

## Implementation of Fuzzy Expert System as a Decision Support System in the Personnel Development Processes

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### Abstract

In this day where quality personnel employment is also important for the production of quality products and services, the organizations evaluate the performances by their performance management systems within the organization and try to achieve their targeted business performance by determining appropriate training and development programs. The development activities are spread over a longer period, as they are individual and continuous, and require the implementation of individual development activities. When the studies in the literature are examined, it is observed that standardized development activities are generally applied to the employees in this process and mostly socio-psychological factors are not taken into consideration. In this study, a decision support system, in which the employees' knowledge and skills, psychological status, communication skills, job satisfaction and demographic characteristics can be evaluated, has been developed in order to assist managers in their decision-making during the job placement and development processes of the employees. It will be possible to obtain the maximum efficiency and work performance with minor cost and time by planning the development activities in accordance with the needs and situation of each personnel thanks to the system developed in the study.

### 1. Introduction

In a globalizing world, the conditions of competition are constantly increasing and forcing businesses to be better in every respect. Accordingly, the employment of qualified personnel for the production of quality products and services is gaining importance gradually. The phenomenon of development and change, which is already the return of the modern era, requires the restructuring of each organization and thus the determination and development of the employee needs. In this context, the organizations evaluate performance by their performance management systems within the organization and try to achieve their targeted business performance by determining appropriate training and development programs [1].

For increasing the performance in the organizations, on one hand, the training activities are

performed in order to allow the personnel to have technical and professional knowledge that he needs in daily business life and on the other hand, development activities are performed in order to allow the personnel to develop his knowledge, skills and behaviors that he will need for doing his job better [2], [3]. These development activities require a longer process as they are individual and continuous.

In the literature and in practice, there are many methods especially for personnel selection and these methods are mostly applied to the candidates in recruitment processes. However, as much as the personnel selection, it is also very important that the personnel is placed in the right position and then trained [4]. When the studies in the literature are examined, it is observed that mostly socio-psychological factors are not taken into consideration in this process [5]. However, the employees encounter many socio-psychological phenomenon both in their

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workplaces and in their daily lives, and these factors directly affect the work performance of employees [6].

In this study, a decision support system, in which the employees' knowledge and skills, psychological status, communication skills, job satisfaction and demographic characteristics can be evaluated, has been developed in order to assist managers in their decision-making during the job placement and development processes of the employees. In this way, it is aimed to enable the employees to work in job positions where they can be most productive and to benefit from the development programs just for themselves by identifying the shortcomings of each employee. In addition, by means of the system developed in this study, it is possible to support the managers regarding the evaluation of employees' existing job positions, their promotions, their dismissals or their assignment to another job position. On the other hand, it's also possible to evaluate the shortcomings of the employees and therefore to obtain maximum efficiency and work performance by implementing a special development program only for that employee and especially by saving cost and time.

This study consists of five parts. In the second part, detailed information about personnel development is given and a summary of the studies in the literature is presented. In the third part, the performance criteria determined for this study (stress and anxiety, anger, job satisfaction, communication and business knowledge) is discussed. In the fourth part, the expert systems and fuzzy expert systems are described and in the fifth part, the fuzzy expert system and the user interface of this system developed by taking into consideration the professional and technical information of the employees as well as the socio-psychological and demographic characteristics have been introduced. The study concludes with the conclusion and discussion part.

## 2. Personal Improving

The development consists of implementing and developing strategy and plans to improve the performance of individuals and groups in order to improve the long-term competitiveness potential of an organization; implementing the performance plan and revision processes; promoting education, long-term personal development and team development to increase the capacity of individuals [7], [8].

Organizations can achieve targeted corporate performance only if the employees perform their activities in a quality way. In order to achieve

organizational goals, it is important that the employees are motivated to develop individual performance skills, to understand the relationship between institutional goals and individual goals [9]. However, the employees of an organization may not always perform the desired or expected performance from them in their existing job positions. While the performance of the employee may be below the expected performance, it is another reason that the actual performance of the employee may be higher than the performance required by the job. [10]. The first problem is considered as a problem and it's tried to be solved by improvement and development efforts, and the second problem is mostly ignored. The second issue, which we encounter, should be emphasized especially in terms of evaluation of the possible opportunities by the company, verification of employee's job satisfaction and employee's efficiency. In this way, in case that a balanced match between job positions and employee capacity is achieved, it will be possible for the enterprise to achieve a higher performance than the average and to gain a competitive advantage that can compete with its competitors.

