

# TAKIM KOMPOZİSYONU OPTİMİZASYONU İÇİN BİR HEDEF PROGRAMLAMA MODELİ

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## ÖZ

İş takımlarının etkinliğini belirleyen en önemli faktör takım bağlılığıdır. Takım çalışmaları ile ilgili literatürde genel olarak iki tür takım bağlılığından bahsedilmektedir. Bunlar, görev bağlılığı ve sosyal bağlılıktır. Her iki bağlılık türünü etkileyen en temel faktör ise takım üyelerinin kişilikleridir. Bu çalışmanın amacı takım bağlılığının ve dolayısıyla takım etkinliğinin iyileştirilmesini sağlayan takım kompozisyonu oluşturacak takım üyelerinin seçilmesine ilişkin bir hedef programlama modeli ortaya koymaktır.

**ANAHTAR KELİMELEER:** Takım kompozisyonu, hedef programlama

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# **A GOAL PROGRAMMING MODEL FOR OPTIMIZING TEAM COMPOSITION**

## **ABSTRACT**

The most important factor affecting the team effectiveness is the team cohesion. Generally, two types of team cohesion are reported in the team working literature: task cohesion and social cohesion. The fundamental factor which affects both types of cohesion is personality of the team members. The objective of this study is to present a goal programming model for selecting the team members in order to maintain a team composition which will enable the improvement of team cohesion and consequently team effectiveness.

**KEYWORDS:** Team composition, goal programming

## 1. Introduction

A work team is composed of two or more individuals who (a) exist to perform organizationally relevant tasks, (b) share one or more common goals, (c) interact socially, (d) exhibit task interdependencies (i.e., work flow, goals, outcomes), (e) maintain and manage boundaries and (f) are embedded in an organizational context that sets boundaries, constrains the team and influences exchanges with other units in the broader entity (Alderfer, 1977; Hackman, 1987; Hollenbeck et al., 1995; Kozlowski, Gully, McHugh, Salas and Cannon-Bowers, 1996; Kozlowski, Gully, Nason and Smith, 1999; Salas, Dickinson, Converse and Tannenbaum, 1992). Teams are often introduced with the objective of improving organizational performance as well as the outcomes of the individual worker. It is thought that teams are capable of increasing an organization's adaptability to dynamic environments, are able to handle more complex and variable products and production processes and that team members can more easily mutually adjust and coordinate their efforts (Molleman et al., 2004).

The formation of multi-functional teams has gained increasing attention in recent years due to the fact that organizations must be able to react quickly to technological innovations and the changing demands of markets (Water et al., 2007). However, there has been little research evaluating selection and placement strategies to enhance team process and performance, especially for variables such as personality (Klimoski and Jones, 1995; Morgan and Lassiter, 1992). Despite the scarcity of research specifically related to work-team staffing, research in team processes may provide a basis for making predictions of how personality is likely to contribute to work-team effectiveness (Hackman, 1987; Fitzpatrick and Askin, 2005; Chi and Chen, 2009). Based on this premise, the objective of this study is to propose a goal programming model for allocating from a set of available candidates into a predetermined number of teams with respect to their knowledge, skills and personality characteristics so that the best team compositions are maintained. In the following sections, a summary of the literature about team effectiveness, impact of personality on team performance will be given. Then, the proposed model will be presented with an illustrative example and conclusions will be given.

## 2. Team Effectiveness

From an organizational psychology perspective, *team effectiveness* is the core focus of theory and research on teams (Kozlowski and Bell, 2003). Team effectiveness refers to the extent that team goals such as productivity, lead times and the quality of products or services are realized (Molleman et al., 2004). However, team effectiveness, according to group researchers, also pertains to aspects that are not explicitly part of the formal team performance goals, such as job satisfaction or team viability (e.g., Hackman, 1987; Shea and Guzzo, 1987).

Most models of team effectiveness are based on input-process-outcome (IPO) framework proposed by McGrath (1964). According to this framework (see Figure 1), inputs are the primary cause of processes that in turn mediate the effect of inputs on outcomes. *Inputs* represent various resources available to the team both internally (e.g., composition of knowledge, skills and abilities, personalities, demographics, group structure, team design) and externally (e.g., rewards, training, organizational climate) at multiple levels (e.g., individual, group, organization). *Processes* represent mechanisms that inhibit or enable the ability of team members to combine their capabilities and behavior. *Outcomes* represent criteria to assess the effectiveness of team actions (Kozlowski and Bell, 2003).

