive theory (SCT), self-efficacy is the most important characteristic that changes human behaviour. Self-efficacy is the extent or strength of one's belief in his own willingness and ability to complete tasks and reach goals.

Individuals with high self-efficacy have high expectation that the outcomes or consequences of the tasks they perform must be effective, valuable and beneficial to them, and they believe that they can exhibit such behaviour. Self-efficacy is not only influenced by the individual's capability, but also by other people around who may have positive or negative attitude towards a specific behaviour. For example, a heavy smoker who is surrounded by heavy smokers may not expect to get positive influence from colleagues to quit smoking. Broader environmental influence such as from mass media and campaigns is another factor. According to SCT, people learn positive

behaviours which they believe is beneficial to them by observing the benefits of other people exhibiting the same behaviours or by paying attention to public campaigns, research and media discussing the benefits of these actions and behaviours". (Analysis of Online Social Networks to Understand Information Sharing Behaviors Through Social Cognitive Theory, Annu ORNL Biomed Sci Eng Cent Conf. 2014 May; 2014: 1–4.)

In order to produce successful project, every individual in the team should have sense of essential principles that he/she could immediately apply at decision-making, the process might be flexible and sometimes even creative.

"Cognitive readiness has been defined as the "mental preparation (including skills, knowledge, abilities, motivations, and personal dispositions) an individual needs to establish and sustain competent performance in the complex and unpredictable environment of modern operations" (Morrison & Fletcher, 2002; p. I-3, emphasis added).

Cognitive readiness is the ability to "accomplish a mission by making and implementing decisions in a timely, efficient, and effective manner, often with very limited information in a constantly changing, complex, and dangerous environment" (Dyer, Centric, & Wampler, 2007, p. 19).

Besides the definition of cognitive readiness presented previously, it must be noted that the concept also relates to the "capability to adapt to and quickly address with

manageable stress new, unpredictable, unforeseen changes, acting dynamically and proactively with self-efficacy sensations" (Archibald et al., 2013). The characteristics of a competent cognitive ready team include:

- Specific but complimentary roles coupled with the necessary skills and talents aligned with and committed to a common purpose.
- Team members are so devoted to their purpose that they will do all that is humanly possible to surmount any barrier hindering the achievement of project goals.
- Consistent and reliable performance demonstrating adaptive competence and accomplishing results.
- Interchangeable roles within realistic boundaries to better serve project goals. Leadership within the team is not dependent on a single individual but may be taken up by various team members, according to the current needs within realistic limits of scope and authority.
- Proactive in managing the tasks assigned
- Empathetic to the problems of other team members.
- Demonstration of positive attitude coupled with job satisfaction
- Robust methods for resolving conflicts ensuring progression and achieving goals.

- Sense of focus and intense energy based on own consciousness and common norms and values.
- Accountability in relation to actions based on high levels of mutual trust.

3.3 Identification of the Cognitive barriers:

Cognitive model that helps to eliminate Organizational constraint which prevents individuals from the timely mannered decision making thereafter prevents the organization from the constant increase of throughput.

Cognitive enablers: leadership, emotional intelligence, metacognition strategy, lateral thinking, cognitive appraisal, cognitive adaptability, metacognition, resilience, agency, self-efficacy, automaticity of action or Heuristics in judgement and decision making, communication strategy, arousal, assertiveness.

Cognitive barriers: the student syndrome, Parkinson's law, burnout syndrome, internal conflicts that can lead to crises, drastic commitment reduction, overloading stress, multitasking stress (many tasks simultaneously), competence borderline syndrome or cognitive balance, the skill syndrome, cognitive lock, haste, over commitment to bureaucratic goals, denial, fear of satisfying, perfection is the enemy of good

3.4 Cognitive modeling Innovative principles for managing development programs/Azarov N.Y., Yaroshenko F.A., Bushuyev S. D. –Second edition.– K.: «Summit-Book», 2012)

Factors necessary for use of cognitive models

Identification of failed project parameters. In the NU projects these were:

- delayed execution / late completion of projects
- inadequate quality of work
- stakeholders (Keeping the promise on stakeholders' expectations)
- exceeded project budget

A key approach used to improve the implementation of NU projects is the use of experience, gained during project implementation. At FCD failures are recorded in order to learn from them and achieve success in future projects. Not only were the situations that led to failure, but their causes. The use of cognitive models for project analysis, formation, accumulation and updating the bases of formalized methodologies for their use by FCD in future projects provided methods and tools of application and best practices in project management. A key resource gained during the implementation of NU projects is **information** and **knowledge**. This resource was used to develop integrated solutions for analysing the complex project management systems we have. In

particular, this resource was used in cognitive structuring processes and decisions making based on cognitive modeling.