In case that the employee doesn't provide the qualifications required by the job position, the enterprises may perform development methods for the employees. This development process depends on four factors. These are organization, human resources department, employer and the individual himself. If any negativity is experienced due to any of these factors, the benefit of development may decrease [11]. In addition, performance development should not only be a study that is aiming the unsuccessful personnel but at the same time it should be aiming the performance development of the successful employees [12]. In this context, there may be various motivations for development. For example, while the subordinate focuses on an upward mobility by asking "What can I do to get promoted", the manager may want to increase the motivation and productivity of the employees by asking "What can I do to encourage my employees to do their best". On the other hand, a senior executive may address issues like what it takes to keep and develop the most talented ones in order to make them support leading the company in the future by asking "What shall we do in order to ensure that the most skilled people in our company are in the right positions" [13].

On the job trainings are usually provided to increase the job performance of employees in organizations. The aim of these trainings is to enable the personnel to have the knowledge, skills and behaviors that they may need in their daily work life.

Unlike Training, the development is the activities that will help the personnel to upgrade his existing skills and thus to perform and to be productive at the desired level, in addition to the knowledge and skills that the personnel needs in order to do his job better. The development can't be considered as a short-term activity like training. The development is individual and continuous. However, it must be known that there won't be any development without training. Training and development are integral parts of a process. The training is performed in order to add new ones to the ones previously learned by an individual. And in the development, it's aimed to make full use of the capacity of the employees and to increase this capacity further [14].

Development activities are carried out especially in order to increase the performance. In the study in [15], it has evaluated the components affecting performance improvement in the following six dimensions;

- ✓ Information (information) development is ensuring that the employee has sufficient information about the quality and quantity of the performance expected from him.
- ✓ Knowledge (knowledge) and skills development means developing the knowledge and skills required for the expected performance of the employee.
- ✓ Motivation development is providing sufficient motivation to the employee in order to make him realize what is expected from him.
- ✓ Structure and process development is the arrangement of the structure and processes in which the employee takes part in such a way that will facilitate the performance expected from him.
- ✓ Development of working tools and conditions is improving the working tools and conditions in a way that will support employee's performance.
- ✓ Health development means supporting the employee if the employee's mental, physical and mental health prevents the employee from performing the expected performance from him.

Personnel development has two dimensions, both individual and organizational. Personnel development programs let people learn, be open to new ideas and receive feedback from their colleagues, take decisions on their own and perform them, self-assess, create goals for development and improve their power of analysis. Personnel development program is developed in the organization in order to

meet the objectives, improve the quality of relationships for developing group effectiveness, develop a professional working climate, developed a structure that facilitates development, eliminate the structures and factors that fail to perform their tasks and create processes that provide feedback for continuous regeneration [16].

In the study in [16] it is conducted a study on the development of managers and teachers working in primary schools. According to the findings, he emphasized that in the personnel development program to be organized for administrators and teachers, it's necessary to give importance to emotional, mental and physical development especially for female staff, and also to consider the characteristics such as gender, seniority, duty, level of education while organizing personnel development programs. In the study in [17] it is researched the status of training activities for the development of human resources in small and medium-sized enterprises by a survey and it has been emphasized that training activities were carried out in a way that was inconsistent with the program development perspective, the activities for the determination of the requirements were not performed sufficiently or the educational institutions were sending their own personnel to the training programs that they suggested through notification. In the study in [18] it is examined the effect of employee satisfaction on employee performance by training and development activities in the companies. Because of his survey, he stated that the training and development granted to company employees had a positive effect on employee satisfaction and performance. In the study in [19] it is examined the evaluation of the effects of training and development provided by human resources in the companies on employee performance, and also the positive and negative effects of training and development on employees. According to this, he stated that in the light of the career, material, productivity, positivity and psychological effects of the employee, the trainings provided within the institution have positive results. In addition, he reached the conclusion that training and development activities within the company satisfied the employees averagely. In the study in [20] it has been comprehensively addressed the issues of performance, learning and development, guidance-based learning and development conceptually, and has proposed a model for development-oriented performance management by taking expert and practitioner views on the subject. The model is based on one-to-one training and development process, such as mentoring or coaching. In the study in [21] it has

been researched the relationship between the human resources management and job satisfaction. According to this, he has defended that increasing the level of success in the human resources management functions of enterprises will make a significant contribution to achieving their organizational goals and increase the performance of their employees. Especially, he emphasized that the enterprises should review and improve continuously their overall functions such as personnel selection and placement, performance evaluation, remuneration and rewarding, career management, training and development, and their level in occupational health and safety function. In the study in [22] it is tried to determine the effect of performance empowerment on performance and efficiency with the survey that he conducted on bank employees by emphasizing that empowerment is one of the most important elements of human resources development. According to this, he stated that performance strengthening has no effect on performance but it has an impact on efficiency.

