Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management
Istanbul, Turkey, July 3 – 6, 2012

Developing a Mathematical Model for Team Configuration in Creativity Process

Iraj Mahdavi
Department of Industrial Engineering
Mazandaran University of Science and Technology
Babol, Iran

Hamed Fazlollahtabar
Faculty of Industrial Engineering
Iran University of Science and Technology
Tehran, Iran

Amin Aalaei
Faculty of Industrial Engineering
Amirkabir University of Technology
Tehran, Iran

Mohammad Hassan Yahyanejad
Mazandaran Gas Company
Sari, Iran

Abstract

Here, we investigate a mathematical model to configure teams in creativity process. Initially, a pilot group of employees in an organization is selected. This group is evaluated through creativity parameters using a questionnaire. Considering the questionnaires' data, a creativity matrix is configured by a binary scoring. Applying the creativity matrix, clustering is performed via mathematical programming. The pilot group is divided into some research teams. The research subjects are submitted to the teams. Finally, an allocated problem is solved and some new research subjects are evolved to be assigned to the next configured teams. This procedure is repeated dynamically for different time periods.

Keywords

Creativity process; Intelligent clustering; Mathematical model

1. Introduction

In today's knowledge-intensive environment, creativity is increasingly employed for executing innovative efforts (Oxley and Sampson, 2004; Smith and Blanck, 2002). Researchers and practitioners mainly agree that effective management plays a critical role in the success of creativity process (Pinto and Prescott, 1988). Unfortunately, the knowledge and experience base of most managers refer to smaller-scale projects consisting of only a few project teams. This may be responsible for what Flyvbjerg et al. (2003) call a 'performance paradox': ''At the same time as many more and much larger infrastructure projects are being proposed and built around the world, it is becoming clear that many such projects have strikingly poor performance records ...". The information network of the teams defines the opportunities available to them to create new knowledge (e.g., Uzzi, 1996). As many scholars have argued, networks of organizational linkages are critical to a host of organizational processes and outcomes (e.g., Baum and Ingram, 1998; Darr et al., 1995; Hansen, 1999; Reagans and McEvily, 2003; Szulanski, 1996). New knowledge is the result of creative achievements. Creativity, therefore, molds the foundation for poor or high degree of performance. Since new knowledge is mainly created when existing bases of information are disseminated through interaction between interacting teams with varying areas of expertise, creativity is couched in interaction networks (e.g., Leenders et al., 2003; Hansen, 1999; Ingram and Robert, 2000; Reagans and Zuckerman, 2001; Tsai, 2001; Uzzi, 1996). Any organization needs team work among employees for productivity purposes in problem solving. Organizations face various problems in their determined missions. A useful approach to address these problems is to configure teams consisting of expert employees. Due to their knowledge and experience of the organization, these teams understand the organization's problems better more than external research groups and thus may solve the problems more effectively. Hence, the significant decision to be made is configuration of the teams. Creative teams would be able to propose more practical and beneficial solutions for organization's problems. Since creativity is a qualitative concept, analyzing and decision making require knowledge management algorithms and methodologies. These methodologies are employed in the different steps of configuring teams, task assignment to teams, teams' progress assessment and executive solution proposals for problems. In the present work, we propose a creativity matrix analyzing creativity parameters of a pilot group in an organization. Then, using an intelligent clustering technique, research teams are configured and research subjects are allocated to them.

2. Proposed Creativity Process

To conceptualize creativity in an organization, we develop an intelligent algorithm based on matrix and clustering concepts. Any person can be analyzed using the creativity parameters via a questionnaire. Several parameters may be considered as the creativity assessment factors. Here, we make use of some parameters being effective to identify the creativity potential in an employee. Also, the concept of “interest to work with each other” is a novel aspect being considered in the proposed algorithm. The steps of the proposed clustering algorithm are given below.

Step1: An initial study is worked out on the structures of the organization’s employees and considering a threshold (e.g., the academic study grade) some potentially appropriate employees are selected for the creativity process.