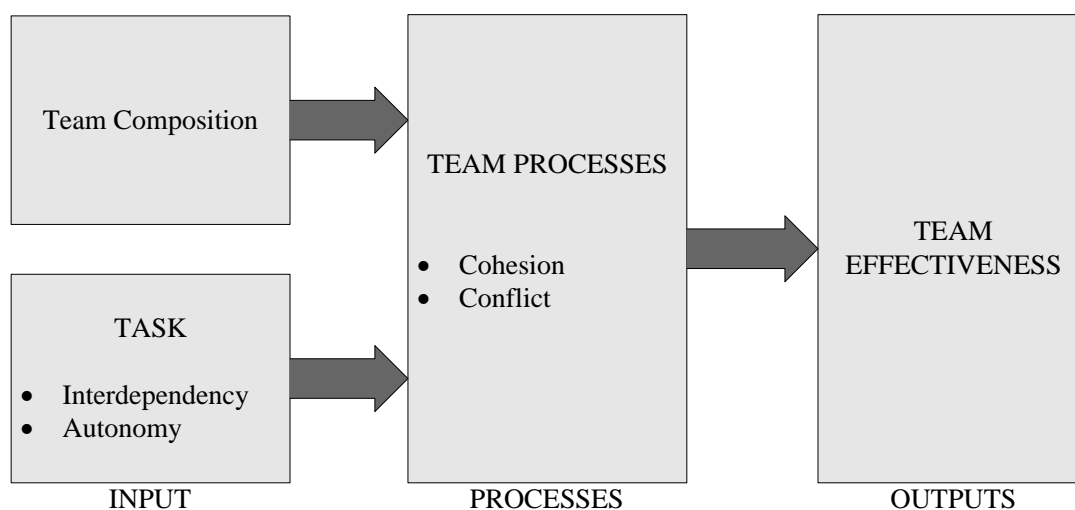


Figure 1. Input-process-outcome framework (McGrath, 1964)

Cohesion and conflict are the most significant team processes. Team cohesion is a proxy to team functioning and defined as “the resultant of all the forces acting on the members to

remain in the team” (Festinger, 1950). Team cohesion can be analyzed in two parts: interpersonal or social cohesion and task cohesion (Kozlowski and Bell, 2003). Social cohesion concerns an individual’s attraction to the group because of positive relationships with other members of the group. Social cohesion allows groups to have less inhibited communication and to effectively coordinate their efforts. Task cohesion refers to an individual’s attraction to the group because of shared commitment to the group task (Brawley, Carron and Widmeyer, 1987; Zaccaro, 1991). Mullen and Copper (1994) found that task cohesion had the largest impact on team performance, because it increases task commitment. Gully, Devine and Whitney (1995) suggested that cohesive groups perform well on interdependent tasks because they can coordinate better, whereas coordination is unimportant for more independent tasks. Kozlowski and Bell (2003) state that, the relative impacts of task and interpersonal cohesion may depend on the effectiveness outcome being examined.

Conflict is an opposition or discrepancy between the ideas, beliefs or interests of the team members (Acuña et al., 2009). Research has shown that there are two types of conflict (Jehn (1995, Vianen and De Dreu, 2001): task conflict and social conflict. There is a task conflict when the parties have different viewpoints, ideas or opinions about a decision that has to be taken or a specific task. Social conflict develops when the parties have incompatible tastes, ideas or values and there is personal enmity between the team members involved (Acuña et al., 2009). Jehn (1995) found that for groups performing routine tasks, both task conflict (disagreement about task content) and relationship conflict (interpersonal incompatibilities) were detrimental. However, for groups performing non-routine tasks, only relationship conflict was detrimental. Amason (1996) found that higher levels of cognitive conflict (task based) and lower levels of affective conflict (relationship based) led to increased effectiveness in top management teams. Furthermore, research by Simons and Peterson (2000) found that top management teams low in interpersonal trust tended to attribute conflict to relationship-based issues, whereas top management teams high in interpersonal trust tended to attribute conflict to task-based disagreements (Kozlowski and Bell, 2003).

For the task component of IPO framework, there are two important characteristics, interdependency and autonomy. *Task interdependency* refers to a situation where the process and result of a task affects the process and result of other tasks (Molleman et al., 2004). Interdependency will be strongly related to the distribution of task relevant knowledge within a team or to its multidisciplinary. People in a multidisciplinary team are considered to be

more interdependent and must pay more attention to their contextual performance in order to integrate their knowledge for the completion of the team tasks (Peeters et al., 2006).