On the other hand, there are decision support systems in the literature that use various techniques developed to evaluate personnel for personnel development or recruitment. In the study in [23] it is proposed a fuzzy Analytic Hierarchy Process (AHP) based model that can be used to select the personnel by using general and personal criteria such as education, foreign language, experience, age, physical appearance, effective time use, and teamwork skills. In the study in [24] it is used Gray Relational Analysis (GRA) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods to select research and development personnel. In the study, the benchmark weights and linguistic variables showing the qualities of the candidates were expressed in gray numbers, and the ranking was made according to the gray relationship degrees. In the study in [25] it is evaluated the degree of adaptation between the characteristics of the employees and the needs of the employer by taking into account factors such as foreign language skills, computer skills, experience, age, military service, gender, non-smoking personnel, driver's license and education graded by 3 different authorities in an enterprise by combining Matlab fuzzy tool and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) method which is one of the multi-criteria decision making methods. In the study in [26] it is proposed a TOPSIS based approach for the selection of senior executives and considered the fuzzy TOPSIS method with veto thresholds. In the study in [27] it is addressed the problem of personnel

selection for an institution providing training services by using GRA and Gray Analytical Network Process (GANP) in an integrated way to solve group decision making problems involving both subjective and objective criteria. In the study in [28] it is proposed an intuitive fuzzy multiple criteria group decision-making method with GRA in the selection of the appropriate one among four candidates for the system engineering position in a software company.

### 3. Personnel Improving Performance Critters

The performance criteria required by any business position in the enterprises refer to the criteria required for the successful performance of that business. These criteria can be listed as the knowledge and skills required by the job, personal characteristics and expected results/outputs. In addition, productivity, self-development effort, management skill, cooperation and communication skill is also the recommended elements to be considered as general performance criteria [29]. After the determination of main performance criteria, the important sub-criteria can be determined for each criteria according to the quality of the job and employee.

When the studies conducted on personnel development and presented in the second part are examined; in the studies it is observed that the performances of people are mostly evaluated with traditional performance evaluation scales or behavioral expectation scales such as quantity and quality of work, knowledge level, cooperation and communication skills, undertaking etc.

In this study, demographic, psychological, personal and professional characteristics of the employees were evaluated together in order to enable employees to benefit more effectively from personnel development programs. According to this, "stress and anxiety", "anger", "job satisfaction", "communication level", "professional knowledge level" criteria are evaluated according to the following methods.

Stress and anxiety level of the employees have been evaluated by a scale developed in [30]. According to this, at this scale, which is developed to measure job stress, psychological and psychosomatic symptoms related to the stress experienced by the employee at work are measured. On the scale consisting of 7 questions, answers are measured with 5-point Likert scale.

The anger states of the employees are measured by the Multidimensional Anger Scale developed in [31]. On this scale, people's feelings, thoughts and attitudes about anger are determined.

The questions on the scale consisting of 5 parts are being scored between 1 to 5 as Likert type.

For the evaluation of employees' job satisfaction, a four point Likert type scale has been used consisting of 10 items developed in [32]. Items in the scale are scored between 1 and 4. Here, the lowest and highest scores in the scale will be between 10 and 40 and 20 and higher scores will be considered as job satisfaction.

And the communicational skill of employees is being evaluated in [33]. It's a five point likert scale and it consists of 25 statements. The excess score obtained from the scale without the contrary items means that individuals evaluate their own communication skills positively.

Occupational knowledge of the employees is measured by the questions prepared by the managers and experts determined within the institution according to the employees' area of specialization. Here, each point received by the employees according to five different criteria is calculated according to the rating level from 1 to 10 (1 is the lowest and 10 is the highest) and it is provided that all points taken from the criteria are evaluated on the same scale.