Cognitive modelling is one of the classes of simulation modeling, that is based on the construction and study of cognitive maps of investigated system. For these purposes the device of targeted, functional and balanced graphs is used. It allows working with both qualitative and quantitative data types, and it is convenient for use within the study of development and functioning of socio-economic systems.

Cognitive models of projects are project models with built-in mechanisms of analysis, selection, and the formalization of lessons learned and best practices for their further use. This included the introduction of gained experience in relevant knowledge base, creation of new projects models and their monitoring taking into account the accumulated knowledge bases.

At FCD the following operations on applying lessons learned and accumulated experiences in projects were used:

- create a new project based on the methodology describing a standard project model and standard organizational model (characteristics), implemented in a specific area of activity;
- update the project management methodology with necessary changes to the base methodology;

- transfer the experience of successful actions from previous project experience;
- transfer best practices in project database through a system of monitoring;
- transfer from projects into the database lessons learnt concerning the project completion
- adjust the basic methodology based on the lessons of other projects;
- Transfer or apply best practices in the new project as the basic methodology or adjust existing base methodology.

In FCD these operations are implemented in accordance with procedures, which are part of the project management control system. At project initiation these practices are reflected in the project management plan (PMP) jointly developed with the participation of the project management office to ensure the transfer and application of best practices in project management.

Factors considered in FCD cognitive model

Identified failed project parameters. In the NU projects these were:

- Delayed execution / late completion of projects. Snag list with more than 100 items
- inadequate quality of work leading to rework
- stakeholders (Keeping our promise on stakeholders' expectations)

- exceeded project budget

Cognitive model of the current status of a project is a model description of weakly structured systems, consisting of a directed balanced graph, where:

- nodes of the graph correspond to the base factors of the system in terms of which the processes in the system are described;
- the direct interaction between the factors are determined.

The influence of factors may be reinforcing (positive), weak (negative) or changing (alternating sign). Cognitive map shows the mutual influence of factors on each other. Cognitive maps modelling is a tool for constructing situational models for decision-making. These unique situational models expose the failure of basic project parameters. Areas of Weakness of this approach include:

- subjective measurement of the mutual influence of the factors, shaping the considered current state of the project, and
- Possible low competence and lack of experience of the project management expert who built the cognitive map.

Building a cognitive map is a way to create an «image» of the system (or changes occurring in it). This image, been built, is representative of the system.

Cognitive map shows the current state of the project and accumulates the views of experts, many of which have never communicated with each other. The opinion of each participant in the process of creating the map is taken into account.

In cognitive models of knowledge accumulation in projects the use of cognitive maps, based on the relationship between the stakeholders of the project and the interaction of these stakeholders, depend on their competences. The incompetence of a stakeholder in project management can cause significant problems at all project phases of initialization, planning, project execution, and completion. Mutual influence of stakeholders is determined in a cognitive model. **The information and experience owned by each stakeholder determines its behaviour during the project execution.**

Cognitive maps of the following processes were created:

- project start-up,
- change management,
- Project implementation and
- Project monitoring.

These processes determine the basic dynamics of both project implementation and changing values of basic projects parameters. Modeling these processes expose the main causes of problems and create scenarios of behaviour in

different situations, which is aimed at limiting the negative impact of typical problems. These scenarios are later used in future situations.

The elements of the cognitive model are project stakeholders, displayed as nodes in the graph, and the lines of their mutual influence displayed as arcs. Also indicated in the cognitive model are the corresponding potentials (magnitude of influence) of each stakeholder, defined on the basis of competence elements.

The cognitive capacity (potential) is determined, in accordance with the elements of competence, represented in IPMA ICB 4

The value of cognitive capacity (potential) is determined by expert evaluation and ranges from -1 to +1. The value of the cognitive potential of each stakeholder is determined for each **group of competence element**, and then a weighted average of the overall capacity of the concerned party is calculated.