Teams generally perform tasks that are highly interdependent, including additive, conjunctive and disjunctive components (Saavedra, Earley and Van Dyne, 1993; Steiner, 1972; West, Borrill and Unsworth, 1998). The *additive task* considers that the team can successively achieve its objectives by adding together the effort of each team member. The *conjunctive task* requires the input of all the team members and each team member must meet some minimum requirements. The *disjunctive task* depends on one of the team members being able to do the job successfully (Acuña et al., 2009). For instance, when the task requires the team to come up with a good solution; the best solution proposed by an individual member will then determine the team's performance. (Kozlowski and Bell, 2003).

*Task autonomy* refers to the team's perception of how much freedom they have to make decisions about objectives (what), work methods (how), delivery schedules (when), distribution of work among team members (who) (Breugh, 1985). Team task autonomy enhances the impact of worker and team characteristics on team functioning and therefore it is likely that team task autonomy will moderate the relation between team attributes, which stem from the individual member's personality traits and team outcomes (Molleman et al., 2004).

*Team composition* describes matching personnel to appropriate teams and team roles (Hollenbeck, DeRue and Guzzo, 2004). An understanding of team composition can serve as a valuable tool for selecting and constructing effective teams. Paris, Salas and Cannon-Bowers (2000) stated that member selection is the first thing to do to ensure successful team performance. The basic question in starting the team formation process is the team size and member attributes.

Researchers have offered recommendations concerning the best size for various types of teams (Kozlowski and Bell, 2003). Some research suggests that size has a curvilinear relationship with effectiveness such that having too few or too many members reduces performance (Nieva, Fleishman and Reick, 1985), whereas other studies have found team size to be unrelated to performance (Hackman and Vidmar, 1970; Martz, Vogel and Nunamaker, 1992) or have found that increasing team size actually improves performance without limit (Campion, Medsker and Higgs, 1993). Hoegl et al. (2003) and Hackman (1987) stated that

team size must be determined with respect to both staffing requirements, deriving from the size of the project task, as well as teamwork requirements, deriving from task complexity and uncertainty.

After determination of the team size, the next step is to decide who the members of the team will be. In the first place, this decision is based on the technical skills and knowledge required to perform the team tasks. However, solely technical skills and knowledge are not sufficient to obtain a high team effectiveness. In addition to technical skills and knowledge, researchers have also considered team composition effects of personality on team effectiveness. The results of these researches reveal that although team personality composition appears to be a relatively robust predictor of team effectiveness, research suggests that different compositions may be more or less effective, depending on the task and the amount of member interaction required for effective team performance. In the following section the impact of personality traits of the members on the team outcomes will be discussed in more detail.

### **3. Personality and Team Performance**

The relationship between personality and individual job performance has received considerable attention and debate throughout the 20<sup>th</sup> century. Research conducted up until the mid-1980s concluded that personality and job performance had no meaningful relationship across situations. In a review of the literature, Guion and Gottier (1965) concluded that, there is no generalizable evidence that personality measures can be recommended as good or practical tools for employee selection. By the 1990s however, methodological innovations in meta-analysis spurred a series of meta-analytic studies that have provided a much more optimistic view of the ability of personality measures to predict job performance. Although several personality typologies can be found in literature (e.g., Goldberg, 1993), during the last two decades, based on extensive empirical work, a typology with five general personality traits has emerged, which is referred to as the “Big Five” or “B5”: extraversion, agreeableness, conscientiousness, emotional stability and openness to experience (Digman, 1990; McCrae and Costa, 1989). Recent studies on the role of personality in team-based work settings also focus on one or more of the personality traits that are part of the B5 (e.g., Barrick and Mount, 1991; Barrick et al, 1998; Barry and Stewart, 1997; Neuman et al., 1999; Thoms, Moore and Scott, 1996; Van Vianen and De Dreu, 2001). There are no clear-cut definitions

for each of the five general factors, but each factor is described in Table 1 by means of keywords, which give an indication of its meaning and content (McCrae and Costa, 1989).

