

ISSN 2146-7390

# The Online Journal of Science and Technology

# Volume 6 Issue 1 January 2016

Prof. Dr. Aytekin İşman Editor-in-Chief

Prof. Dr. Mustafa Şahin Dündar Editor

> Hüseyin Eski Technical Editor



www.tojsat.net January 2016



# Copyright © 2016 - THE ONLINE JOURNAL OF SCIENCE AND TECHNOLOGY

All rights reserved. No part of TOJSAT's articles may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher.

Published in TURKEY

### **Contact Address:**

Prof. Dr. Mustafa Şahin Dündar - TOJSAT, Editor Sakarya-Turkey



# Message from the Editor-in-Chief

# Dear Colleagues,

TOJSAT welcomes you. TOJSAT would like to thank you for your online journal interest. The online journal system has been diffused very fast for last 5 years. TOJSAT has continued to diffuse new trends in science and technology to all over the world since January, 2011. We hope that the volume 6, issue 1 will also successfully accomplish our global science and technology goal.

TOJDEL is confident that readers will learn and get different aspects on technology and science. Any views expressed in this publication are the views of the authors and are not the views of the Editor and TOJSAT.

TOJSAT thanks and appreciate all reviwers who have acted as reviewers for one or more submissions of this issue for their valuable contributions.

TOJSAT, TASET, Governor State University, Vienna University of Technology & Sakarya University will organize the ISTEC-2016 (www.iste-c.net) between July 13-15, 2016 in Vienna, Austria. For any suggestions and comments on the international online journal TOJSAT, please do not hesitate to send mail.

# **Call for Papers**

TOJSAT invites you article contributions. Submitted articles should be about all aspects of science and technology. The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to TOJSAT. Manuscripts must be submitted in English.

TOJSAT is guided by it's editors, guest editors and advisory boards. If you are interested in contributing to TOJSAT as an author, guest editor or reviewer, please send your cv to tojsat.editor@gmail.com.

January 01, 2016

# Prof. Dr. Aytekin ISMAN

Sakarya University



# Letter from the Editor

# Dear Friends,

TOJSAT becomes a valuable journal day by day. It consists of new trends in science and technology to all over the world since January, 2011. The volume 6 of the journal will also successfully accomplish our global science and technology goal. Any views expressed in this publication are the views of the authors and are not the views of the Editor and TOJSAT.

TOJSAT thanks and appreciate all reviwers who have acted as reviewers for one or more submissions of this issue for their valuable contributions.

TOJSAT, TASET, Governor State University, Vienna University of Technology & Sakarya University will organize the ISTEC-2016 (www.iste-c.net) between July 13-15, 2016 in Vienna, Austria.