The central project stakeholder is the Project management team (FCD) assessed by groups of competence elements. It is much easier to identify cognitive potential if the entire team consists of certified project managers. In this case, one can assume that the cognitive capacity (potential) varies from 0 to 1.

This model is created during change management within the **initialization** and **implementation** phases of the project. During the initialization phase it is very important to determine the cognitive potentials of stakeholders in order to evaluate

mutual influence before active implementation of the project: whether one party will dictate to the other party, or they will together positively impact the project. At this phase we notice the alignment of stakeholder potential towards reducing their mutual negative influence. Alignment of cognitive capacities leads to elevation of the competence of the stakeholder, whose cognitive potential does not allow for effective interaction with other parties.

Models created with the help of linguistic means of «soft» computing (developed within the framework of the theory of fuzzy sets) belong to logico-linguistic class and are characterized as follows:

- such models use qualitative not quantitative variables (sometimes it is called linguistic. That is, their values are not numbers, but words expressed in natural language);
- relationships between variables are not defined in the form of mathematical equations, but linguistically;
- performance requirements are described solely by qualitative criteria.

Logico-linguistic models are applied, usually at the strategic (conceptual) level of management and solutions developed in projects and programs.

Cognitive structuring of knowledge about the object and its external environment is based on cognitive analysis and modelling. The object and the external environment are described as fuzzy set.

3.5 Stages of cognitive maps modelling:

1) Cognitive structuring: Analyse problem situation. Determine basic factors (in this case, stakeholders) impacting the situation. Determine the structure of the relationship between them;

2) Structural analysis of the cognitive map: Analyse the direction and strength of mutual influence of the factors. Select target and control factors. Study management decision for consistency and coherence with the objectives of the organization (project);

3) Scenario modelling: model scenarios of the project (both in unmanaged and managed regime);

4) Evaluation of modelling results: this stage is quite controversial, because been evaluated is the efficiency of decisions-making (which, in essence, is subjectivity square: subjective evaluation of a subjective action);

5) System (project) monitoring is implemented at the last stage of *modeling.* If required appropriate corrections to the cognitive map are made.

The information is structured in order to determine the set of stakeholders of the project $S=\{s_1, s_2,..., s_n\}$ (***S*** — Stakeholder), as well as the set of causal relationships between them $I=\{I_1, I_2, ..., I_n\}$ (***I*** — Influence), which determine the effectiveness of the project implementation. Accordingly, these **causal relationships are defined in the context of impact on effective implementation of the project.**

The competence of each stakeholder is determined in accordance with the cause-effect relationships between project stakeholders. This competence is called cognitive potential. The definition of cognitive potentials, based on the standards of determining competence enables more precise formalization of those areas where a stakeholder has a negative impact on project implementation, and enables accurate development of principles to enhance its competence and ways to overcome the project challenges slowing down its implementation.

When defining the cognitive potentials of stakeholders in the project, an expert, the project management office or management of an organization may **choose only those elements of competence**, **which have a direct impact on the Project and of relevance at that stage of the project** (see Table 3.1). Then one needs to rank these elements and identify cognitive potentials of each stakeholder. The value of cognitive potential of a stakeholder, can range from -1 to +1, ie, $C_s=\{-1;+1\}$.

A negative value of cognitive potential means that a stakeholder negatively affects the project at a given time, the positive – stakeholder affects positively. A value of zero potential shows, that the competence of stakeholder is adequate.

At the nodes of a cognitive map project stakeholders that exert only indirect influence on the project situation are also shown.

Formulate a tendency:

- figure out what **direction** and **intensiveness** of influence the stakeholders have on each other.
- Determine cause-effect relationship that is the **nature** (**positive or negative**) of relationship between the parties, the degree of influence of one stakeholder on another (on the graph show the **weight** of the corresponding arc between the vertices of the graph).
- The values of the variables are defined linguistically and to each linguistic variable a number between -1 and +1 is assigned (Table 3.2 The value of linguistic variables).