Table 1. The Big Five Taxonomy of Personality (McCrae and Costa, 1989)

<b>Big Five Factor</b>	<b>Alternate Names</b>	<b>Trait Descriptions - Positive Pole</b>	<b>Trait Descriptions - Negative Pole</b>
Extroversion	Surgency, Assertiveness	Sociable, Gregarious, Assertive, Talkative, Active, Ambitious, Expressive, Energetic, Enthusiastic, Outgoing	Quiet, reserved, Shy, Retiring, Taciturn, Inhibited
Conscientiousness	Conformity, Dependability	Careful, Thorough, Responsible, Planful, Persevering, Achievement-oriented, Efficient, Self-disciplined, Diligent	Inconsistent, Impulsive, Undisciplined, Unreliable
Emotional Stability	Neuroticism	Calm, Relaxed, Self- confident, Steady, Easy-going	Anxious, Depressed, Angry, Worried, Insecure, Tense, Vulnerable, High-strung
Agreeableness	Likeability, Friendliness	Courteous, Flexible, Cooperative, Tolerant, Caring, Trusting, Supportive, Altruistic, Sympathetic, Kind, Modest	Spiteful, Self-centered, Self-aggrandizing, Hostile, Indifferent, Cold, Coarse, Mean- spirited
Openness to Experience	Culture, Intellectance, Inquiring Intellect	Imaginative, Creative, Curious, Cultured, Sharp-witted, Broad-minded, Inventive, Insightful, Complex	Simple, Concrete, Narrow, Imitative, Unimaginative

Personality traits needed for successful performance in team contexts might be somewhat different than the ones required in more traditional individually oriented jobs. Not only must the personality profile of the team match the demands of the task, but the people on the team (and hence, their personalities) must be compatible as well. There are not a vast number of studies relating team member personality to team performance. These studies have operationalized personality in terms of elevation and diversity. *Team personality elevation* is a team's mean level on a particular personality trait or set of personality traits whereas *team personality diversity* is the variance or differences among team members for a particular personality construct or set of constructs. Most of these studies measure and relate specific personality traits to team performance or team satisfaction. There is no replication of any of



the results due to the task specificity and the situational nature of the experiments. Therefore, there are no specific conclusions relating personality to team performance. However, the preliminary results from the studies in existence indicate that some personality traits may affect performance for certain tasks in certain situations (Driskell et al., 1987). A brief overview of the findings for each of the B5 factors is described below.

### **3.1. Extraversion**

With regard to the elevation of extraversion, researchers acknowledge extraversion to be important for a smooth functioning of the social mechanisms within a team, since it is by description strongly linked to intra-team processes or contextual performance (i.e. performance regarding the social and motivational context in which a team operates (Borman and Motowidlo, 1993). With regard to effects of elevation of extraversion, researchers propose different hypotheses. On the one hand, extraverts are talkative, outgoing, enthusiastic, energetic, optimistic and assertive (McCrae and Costa, 1989) and researchers expect these characteristics to result in a positive attitude towards teamwork (Barrick et al., 1998; Barry and Stewart, 1997) and high performance expectations (Barry and Stewart, 1997). Furthermore, extraverts in a team are expected to stimulate discussion (Mohammed and Angell, 2003; Taggar, 2002) and their attitude should foster a climate in which team members feel free to express themselves (Barry and Stewart, 1997). This freedom of expression is critical for the quality of the decisions the team will have to make with regard to the task (Schultz, Ketrow and Urban, 1995). On the other hand, researchers also express caution over the inclusion of too many extraverts in a team, since this may harm the team's effectiveness. Extraverts may be expected to like to work within a team only for the possibility of social interaction (Neuman et al., 1999). This focus on social interaction is expected to distract their attention from task completion (Barry and Stewart, 1997; Mohammed and Angell, 2003). Furthermore, because of their talkativeness and assertiveness, extraverts tend to be dominant (Kichuk and Wiesner, 1998). Researchers expect that a team that is composed of too many dominant individuals will likely engage in conflict over team issues (Mazur, 1973), like, for instance, leadership (Barry and Stewart, 1997; Mohammed and Angell, 2003). Results of Barry and Stewart (1997) indeed showed that intermediate levels of the elevation of extraversion within a team lead to high team performance. The emphasis of researchers on either positive or negative effects of the elevation of extraversion at the same time forms the basis for the expectation of a positive effect of variability in extraversion.

### **3.2. Agreeableness**

Elevation in agreeableness is, expected to be positively related to team effectiveness. As with extraversion, the effect of agreeableness is expected to manifest itself through its favourable effect on team processes or contextual performance. Team members high in agreeableness are friendly, tolerant, helpful, altruistic, modest, trusted, straightforward (Costa and McCrae, 1992) and non-competitive (Graziano, Hair and Finch, 1997). Researchers expect these characteristics to facilitate interpersonal attraction (Neuman and Wright, 1999) and thus cooperation (Barrick et al., 1998; Mohammed, Mathieu and Bartlett, 2002; Neuman and Wright, 1999; Taggar, 2002), smooth conflict resolution (Barrick et al., 1998; Neuman and Wright, 1999; Taggar, 2002), open communication (Neuman and Wright, 1999), information-seeking (Taggar, 2002), compliance with team goals and task cohesion (Van Vianen and De Dreu, 2001), team cohesion (Barrick et al., 1998; Greene, 1989) and alignment (shared mental model) on the most effective way to work together as a team (Klimoski and Mohammed, 1994). Results of empirical studies confirm the expectation that higher levels of agreeableness lead to higher team performance (Barrick et al., 1998; Graziano et al., 1997; Neuman et al., 1999; Neuman and Wright, 1999; Van Vianen and De Dreu, 2001). In addition, it is also stated that the variability in agreeableness or even the presence of one single disagreeable team member is expected to disrupt cooperation (Barrick et al., 1998, Mohammed and Angell, 2003).