Step 2: After choosing the employees, research groups should be organized to work on organization problems in a creative manner. To do that, the research tasks should be determined. The research tasks for employees are collected in a 2-dimentional matrix. This matrix is completed by 0 or 1 values, where if employee (E_i) has experiences for task (T_j) then the numerical value R_{ij} for i=1,..,m and j=1,..,n is 1 and 0, otherwise. A task-employee matrix is configured in Table 1.

Table 1. Task-Employee matrix

Task (T) Employee (E)	T_1	T_2	…	T_n
E_1				
E_2				
.				
.			$R_{ij} \in \{0,1\}$	
.				
E_m				

It should be noted that all employees deliver their favorite research tasks’ vector by filling a questionnaire. Aggregating the questionnaires provide the tasks’ vector of all employees. This concept is illustrated in Figure 1.

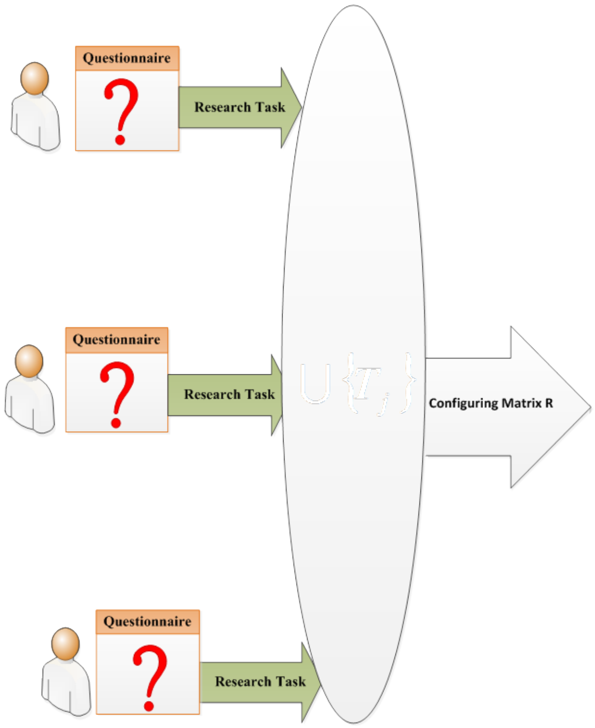

Figure 1: Tasks' vector of all employees

This way, a matrix containing all employees and their favorite research tasks is configured.

Step 3: Another effective parameter required for the team organization is the interest to work with each other. To consider interest, the previous employee-task matrix is assumed and a third dimension of "interest" is added. Now, each employee expresses his opinion about the "interest" to work with other employees with 1 (if interested) and 0 (otherwise). Integrating all employees' opinions, an employee-employee matrix is configured in Table 2.

Table 2. Employee-Employee matrix

Employee (E) / Employee (E)	E_1	E_2	…	E_m
E_1				
E_2				
.				
.			$P_{ij} \in \{0,1\}$	
.				
E_m				

Note that, P_{ij} is 1 if both employees interest to work with each other.

Step 4: Here, the 3-dimensional matrix F is configured. The values of F_{ijk} are 1 and 0. The 3-dimesional matrix F is shown in Figure 2. Now, the clustering based on matrix F is performed. Clustering is performed to organize creativity teams using a cubic space mathematical programming.