#### 4. Fuzzy Logic and Fuzzy Expert Systems

##### 4.1 Fuzzy Logic

Fuzzy logic, based on fuzzy sets, helps in modeling uncertain and imprecise data in the real world by enabling the realization of the processes similar to human thought in [34]. In the classical set concept, an element is either an element of a set or it is not, and there can never be a partial membership to a set. If the element's membership value is 1, then it is the complete element of the set, if it is 0, then it is not the element of the set. In other words, the membership of the elements can only have [0, 1] values in the classical sets. Unlike classical sets, membership degrees of the elements in the fuzzy sets can have an infinite number in the range of [0, 1] as shown in Figure 1.

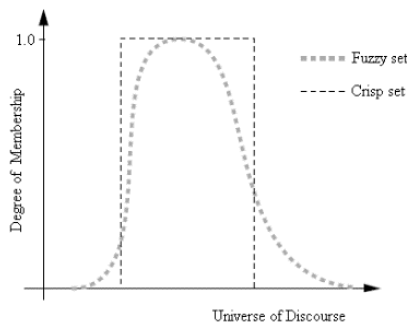


Figure 1. Illustration of a crisp and a fuzzy set.

##### 4.2 Fuzzy Expert Systems

The experts, who specialize in tasks that require expertise, make logical inferences and reach conclusions based on the information in their fields. In cases where adequate specialists cannot be reached or where the employment of specialist is expensive or limited, the systems used to make conclusions by transferring the opinions of experts to an informatics system and making inferences are called expert systems. Expert systems consist of the following components [35];

- ✓ Database that contains facts, rules and information about a certain problem;
- ✓ Inference Mechanism that uses the information stored expertly to find solutions to problems;
- ✓ User Interface that ensures communication with the user;
- ✓ Information Acquisition Module that helps to improve the database

Fuzzy expert systems are expert systems consisting of blurring, inference, knowledge base (rule base and database) and defuzzification subsystems, which use fuzzy logic instead of classical logic in data processing [36]. By applying the fuzzy logic developed by Lotfi A. The definitive statements on the input and output of the expert systems are expanded to fuzzy expressions sets and these developed expert systems may exhibit closer expertise to the human justice system [37]. In this way, expert systems that adapt better to real life problems can be developed by eliminating small errors and small uncertainties in the input data and the sharp limits in the logic of inference. The structure of a fuzzy expert system is shown is Figure 2 [38].

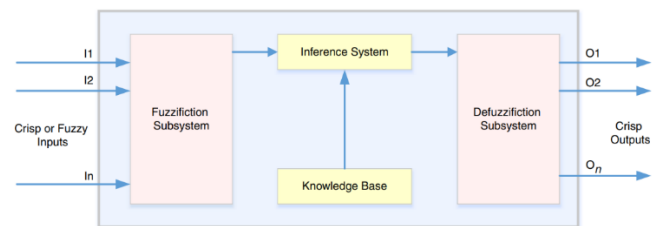


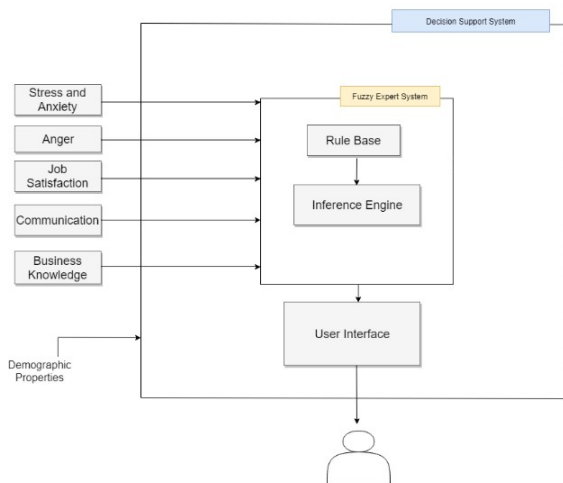
Figure 2. Structure of a fuzzy expert system.

In a fuzzy expert system, the inputs are taken as crisks and the input values are blurred by using the input membership functions whose boundaries and shapes are defined by the actual experts of the job. The inference mechanism in the fuzzy expert system, evaluates the data coming from the blurring block with the rules in the rule base and produces fuzzy output data appropriate to input data. The fuzzy data

in the output of this block are also presented to the output as definite values by using the output membership functions and the defuzzification method whose boundaries and the shapes are determined by the experts. All this process can be monitored comprehensibly by a prepared user interface and the parameters can be changed.

**5. Developed Decision Support System**

Expert knowledge, incomplete and uncertain information and situations can be modeled by using artificial intelligence techniques such as expert systems, fuzzy logic, artificial neural networks in decision support systems. Decision support systems using these techniques are called intelligent decision support systems. Since intelligent decision support systems give successful results, a decision support system has been developed with the fuzzy expert system in this study. The block diagram of the personnel assessment decision support system developed within the scope of the study is given in Figure 3.