On the other hand, high cohesiveness can also lead to “groupthink”. According to Janis (1972) when teams are highly cohesive they are susceptible to “groupthink”. Groupthink occurs when team members shut themselves off from the environment or from others that may have different views, they develop an unrealistic sense of righteousness and may refuse to change their decision despite being confronted with conflicting information. Janis points out that these behaviors impede a team’s effectiveness on problem solving tasks.

### **3.3. Conscientiousness**

Since conscientiousness is the most consistent predictor of individual performance (Hurtz and Donovan, 2000; Salgado, 2003), researchers expect this effect of the elevation of conscientiousness to present itself at the team level as well. Highly conscientious team members are thorough, hardworking, responsible, self-disciplined, organized, self-motivated

and achievement- and task-oriented (Barrick and Mount, 1993; Costa and McCrae, 1989; Goldberg, 1993). Researchers expect these characteristics to result in effort and perseverance toward team goal completion (LePine, 2003; Molleman, Nauta and Jehn, 2004; Mohammed and Angell, 2003; Neuman and Wright, 1999; Taggar, 2002; Van Vianen and De Dreu, 2001), a focus on and commitment to the task (Barry and Stewart, 1997; Taggar, 2002), cooperation (Molleman et al., 2004) and role adaptation in face of changes within the team or task (LePine, 2003). Thus results of several empirical studies support these expectations, as they show that higher elevation of conscientiousness within a team leads to higher team performance.

With respect to variability in conscientiousness, researchers hypothesize that similarity in conscientiousness will lead to cohesion (Van Vianen and De Dreu, 2001), whereas dissimilarity in conscientiousness may lead to conflict and diminish a team's effectiveness (Mohammed and Angell, 2003; Molleman et al., 2004). Thus, a negative effect of variability in team member conscientiousness on team performance is predicted. In the empirical studies that have been carried out, it has indeed been demonstrated that higher team performance is reached when teams have a lower variability in conscientiousness among team members (Barrick et al., 1998; Kichuk, 1999).

### **3.4. Emotional Stability**

Researchers expect emotional stability fosters cooperation, a relaxed team atmosphere (Barrick et al., 1998; Molleman et al., 2004), stability within the team and coordination of work behaviours (Neuman et al., 1999) and task cohesion (Van Vianen and De Dreu, 2001). Based on this and on previous findings of Haythorn (1953), Helslin (1964) and Thoms, Moore and Scott (1996), the elevation of emotional stability is expected to be positively related to team performance. Results of separate studies support this expectation (Barrick et al., 1998; Kichuk and Wiesner, 1998; Molleman et al., 2004).

Considering variability in emotional stability, researchers hypothesize that the presence of one single (Barrick et al., 1998; Neuman et al., 1999; Van Vianen and De Dreu, 2001) or just a few (Mohammed and Angell, 2003) unstable or neurotic team members will have an adverse effect on team effectiveness by disrupting the cooperation, the atmosphere or the cohesion

within a team. So, variability in emotional stability is expected to be negatively related to team performance.

### **3.5. Openness to Experience**

With regard to the elevation in openness to experience, researchers reckon team members high in openness to be creative, broadminded and willing to experiment or to try new things (LePine, 2003; Molleman et al., 2004). Team members possessing these characteristics are expected to adapt easily to new situations, build upon each other's ideas and look for alternative ways to solve problems they encounter (LePine, 2003). They are also expected to foster a creative atmosphere in which team members have opportunities to learn and to experience satisfaction (Molleman et al., 2004). Thus, openness should be related to the success of teams involved in creative tasks, or tasks performed under conditions of high uncertainty, such as radical innovation. Openness may be less important for group performance on a routine mechanical or a social task than for a problem-solving, or may even have negative relationships with performance with highly structured tasks (Driskell et al., 1987; Gibb, 1969; Cattell and Stice, 1954).