Table 3.1 **Stages of the project and relevant competence elemets.**

Phase	Subject groups	ISO21500 correspondence	ICB Competence elements	
01_Initialing	Integration	4.3.2 Develop project charter	Practice 01:	Project design
			Practice 02:	Requirements and objectives
	Resource	4.3.15 Establish project team	Practice 05:	Organisation and information
			Practice 08:	Resources
	Stakeholder	4.3.9 Identify stakeholders	Practice 12:	Stakeholders
02_Planning	Communication	4.3.38 Plan communications	Practice 05:	Organisation and information
			Practice 12:	Stakeholders
	Cost	4.3.25 Estimate costs	Practice 07:	Finances
		4.3.26 Develop budget	Practice 07:	Finances
	Integration	4.3.3 Develop project plans	Practice 10:	Plan and control
	Procurement	4.3.35 Plan procurements	Practice 09:	Procurement
	Quality	4.3.32 Plan quality	Practice 06:	Quality
	Resource	4.3.16 Estimate resources	Practice 08:	Resources
		4.3.17 Define project organisation	Practice 05:	Organisation and information
	Risk	4.3.28 Identify risks	Practice 11:	Risk and opportunity
		4.3.29 Assess risks	Practice 11:	Risk and opportunity
	Scope	4.3.11 Define scope	Practice 03:	Scope
		4.3.12 Create work breakdown structure	Practice 03:	Scope
		4.3.13 Define activities	Practice 03:	Scope
	Time	4.3.21 Sequence activities	Practice 04:	Time
		4.3.22 Estimate activity durations	Practice 04:	Time
		4.3.23 Develop schedule	Practice 04:	Time
03_Implementing	Communication	4.3.39 Distribute information	Practice 05:	Organisation and information
			Practice 12:	Stakeholders
	Integration	4.3.4 Direct project work	Practice 10:	Plan and control
	Procurement	4.3.36 Select suppliers	Practice 09:	Procurement
	Quality	4.3.33 Perform quality assurance	Practice 06:	Quality
	Resource	4.3.18 Develop project team	Practice 08:	Resources
	Risk	4.3.30 Treat risks	Practice 11:	Risk and opportunity
	Stakeholder	4.3.10 Manage stakeholders	Practice 12:	Stakeholders
04_Controling	Communication	4.3.40 Manage communications	Practice 05:	Organisation and information
			Practice 12:	Stakeholders
	Cost	4.3.27 Control costs	Practice 07:	Finances
	Integration	4.3.5 Control project work	Practice 10:	Plan and control
		4.3.6 Control changes	Practice 10:	Plan and control
	Procurement	4.3.37 Administer procurements	Practice 09:	Procurement
	Quality	4.3.34 Perform quality control	Practice 06:	Quality
	Resource	4.3.19 Control resources	Practice 08:	Resources
		4.3.20 Manage project team	People 03:	Personal communication
			People 04:	Relations and engagement
			People 05:	Leadership
			People 06:	Teamwork
			People 07:	Conflict and crisis
			People 10:	Results orientation
	Risk	4.3.31 Control risks	Practice 11:	Risk and opportunity
	Scope	4.3.14 Control scope	Practice 03:	Scope
	Time	4.3.24 Control schedule	Practice 04:	Time
05_Closing	Integration	4.3.7 Close project phase or project	Practice 10:	Plan and control
		4.3.8 Collect lessons learned	Practice 01:	Project design

Table 3.2 **The value of linguistic variables**

Linguistic value of the variable "cognitive capacity" ("potential")	Linguistic value of a variable, which characterizes the relationship between stakeholders	Numerical values of the variables (Cognitive capacities and connections)
None	No influence	0
Soft	Mildly enhances (weakens)	0,1-0,3 (-0,1; -1,3)
Average	moderately enhances (weakens)	0,4-0,6 (-0,4; -0,6)
High/Low	Strongly enhances (weakens)	0,7-1,0 (-0,7; -1,0)

The stakeholders, causal relationships between them and the relevant variables are determined by results of interviews, expert survey or analysis, conducted by the project management office of FCD. See appendix

Cognitive map is a weighted graph $\boldsymbol{G = (S, I)}$, where $\boldsymbol{S}$ (Stakeholder) - node (stakeholders of the project), $\boldsymbol{I}$ (Influence) - the set of arcs represent the direct influence of stakeholders on each other.