**Figure 3.** Structure of the decision support system.

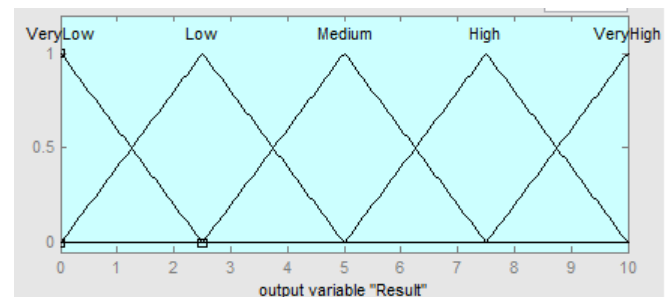
In this context, first of all, each personnel, who is wanted to be evaluated, has been evaluated by stress & anxiety, anger, job satisfaction, communication and business knowledge scales that were presented in the previous chapters. The indicators of scales are different from each other and each of these are between 0-10 and each personnel gets a definite point between 0-10 for each of this criteria in the system. Also, according to the professional knowledge, a definite point is obtained again between 0-10 by performing measurements with a professional test according to employee’s professional field. For each criteria, definite values

are entered in the fuzzy expert system as an input. The membership function, which is prepared thanks to the opinion of the experts and used to blur “low, medium, high” linguistic values of all inputs, is shown in Figure 4.



**Figure 4.** Membership function regarding all input criteria.

In the developed system, two-stage inference mechanism has been applied. In the first stage, Max-Min inference mechanism developed in [39] has been used for inference. In this model, the premise (rule’s “if” part) and final part (rule’s “then” part) consist of fuzzy propositions. The weighted average method is used for defuzzification. The inference mechanism consists of 35 rules because there are 5 criteria in the system and each criteria has 3 fuzzy sets. The rules are created with the knowledge and experience of a group of experts consisting of a manager, a human resources personnel and a psychologist. The weight of all rules is equal. The fuzzy values obtained as a result of inference mechanism are defuzzified by the membership function shown in Figure 5 and consisting of five sets determined also by the experts as “very low”, “low”, “medium”, “high”, “very high”. After the defuzzification, “Result” intermediate output, where employee status assessment is performed in the system, is produced.



**Figure 5.** Membership function regarding result.

In the second stage, Takagi-Sugeno mechanism produced in [40] is used for inference. In this model, while the premise of the rule is defined as

a fuzzy, the final part contains definite values and it is defined as a linear function of input variables. In the system, the status of the employees according to all their input criteria is evaluated by Sugeno and “Action To Be Done” output.

According to the linguistic values, in compliance with five sample employees’ criteria, “Result” output determined by mandami and the development program output that is necessary to be applied to the employee determined by sugeno is shown in Table 1.

Owing to the created rules, each criteria is evaluated jointly and an inference is made for the operation which is necessary to be applied to each

employee accordingly. There will be no training and development for those in very good condition. For the ones in a very bad situation, no training will be given and they can be dismissed after their demographic characteristics in the decision support system are also evaluated.

For the decision support system developed in the study, demographic characteristics are defined as indispensable criteria or a preferable criterion according to the job position. Thus, by considering the demographic characteristics required from the employees, their positions in the work place can be reassessed. All criteria used for decision support system is shown in the following Table 2.

**Table 1.** Evaluation of employees according to the criteria and development program to be implemented.

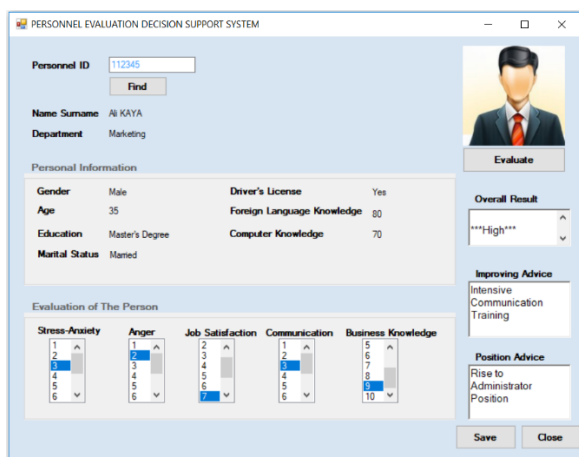
No	Stress & Anxiety	Anger	Job Satisfaction	Communication	Business Knowledge	Result	Action
1	High	High	Medium	Low	Low	Very Low	No operation (Very Bad)
2	Medium	High	High	Low	Medium	Low	Intense Anger and communication, medium business knowledge
3	High	High	Medium	Medium	Medium	Low	Intense Stress and Intense Anger Training
4	High	Low	High	High	Medium	Medium	Intense Stress and Medium Business Knowledge Training
5	Low	Medium	Low	Medium	High	Medium	Organizing Business Conditions
6	Low	Low	Medium	Low	High	High	Intense Communication Training
7	Low	Medium	High	High	High	Very High	No operation (Very Good)