With respect to variability in openness, researchers hypothesize that if all team members are highly open to experience, this may result in conflict and lowered cohesion, because all team members want to get their way (Van Vianen and De Dreu, 2001). However, none of the studies conducted so far has shown either positive or negative effects of variability in openness to experience on team performance.

## **4. The Proposed Model for Team Formation**

The problem is to extract multiple teams given an existing labor pool. Before we explain the proposed model, we should note our assumptions. It is first assumed that technical skill categories and personality trait requirements have been clearly defined by the management. It is also assumed that the set of individuals in each skill group is known as well. An individual may possess more than one skill at a sufficient level to fulfill the team requirements, however, he/she is counted only in one of the skill categories; but may fulfill other technical skill requirements as well. It is also assumed that there exist sufficient individuals in the various

skill categories to meet the requirements for the teams. That is, all team skill requirements will be met.

We assume that we have personality profiles of all potential team members being considered. The desired level of the personality traits will be an important factor in deciding the construction of the team. In order to determine the desired level personality traits, based on the IPO model explained in section 2, the manager(s) who determine the team composition should set well defined team effectiveness measures, i.e. they should establish realistic and clear team objectives. Based on these measures, they should determine the team tasks required to achieve team objectives and consider the necessary level of interaction between the team members based on the team task characteristics (level of autonomy and interdependency). Finally, they should determine which personality traits are required to maintain task and interpersonal cohesion and minimize the possible task and personal conflicts.

In the proposed model, we use B5 to describe the personality of the potential team members and the proposed model optimizes the team composition in terms of elevation and diversity (variability) measures. The technical skills and personality traits of the potential team members should be assessed subjectively by using a five-point or seven-point scale. In our illustrative example, presented in the next section, we use a five-point scale where 1, 2, 3, 4 and 5 represent “very poor”, “poor”, “moderate”, “good” and “very good” respectively.

Based on the impacts of personality traits delineated above, the proposed team formation model is as follows.

*Decision variables:*

$$x_{ijk} = \begin{cases} 1, & \text{if employee } i \text{ with specialization } j \text{ is assigned to team } k \\ 0, & \text{otherwise} \end{cases}$$

*Data coefficients:*

$a_{ijp}$  : Score of employee  $i$  with specialization  $j$  with respect to personality trait  $p$

$b_{ij}$  : Score of employee  $i$  with respect to specialization  $j$

$E_{pk}$  : Elevation score of team  $k$  with respect to personality trait  $p$

- $D_{pk}$  : Diversity of team  $k$  with respect to personality trait  $p$   
 $E_{jk}$  : Elevation score of team  $k$  with respect to specialization  $j$   
 $D_{jk}$  : Diversity of team  $k$  with respect to specialization  $j$   
 $N_{jk}$  : Number of employees in specialization  $j$  who are required for team  $k$   
 $N_k$  : Number of employees who are selected for team  $k$   
 $Z_{pk}^E$  : Desired level of elevation of personality trait  $p$  in team  $k$   
 $Z_{pk}^V$  : Desired level of diversity of personality trait  $p$  in team  $k$   
 $Z_{jk}^E$  : Desired level of elevation of knowledge on specialization  $j$  in team  $k$   
 $Z_{jk}^V$  : Desired level of diversity of knowledge on specialization  $j$  in team  $k$   
 $w_{pk}^E$  : Weight of elevation of personality trait  $p$  for team  $k$   
 $w_{pk}^V$  : Weight of diversity of personality trait  $p$  for team  $k$   
 $w_{jk}^E$  : Weight of elevation of knowledge on specialization  $j$  for team  $k$   
 $w_{jk}^V$  : Weight of diversity of knowledge on specialization  $j$  for team  $k$

$$\begin{aligned}
 \text{Minimize } D = & \sum_k \sum_j w_j^E (d_{jk}^{E+} + d_{jk}^{E-}) + \sum_k \sum_j w_j^V (d_{jk}^{V+} + d_{jk}^{V-}) + \\
 & \sum_k \sum_p w_p^E (d_{pk}^{E+} + d_{pk}^{E-}) + \sum_k \sum_p w_p^V (d_{pk}^{V+} + d_{pk}^{V-})
 \end{aligned} \tag{1}$$