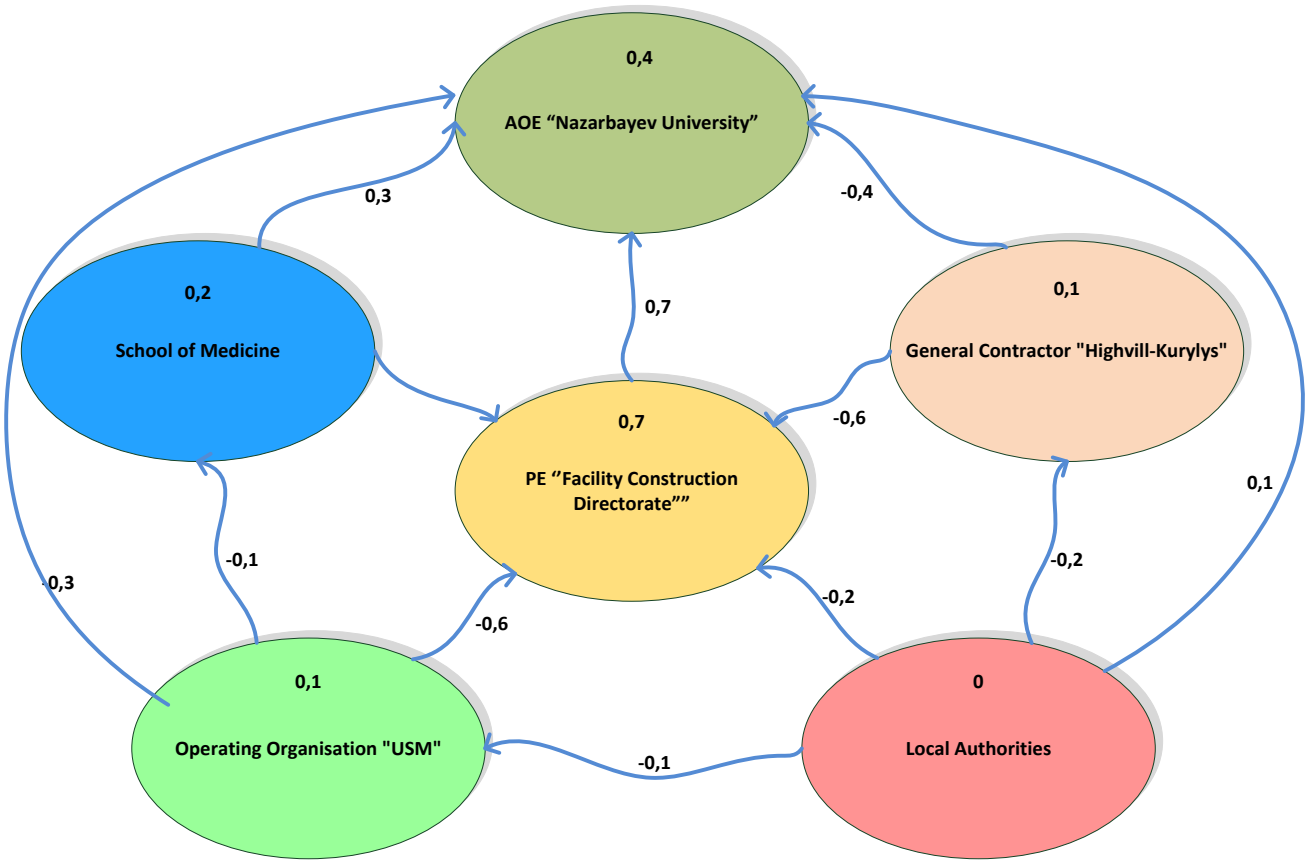
Each arc connecting the stakeholder $\boldsymbol{s_i}$ with stakeholder $\boldsymbol{s_j}$, has a weight $\boldsymbol{a_{ij}}$, which reflects the nature and degree of influence of a stakeholder $\boldsymbol{s_i}$ on stakeholder $\boldsymbol{s_j}$. If $\boldsymbol{a_{ij}}$ is a positive value, then with the change of cognitive potential $\boldsymbol{s_i}$, the value of $\boldsymbol{s_j}$ will change in the same direction, if $\boldsymbol{a_{ij}}$ is a negative value, then change in the value of $\boldsymbol{s_i}$, will change $\boldsymbol{s_j}$ in the opposite direction. The module value $\boldsymbol{a_{ij}}$ characterizes the degree of influence.