January 01, 2016 Prof. Dr. Mustafa S. DUNDAR Sakarya University



# Editor-in-Chief

Prof. Dr. Aytekin İŞMAN - Sakarya University, Turkey

# Editor

Prof. Dr. Mustafa Şahin DÜNDAR - Sakarya University, Turkey

# **Technical Editor**

Hüseyin Eski, Sakarya University, Turkey

# **Editorial Board**

Abdülkadir MASKAN, Dicle University, Turkey	M. Şahin DÜNDAR, Sakarya University, Turkey
Ahmet AKSOY, Erciyes University, Turkey	Mehmet Ali YALÇIN, Sakarya University, Turkey
Ahmet APAY, Sakarya University, Turkey	Mehmet BAYRAK, Sakarya University, Turkey
Ahmet BİÇER, Gazi University, Turkey	Mehmet CAGLAR, Eastern Mediterranean University,
Ahmet ÖZEL, Sakarya University, Turkey	TRNC
Ahmet Zeki SAKA, Karadeneniz Technical University,	Mehmet TURKER, Gazi University, Turkey
Turkey	Mehmet YILMAZ, Gazi University, Turkey
Ali ÇORUH, Sakarya University, Turkey	Melek MASAL, Sakarya University, Turkey
Ali DEMIRSOY, Hacettepe University, Turkey	Metin BAŞARIR, Sakarya University, Turkey
Ali Ekrem OZKUL, Anadolu University, Turkey	Moinuddin Sarker, MCIC, USA
Ali GUL, Gazi University, Turkey	Moinuddin Sarker, Natural State Research, Inc., USA
Ali GUNYAKTI, Eastern Mediterranean University,	Muhammed JAVED, Islamia University of
TRNC	Bahawalpur, Pakistan
Alparslan FIGLALI, Kocaeli University, Turkey	Muharrem TOSUN, Sakarya University, Turkey
Antonis LIONARAKIS, Hellenic Open University,	Murat DIKER, Hacettepe University, Turkey
Greece	Murat TOSUN, Sakarya University, Turkey
Arif ALTUN, Hacettepe University, Turkey	Mustafa BÖYÜKATA, Bozok University, Turkey
Atilla YILMAZ, Hacettepe University, Turkey	Mustafa DEMİR, Sakarya University, Turkey Mustafa
Aydın Ziya OZGUR, Anadolu University, Turkey	GAZI, Eastern Mediterranean University, TRNC
Bekir SALIH, Hacettepe University, Turkey	Mustafa GAZİ, Near East University, TRNC
Belma ASLIM, Gazi University, Turkey	Mustafa GUL, Turkey
Bensafi Abd-El-Hamid, Abou Bekr Belkaid University	Mustafa KALKAN, Dokuz Eylul Universiy, Turkey
of Tlemcen, Algeria.	Mustafa YILMAZLAR, Sakarya University, Turkey Nabi
Berrin ÖZÇELİK, Gazi University	Bux JUMANI, Allama Iqbal Open University, Pakistan.
Bilal GÜNEŞ, Gazi University, Turkey	Nilgun TOSUN, Trakya Üniversitesi, Turkey Nureddin
Bilal TOKLU, Gazi University, Turkey	KIRKAVAK, Eastern Mediterranean University, TRNC
Burhan TURKSEN, TOBB University of Economics and	Nursen SUCSUZ, Trakya Üniversitesi, Turkey
Technology, Turkey	Oğuz SERİN, Cyprus International University, TRNC
Cafer CELIK, Ataturk University, Turkey	Orhan ARSLAN, Gazi University, Turkey
Can KURNAZ, Sakarya University, Turkey	Orhan TORKUL, Sakarya University, Turkey
Canan LACIN SIMSEK, Sakarya University, Turkey	Osman ÇEREZCİ, Sakarya University, Turkey
Cüneyt BİRKÖK, Sakarya University, Turkey	Phaik Kin, CHEAH Universiti Tunku Abdul Rahman,
Elnaz ZAHED, University of Waterloo, UAE	Malaysia
Emine Sercen DARCIN, Sakarya University, Turkey	
Eralp ALTUN, Ege University, Turkey	
Ercan MASAL, Sakarya University, Turkey	
Ergun KASAP, Gazi University, Turkey	
Ergun YOLCU, Istanbul University, Turkey	