subject to

$$\sum_i x_{ijk} = N_{jk}, \quad \forall j, k \tag{2}$$

$$\sum_k x_{ijk} \leq 1, \quad \forall i, j \tag{3}$$

$$E_{pk} + d_{pk}^{E+} - d_{pk}^{E-} = Z_{pk}^E, \quad \forall p, k \tag{4}$$

$$E_{jk} + d_{jk}^{E+} - d_{jk}^{E-} = Z_{jk}^E, \quad \forall j, k \tag{5}$$

$$D_{pk} + d_{pk}^{V+} - d_{pk}^{V-} = Z_{pk}^V, \quad \forall p, k \tag{6}$$

$$D_{jk} + d_{jk}^{V+} - d_{jk}^{V-} = Z_{jk}^V, \quad \forall j, k \tag{7}$$

$$E_{pk} = \frac{\sum_j \sum_i a_{ijp} x_{ijk}}{N_k}, \quad \forall p, k \tag{8}$$

$$E_{jk} = \frac{\sum_i b_{ij} x_{ijk}}{N_k}, \forall j, k \quad (9)$$

$$D_{pk} = \frac{1}{N_k - 1} \left( \sum_j \sum_i a_{ijp}^2 x_{ijk} - \frac{1}{N_k} \left( \sum_j \sum_i a_{ijp} x_{ijk} \right)^2 \right), \forall p, k \quad (10)$$

$$D_{jk} = \frac{1}{N_k - 1} \left( \sum_i b_{ij}^2 x_{ijk} - \frac{1}{N_k} \left( \sum_i b_{ij} x_{ijk} \right)^2 \right), \forall j, k \quad (11)$$

$$x_{ijk} \in \{0, 1\}, \text{ all variables } \geq 0$$

The objective function (1) minimizes the weighted sum of the deviations of actual mean and variance of the skill levels and personality traits from the desired levels of these parameters. The weights in the objective function may be regarded as costs of the deviations. These deviations are introduced in eq. (4) - (7). Eq. (2) ensures that sufficient number of individuals from each specialization is assigned to the teams. Eq. (3) states that an individual is assigned to at most one team. Eq. (8) and eq. (9) are about the computation of mean personality traits and level of specific knowledge whereas Eq. (10) and eq. (11) are about the computation of diversity (variability) of the same measures. These are, in fact, basic statistical formulas to calculate sample mean and variance for the assigned team members. Finally, we enforce the binary and non-negativity restrictions on the variables. If required, the model can be run with only one team. Also, the model can be modified to minimize the maximum, or to maximize the minimum value of a certain trait or specialization.

## 5. Illustrative Example

Suppose there are 18 employees to be assigned to *two* teams which share different tasks of a software design and implementation project. The scores of the employees with respect to specialty areas and personality traits are given in Table 2. In this Table, employees 1-6 are in the set of programmers and employees 7-12 and employees 13-18 constitute the set of the network specialists and operating system specialists respectively. The first team is decided to include 4 programmers since it is mainly planned to be a programming team. The second team is planned to work on computer networks and operating systems therefore, it includes 2 network specialists and 2 operating system specialists. Thus, both teams are composed of 4 members.

It is assumed that, due to additive components of the team tasks, a high level of interaction of team members is required. Thus, team compositions must be optimized with respect to personality traits in such a way that a task and social cohesion within the team is maintained and interpersonal conflict is minimized. As a result, team effectiveness is expected to increase accordingly. Moreover, task cohesion is expected to be obtained by the inclusion of highly conscientious individuals in the teams. Since, software implementation project requires a certain level of creativity for generating new ideas within the teams, a moderate level of openness to experience is desired.

Table 2. Employees' scores on specialty areas and personality traits

	EMPLOYEES																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Programming Knowledge	5	5	4	5	4	5	3	2	3	2	4	3	5	1	3	2	1	3
Computer Network Knowledge	2	2	2	3	3	2	5	4	4	4	5	4	3	2	2	3	2	2
Operating System Knowledge	2	1	1	2	3	2	2	2	3	1	3	2	4	5	4	5	5	5
Agreeableness	3	2	3	4	5	5	3	4	3	3	5	3	5	4	4	3	4	4
Extraversion	4	3	4	5	3	3	3	3	3	5	4	4	3	3	2	5	3	3
Conscientiousness	4	3	4	5	4	2	5	4	5	5	5	5	3	4	4	3	3	5
Openness to Experience	5	4	3	4	4	4	4	4	3	3	5	2	4	3	5	3	4	4
Emotional Stability	3	4	4	3	2	2	5	3	5	5	5	5	2	3	4	2	3	3

Based on the team objectives and prediction of required technical skills and personality traits, the following goals are determined:

Goal 1 : The elevation of the Programming Team on *programming knowledge* must be as high as possible (“5” is the desired level). The weight of this goal is determined as 6 and 1 for Team 1 and Team 2 respectively. Thus, minimizing the deviation for the programming knowledge in Team 1 is six times more important than minimizing the deviation for programming knowledge in Team 2.