The matrix $\boldsymbol{A_n}$ is associated with the graph $\boldsymbol{G}$. The element $\boldsymbol{a_{ij}}$ of matrix $\boldsymbol{A_n}$, which lies at the intersection of the $\boldsymbol{i}$-th row and $\boldsymbol{j}$-th column characterizes the influence of a stakeholder $\boldsymbol{s_i}$, on stakeholder $\boldsymbol{s_j}$.

$$An = \begin{bmatrix} a11 & a12 & \dots & a1j \\ a21 & a22 & \dots & a2j \\ \dots & \dots & \dots & \dots \\ ai1 & ai2 & \dots & aij \end{bmatrix}$$

The rows in the matrix determine the influence of a stakeholder on other stakeholders or the weight of the arcs emanating from the corresponding node-weighted graph.

Figure 3.3 shows an example of cognitive map describing current status of the project and defining innovative principles for its development. All major types of stakeholders of the project are listed here. This card is developed to order to conceive a solution on stakeholder management during the implementation stage of the NUSOM project. The set of cognitive maps developed during the process of execution of project situations, decisions and actions, create the basis of FCDs' best practice and lessons, and is used in future projects.



1) Define the cognitive potentials of stakeholders in the project. Choose only those elements of competence, which have a direct impact on the Project and of relevance at that stage of the project.
2) Rank these elements and identify cognitive potentials of each stakeholder. Rank can range from -1 to +1.

Figure 3.3. Situational cognitive map of NUSOM project during implementation stage

At this stage subset of target $Y=\{y_1,y_2,\ldots,y_k\}$ and managing $U=\{u_1,u_2,\ldots,u_p\}$ stakeholders, as well as the vector of initial values of the cognitive potentials of $S(0)=(s^0_1, s^0_2,\ldots, s^0_n)$ stakeholders are determined. According to Fig. 3.3. this vector is represented as $S(0)=(0,7; 0,4; 0,1; 0; 0,1; 0,2;)$.

Managing stakeholders are those stakeholders who, in their turn, would be influenced by the project team in order to implement the project efficiently, in accordance with the base parameters. Target stakeholders are those who, to a greater extent, characterize the state of the controlled object and its purpose, whose change of cognitive potential values is undesirable. In this case, managing cognitive potentials are cognitive potentials of customer and the client, and target cognitive potentials - the project team.

4. **Conclusion:**

- Since projects like the NU construction project reflect a network of interacting stakeholders, the responsibility for decision making must be made borne by a network of decision makers (rather than an individual or a hierarchy). The scale of this network is huge, with as much as five to seven stakeholders organizations involved. Official decision makers (such as the owner, funding agencies, and city and government agencies) have traditionally been members of this network. Similarly, technical staff have been at the forefront of the decision-making network (architects, engineers, construction and project managers, and ultimate operators). Today, in the age of media and the web, knowledge-enabled non-traditional decision makers like customers and end users should play a more active role beyond discussing already-designed projects. This complex network of decision makers is more like to make fast and effective decisions in project

situations given that the agent of change (the project manager) has a positive cognitive potential to influence this network of stakeholders, enhance their competence and cognitive potential and so lead to their likeliness to make fast and effective decisions in project situations. This requires a considerable shift in the mind-set of traditional decision makers: from customer and end users as a source of feedback on predetermined alternatives offered by professionals to them as the idea generator, and **decision maker.** As a result, the future network of decision makers in projects can be considered as a heterogeneous mix of professionals (technical and official decision makers) and nonprofessional end users.

- An **interorganizational networked-based** arrangement is a new paradigm (measure) introduced to facilitate innovation development and diffusion within projects. Taking advantage of innovation by involving nodes from the lower levels of the network of project decision makers (such as site workers and end users) in decision making improves the process of innovation in projects. Extending such networks to **include the nontechnical and external stakeholders and end users of the built facility can expedite the process of innovation** projects even more. This is particularly true in the context of **sustainable development**. Open involvement of end users in the NU projects has

being an effective means for meeting and exceeding the expectation of the major stakeholders. A good example is the NUSOM project.

- Challenges: The heterogeneity of decision-maker networks and the lack of structured input will result in chaotic discussions (Taylor and Bernstein 2009). However, it may present a promising approach to harvest the collective intelligence of the increasingly complex networks of decision makers. The objective here is not only the optimization of decision. Beyond searching for solution mechanisms, the true need is to understand the dynamics of innovation that will take place in such networks (Taylor and Levitt, 2007). The goal is to empower major stakeholders to make value creating decisions through democratizing innovation. The role of technical decision makers will change from the vertex at the top of the hierarchy pyramid, which controls the decision process, into a leading or facilitating node among others within the network of decision makers. The final decision will emerge from the self-stabilizing mechanisms of decision making networks as well as distilling order, agreement, and innovation from chaotic discussions. Other NU projects are plagued with several individual and hierarchical decision making that let to unfavourable project results, like the absence of a bridged connection between S1 and S4 buildings, decisions being unilaterally made that let to delayed decision by as much as many weeks. This eventually led to delays in project delivery and losses