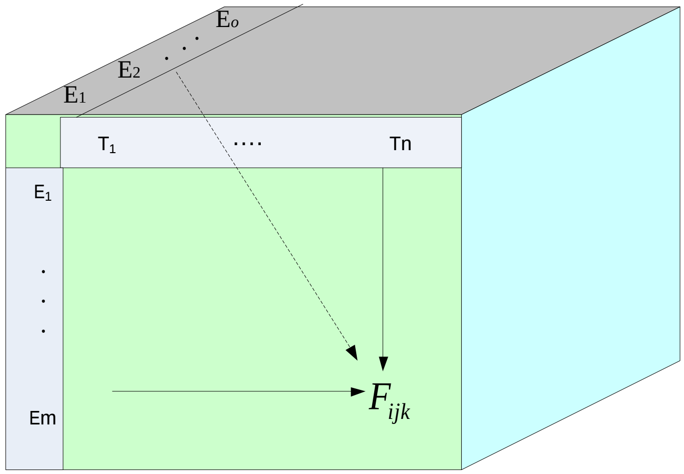

Figure 2: The 3-dimensional matrix of employee-task-employee

Step 5: After clustering team organization, brain storming sessions of teams cause to research subject generation. In this stage, teams may need academic knowledge rather than their own organizational knowledge. This way, university faculty members help teams in conducting a research on a specified subject. The process of research is developed using a knowledge development program and formed gradually to be transformed to an application model. During the research process, external information from internet, or other team members and even members out of the team may be required.

3. Intelligent Clustering

We now have a group of employees with their creativity parameter' scores. In research teams, a significant factor is the homogeneity of team members helping for better cooperation in solving the assigned problems. Here, we use a clustering technique to classify our human resources to teams having more similarity.This proposed model deals with the maximization of the total number of employees that able to team working for process on tasks in the same time and the minimization of the employee movements between clusters for process on the tasks. The problem is formulated according to the following assumptions.

1. The number of clusters, employees and tasks are given and deterministic.
2. The capabilities of processing of tasks by employees are known.
3. Moving employees for processing tasks in different clusters is possible.
4. The minimum of the cluster size is known in advance.
5. Each task can be performed by different and more one employees. This feature providing the flexibility to obtain a better cluster design.
6. The interest matrix for team working of each employee with other employees is given. Also the two employees who does not have interest to team working cannot be processed simultaneously on a task.
7. All employees must participate in team working for processing tasks. Of course there are limits to the processing of tasks by each employee.

The mathematical programming model is presented below. The applied notations, parameters and decision variations in the mathematical model are as follows:

4.1 Problem formulation

4.1.1. Indices

T	Number of Task
C	Number of Cluster
E	Number of Employee
T	Index for Task (t=1,2,…T)
K	Index for Cluster (k=1, 2,…C)
E	Index for Employee (e=1, 2,…E)

4.1.2 Input parameters

a_{te} 1 if Task type t can be processed with employee e ; =0 otherwise

$b_{ee'}$ 1 if employee e interesting cooperation to employee e'; =0 otherwise

LT Minimum size of each cluster in terms of the number of task types;

LW Minimum size of each cluster in terms of the number of employee;

LE Maximum number of tasks that a employee can do

A An arbitrary big positive number

4.1.3 Decision variables

X_{tk} 1 if Task type t is assigned to cluster k; =0 otherwise;

Y_{ek} 1 if employee e is assigned to cluster k; =0 otherwise;

N_{tek} 1 if Task type t is processed with employee e in cluster k; =0 otherwise;

4.1.4 Mathematical model

In this section, we introduce our new mathematical model as follows:

$$Max\ Z = \sum_{k=1}^{C}\sum_{t=1}^{T}\sum_{e=1}^{E}\pi N_{tek} \tag{1-1}$$

$$-\sum_{k=1}^{C}\sum_{t=1}^{T}\sum_{e=1}^{E}\theta N_{tek}.(1-Y_{ek}) \tag{1-2}$$