**Table 2.** Criteria used for decision support system.

Features	Performance Scales	Measurement Value
<b>Psychological</b>	Stress and Anxiety	Fuzzy Categorical (Low, Medium, High)
	Anger	Fuzzy Categorical (Low, Medium, High)
	Job Satisfaction	Fuzzy Categorical (Low, Medium, High)
	Business Knowledge	Fuzzy Categorical (Low, Medium, High)
	Communication Skill	Fuzzy Categorical (Low, Medium, High)
<b>Demographic</b>	Gender	Binary (Men, Women)
	Age	Categorical (18-25, 26-35, 36-45, 46-55, 56-70)
	Educational Level	Categorical (High School, Bachelor's, Master's, Doctorate)
	Marital Status	Binary (Single, Married)
	Driving License	Binary (Yes, No)
	Military Service	Binary (Related, No Connection)
	Language Skill	Categorical (0-20, 21-40, 41-60, 61-80, 81-100)
	Computer Skill	Categorical (0-20, 21-40, 41-60, 61-80, 81-100)

The user interface of the developed application is shown in Figure 6. Here; Questioning by ID number, the department where employees work and demographic characteristics are displayed. In the interface, the assessment of employee no.6 is presented in Table 1. In the third part of the study, the results of tests conducted according to the detailed performance criteria are entered in scale 1-10. After clicking “Evaluate” button, first of all, the assessment is performed between the ranges of Very Low - Very High related to the overall result of the employee that has mamdani output (Overall Result). In addition, according to the employee's information, advice of the programs that can be applied for personnel development (Improving Advice) and advice of the position change (lower level, promotion, management position, etc.) (Position Advice) that may be in the institution, if any, is given.



**Figure 6.** The User interface.

## 6. Conclusion and Discussion

In this study, a decision support system has been developed in order to assist managers in their decision-making during the job placement and development processes of the employees. This system has two stages; at the first stage, the employees were evaluated in terms of the performance criteria determined in the third part, which are “stress and anxiety”, “anger”, “job satisfaction”, “communication”. In addition, for “business knowledge” criteria, occupational success levels of individuals are determined in the range of 1-10 points by applying a test with professional questions appropriate to their work areas. With the developed fuzzy expert system, the crisp values obtained from these tests are blurred in three categories as “low”, “medium” and “high”. And this way, according to these criteria, a status detection is performed for each employee at five different levels: “very low”, “low”, “medium”, “high”, “very high”.

At the second stage, a decision support system is applied in which the people’s demographic characteristics are assessed in order to assign the most appropriate person to a job position or determine if the existing employees are suitable for their jobs and also plan appropriate individual development programs for the employee. The compliance of the characteristics such as gender, age, education level, computer skills, and years of work with the job position is evaluated.

Finally, considering both stages and the demographic characteristics of the personnel who is in a bad position both psychologically and professionally, his compliance with the job can be assessed and he can be left out of the staff before any investment is made. On the other hand, a better level



can be achieved with the related training and development methods which will be applied to the personnel at a low, medium and high level psychologically and professionally. The personnel in the best status in terms of all characteristics can be promoted to a manager position or they can be considered as ready to take additional responsibility.

With the system developed in the study, it will be possible to plan the development activities in accordance with the needs and status of each personnel and to obtain maximum efficiency and work performance with less cost and time. In addition, the employees who need to be dismissed are determined and it's provided that the most appropriate employees are chosen for the job positions. The advantage of other studies is that the effects of

psychological factors on employees are included in the decision support system.

Finally, the outputs of the developed system are compared with the opinions of an expert team consisting of a senior executive, a department manager and a psychologist and the success of the system has been %100 confirmed by experts.

### Statement of Research and Publication Ethics

The study is complied with research and publication ethics.

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