- Adverse attitude is attributable to the behavioural competence level of individuals. This is evident in the NU projects. Upon cognitive modelling of the existing cognitive potential stakeholders and their influencing weight FCD implemented stakeholder management measures, like seminars and training in project management, to enhance their competence. In other words, After taking a snap shot of cognitive potential and influence of decision makers, a strategy is in put in place for change management (competence enhancement)
- Within the FCD a web based Microsoft SharePoint repository and document/information management and communication system was implemented. This system effectively provided stakeholders with on time information needed for timely decision making.
- The NU projects are implemented in an environment of multiple decision makers, whose level of competence in managing projects vary. Through inevitable interaction between stakeholders during implementation they influence each other. The NUSOM project benefited from this interaction through exchange of knowledge and motivators, given a competent project manager with high cognitive potential is involved. This led to a better attitude and effective decision making among the decision makers at top level, middle level and low level.

References

1. Strater et al. 2012
2. Archibald et al., 2013
3. Etter et al., 2000; Morrison & Fletcher, 2001; Fletcher, 2004
4. Green et al., 2000; Jackson and Schuler, 1985; King and King, 1990
5. IPMA Individual Competence Baseline for project, Programme & Portfolio Management, 4th Version
6. Goldratt and Cox 1984 Goldratt, EM and Cox, J. 1984. The goal: A process of ongoing improvement, Great Barrington, MA: North River Press
7. Bandura, A. Social Cognitive Theory. In: Vasta, R., editor. Annals of Child Development. Vol. 6. 1989. p. 1-60
8. Analysis of Online Social Networks to Understand Information Sharing Behaviors Through Social Cognitive Theory, Annu ORNL Biomed Sci Eng Cent Conf. 2014 May; 2014: 1–4.
9. Dyer, Centric, & Wampler, 2007, p. 19
10. Morrison & Fletcher, 2002
11. Azarov N.Y., Yaroshenko F.A., Bushuyev S. D.
12. Innovative principles for managing development programs/ Azarov N.Y., Yaroshenko F.A., Bushuyev S. D. –Second edition.– K.: «Summit-Book», 2012
13.

Appendix Cognitive modeling questionnaire

Cognitive modeling

1) Defining the cognitive potentials of stakeholders in the project. Choose only those elements of competence, which have a direct impact on the Project and of relevance at that stage of the project.
2) Rank these elements and identify cognitive potentials of each stakeholder, as we mentioned earlier, can range from -1 to +1.

1. Cognitive capacity ("potential")

	Strongly weakens	Moderately weakens	Mildly weakens	No influence	Mildly enhances	Moderately enhances	Strongly enhances
JSC "Nazarbayev University"							
PE "FCD"							
School of Medicine							
General Contractor "Highvill-Kurylys"							
Operating Organization "USM"							
Local Executive Authority							

2. JSC"Nazarbayev University"(Relationship between stakeholders (-1; +1))

	Strongly weakens	Moderately weakens	Mildly weakens	No influence	Mildly enhances	Moderately enhances	Strongly enhances
PE "FCD"							
School of Medicine							
General Contractor "Highvill-Kurylys"							
Operating Organization "USM"							
Local Executive Authorities							

3. PE "FCD" (Relationship between stakeholders (-1; +1))

	Strongly weakens	Moderately weakens	Mildly weakens	No influence	Mildly enhances	Moderately enhances	Strongly enhances
School of Medicine							
General Contractor "Highvill-Kurylys"							
Operating Organization "USM"							
Local Executive Authorities							

4. School of Medicine (Relationship between stakeholders (-1; +1))

	Strongly weakens	Moderately weakens	Mildly weakens	No influence	Mildly enhances	Moderately enhances	Strongly enhances
Operating Organization "USM"							

5. General Contractor "Highvill-Курылыс" (Relationship between stakeholders (-1; +1))

	Strongly weakens	Moderately weakens	Mildly weakens	No influence	Mildly enhances	Moderately enhances	Strongly enhances
Local Executive Authorities							