Subject to:

$$\sum_{k=1}^{C} X_{tk} = 1 \qquad \forall t; \tag{2}$$

$$\sum_{k=1}^{C} Y_{ek} \le 1 \qquad \forall e; \tag{3}$$

$$\sum_{t=1}^{T} X_{tk} \ge LT \qquad \forall k; \tag{4}$$

$$\sum_{e=1}^{E} Y_{ek} \ge LW \qquad \forall k; \tag{5}$$

$$\sum_{e=1}^{E} N_{tek} \ge X_{tk} \qquad \forall t,k; \tag{6}$$

$$\sum_{e=1}^{E} N_{tek} \le A.X_{tk} \qquad \forall t,k; \tag{7}$$

$$N_{tek} \le a_{te} \qquad \forall t,e,k; \tag{8}$$

$$N_{tek}N_{te'k}(1-b_{ee'}) = 0 \qquad \forall t,e,e',k; \quad e \ne e'; \tag{9}$$

$$\sum_{k=1}^{C}\sum_{t=1}^{T} N_{tek} \le LE \qquad \forall e; \tag{10}$$

$$X_{tk}, Y_{ek}, N_{tek} \in \{0,1\} \qquad \forall t,e,k; \tag{11}$$

The objective function consists of two components. The first component maximizes the total number of employees that able to team working for process on tasks in the same time and the second component minimizes the employee movements between clusters for process on the tasks.

Constraint (2) ensures that each task type is assigned to only one cluster. Equation (3) guarantees that each employee will be assigned to only one cluster. Constraint (4) forces the lower bound for the number of tasks to be allocated to each cluster. Constraint (5) ensures that at least LW employees will be assigned to cluster k. Constraints (6-8) ensure that when task type t processed with employee e in cluster k,then this task allocated in cluster k and the employee e ability process on task type t. Constraints (9) guarantees that any two employee don't interesting to process same time on one task in cluster k. Constraints (10) guarantees that the maximum number of tasks that a employee can do no more than LE. Constraints (11) specify that decision variables are binary.

6. Conclusions

We investigated different structural aspects of teams' network organization and their creativity. Initially, a pilot group of people in an organization was selected. This group was evaluated through creativity parameters using a questionnaire. Applying the creativity matrix, the intelligent clustering using mathematical programming was performed. The pilot group was divided into some research teams. The advantages of such programs are continuous monitoring, gradual problem solving in an organization, involvement of organization's employees in the problem solving process, updating employees creativity parameters, and intelligent clustering of employees into research teams.

References

Baum, J.A.C. & Ingram, P. (1998). Survival enhancing learning in the Manhatten hotel industry, 1998. *Management Science*, *44*, 996–1016.

Darr, E., Argote, L. & Epple, D. (1995). The acquisition, transfer and depreciation of knowledge in service organizations: Productivity in franchises. *Management Science*,*41*, 1750–1762.

Flyvbjerg, B., Bruzelius, N. & Rothengatter, W. (2003). Megaprojects and Risk: An Anatomy of Ambition. Cambridge University Press.

Hansen, M.T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subteams. *Administrative Science Quarterly*, *44*, 82–111.

Ingram, P. & Robert, P. (2000).Friendships among competitors in the Sydney hotel industry. *American Journal of Sociology*, *106*, 387–423.

Leenders, R.T.A.J., Van Engelen, J.M.L. & Kratzer, J. (2003). Virtuality, interaction, and new product team creativity: A social network perspective. *Journal of Engineering and Technology Management*, *20*, 69–92.

Oxley, J.E. & Sampson, R.C. (2004).The scope and governance of international R&D alliances. *Strategic Management Journal*, *25*, 723– 749.

Pinto, J.K. & Prescott, J.E. (1988).Variations in critical success factors over the stages of the product life cycle. *Journal of Management*, *14*, 5–18.

Reagans, R. & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly*, *48*, 240–268.

Reagans, R. & Zuckerman, E.(2001). Networks, diversity and performance: The social capital of R&D teams. *Organization Science*, *12*, 502–517.

Smith, P.G. & Blanck, E.L. (2002). From experience: Leading dispersed teams. *Journal of Product Innovation Management*, *19*, 294–304.

Szulanski, G. (1996). Exploring internet stickiness: Impediments to the transfer of best practices within the firm.*Strategic Management Journal*, *17*, 27–43.

Tsai, W. (2001). Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business team innovation and performance. Academy of *Management Journal*, *44*, 996–1004.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review*, *61*, 674–698