Goal 2 : The elevation of the Network Team on *computer networking knowledge* must be as high as possible (“5” is the desired level). The weight of this goal is determined as 1 and 6 for Team 1 and Team 2 respectively.

Goal 3 : The elevation of the Operating System Team on *operating system knowledge* must be as high as possible (“5” is the desired level). The weight of this goal is determined as 1 and 6 for Team 1 and Team 2 respectively.



Goal 4 : The elevation of the teams on *agreeableness* must be moderate (“3” is the desired level). The weight of this goal is determined as 1.

Goal 5 : The elevation of the teams on *extraversion* must be moderate (“3” is the desired level). The weight of this goal is determined as 1.

Goal 6 : The elevation of the teams on *conscientiousness* must be as high as possible (more is better, so “5” is the desired level). The weight of this goal is determined as 4.

Goal 7 : The elevation of the teams on *openness to experience* must be moderate (“3” is the desired level). The weight of this goal is determined as 1.

Goal 8 : The elevation of the teams on *emotional stability* must be as high as possible (“5” is the desired level). The weight of this goal is determined as 2.

Goal 9 : The diversity of the teams with respect to *agreeableness* must be as small as possible (variance = 0 is desired). The weight of this goal is determined as 1.

Goal 10: The diversity of the teams with respect to *extraversion* must be as small as possible (variance = 0 is desired). The weight of this goal is determined as 1.

Goal 11: The diversity of the teams with respect to *openness to experience* must be as small as possible (variance = 0 is desired). The weight of this goal is determined as 1.

In the set of goals given above, the maximum weight (i.e. 6) is given to the technical skills whereas maximum weight associated with the personality traits (i.e. 4) is given to the conscientiousness since this personality trait is more important for a member to be more achievement-oriented. As a result, the model is expected to fulfill first the technical requirements, and then satisfy the goals related to personality traits as much as possible. However, these weights can be re-adjusted to set relative importance levels for different characteristics.

Also, other goals may be added to the ones mentioned above. For instance, diversity with respect to conscientiousness and emotional stability could also be minimized. However, as we set our goal for conscientiousness and emotional stability as 5 out of 5, such a goal would be redundant and would not affect the final solution. The same case is also valid for teams with different type of specializations. For the sake of completeness, we can say that the weights of the goals, which are not mentioned above, are equal to zero. Note that the maximum weights (i.e. “6”) are given to the goals about the technical skills required for the teams. Then, conscientiousness, which is related with task cohesion of the team, follows.

The problem was solved by using LINGO 11.0. The results of the solution for this problem can be summarized as follows. The employees 1-4 were selected for Team 1, which is planned to involve only programmers. Employees 7, 9, 14 and 18 were selected for Team 2, which is decided to involve 2 network specialists and 2 operating system specialists. Total deviation from the target levels for Team 1 is found as 16.75 whereas the composition of the Team 2 has a deviation of 24.75 from the target levels and with given weights of the goals. Thus, total deviation has resulted as 41.25.

## **6. Conclusions**

In this study, a goal programming model has been proposed to minimize the sum of the deviations of the team from the desired level of elevation and diversity with respect to technical skills and personality traits. Thus, an optimization of team composition with respect to both skill and personality mix is provided. However, in order to provide the optimum team composition, which will enable task and social cohesion and consequently maximize the team effectiveness, the manager(s) who is responsible with the team formation should be aware of the effect of different personality traits on the team dynamics or processes. Based on this premise, we have reviewed the literature related to personality and team performance and summarized the impact of each dimension of B5 factors on the team effectiveness. This review has shown that the nature of the team tasks (uncertainty, complexity, difficulty and etc.), level of autonomy and interdependency determines the level of team members' interaction and thus, play a major role on the determination the personality traits required for a team in terms of elevation and diversity. Therefore, the first step in a team formation process should be to determine the team effectiveness measures and team outcomes in terms of these measures based on the objectives and context of the team working. Then, hypotheses should be developed about the relation of personality and skill mix of the teams so that goals with respect to technical skills and personality traits may be determined. In this respect, the proposed model also suggests a conceptual framework based on IPO model which can be very helpful for setting goals for determining the individuals who should be involved in the teams. However, we can not ensure that selected team members will form the most effective team(s) since human beings are so complex and their performance may not be stable over time. Therefore, for testing the validity of the proposed model, measurement of correlation between the total deviation obtained from this model and actual team effectiveness measures may be recommended for future research.

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