Fatime Balkan KIYICI, Sakarya University, Turkey Piotr S. Tomski, Czestochowa University of Fatma AYAZ, Gazi University, Turkey Technology, Poland Fatma ÜNAL, Gazi University, Turkey Rahmi KARAKUŞ, Sakarya University, Turkey Galip AKAYDIN, Hacettepe University, Turkey Ratnakar Josyula, Yale University school of medicine, Gilbert Mbotho MASITSA, Universirty of The Free New Haven, USA State - South Africa Ratnakar JOSYULA, Yale University, USA Gregory ALEXANDER, Universirty of The Free State -Recai COŞKUN, Sakarya University, Turkey Recep ILERI, Bursa Orhangazi University, Turkey South Africa Gülay BİRKÖK, Gebze Institute of Technology, Turkey Rifat EFE, Dicle University, Turkey Gürer BUDAK, Gazi University, Turkey Ridvan KARAPINAR, Yüzüncü Yıl University, Turkey Harun TAŞKIN, Sakarya University, Turkey Sanjeev Kumar SRIVASTAVA, Mitchell Cancer Hasan DEMIREL, Eastern Mediterranean University, Institute,USA TRNC Seçil KAYA, Anadolu University, Turkey Hasan Hüseyin ONDER, Gazi University, Turkey Selahattin GÖNEN, Dicle University, Turkey Hasan KIRMIZIBEKMEZ, Yeditepe University, Turkey Senay CETINUS, Cumhuriyet University, Turkey Hasan OKUYUCU, Gazi University, Turkey Serap OZBAS, Near East University, North Cyprus Hayrettin EVIRGEN, Sakarya University, Turkey Sevgi AKAYDIN, Gazi University, Turkey Hikmet AYBAR, Eastern Mediterranean University, Sevgi BAYARI, Hacettepe University, Turkey TRNC Sukumar SENTHILKUMAR, South Korea Hüseyin EKİZ, Sakarya University, Turkey Süleyman ÖZÇELİK, Gazi University, Turkey Hüseyin Murat TÜTÜNCÜ, Sakarya University, Turkey Şenol BEŞOLUK, Sakarya University, Turkey Hüseyin ÖZKAN, Sakarya University, Turkey Tuncay ÇAYKARA, Gazi University, Turkey Hüseyin YARATAN, Eastern Mediterranean Türkay DERELI, Gaziantep University, Turkey University, TRNC Uner KAYABAS, Inonu University, Turkey Iman OSTA, Lebanese American Universiy, Lebanon Ümit KOCABIÇAK, Sakarya University, Turkey Işık AYBAY, Eastern Mediterranean University, TRNC Vahdettin SEVİNÇ, Sakarya University, Turkey İbrahim OKUR, Sakarya University, Turkey Vasudeo Zambare, South Dakota School of Mines İlyas ÖZTÜRK, Sakarya University, Turkey and Technology, USA İsmail Hakkı CEDİMOĞLU, Sakarya University, Turkey Veli CELIK, Kırıkkale University, Turkey İsmail ÖNDER, Sakarya University, Turkey Yusuf ATALAY, Sakarya University, Turkey Kenan OLGUN, Sakarya University, Turkey Yusuf KALENDER, Gazi University, Turkey Kenan OLGUN, Sakarya University, Turkey Yusuf KARAKUŞ, Sakarya University, Turkey Yüksel GÜÇLÜ, Sakarya University, Turkey Latif KURT, Ankara University, Turkey Levent AKSU, Gazi University, Turkey Zawawi Bin Daud, Universiti Tun Hussein Onn Zekai SEN, Istanbul Technical University, Turkey Malaysia, Malaysia



Table of Contents	
AN APPLICATION OF ENVIRONMENTAL ECONOMIC DISPATCH USING GENETIC ALGORITHM	1
Özge Pınar ARSLAN, Yağmur ARIKAN, Ertuğrul ÇAM, İbrahim EKE	
ANALYZING EFFICIENCIES AND TOTAL FACTOR PRODUCTIVITIES OF STAR ALLIANCE MEMBER AIRLINES	5
Yağmur ÖZ, Can Deniz KÖKSAL	
DESIGNING AND IMPLEMENTATION OF AN EXPERT SYSTEM TO BE USED TO DETERMINE THE BODY SIZE	13
Hakan YÜKSEL, Mehmet DAYIK, Oğuz ÇOLAK	
FRENCH MANDATORY EDUCATION: THE CASE OF SANJAK (HATAY) (1920-1939)	18
Yusuf KODAZ	
INVESTIGATION OF BEHAVIOR OF STRUCTURES ACCORDING TO DIFFERENT LOCAL SITE CLASSES FOR L TYPE REINFORCED CONCRETE FRAME BUILDING HAVING A1 AND A3 IRREGULARITIES	21
Rıfat SEZER, Ceyhun AKSOYLU, Nail KARA	
INVESTIGATION OF THE EFFECTS OF CONVENTIONAL AND WIPER COATED CARBIDE TOOLS WITH DRY CUTTING ON CUTTING FORCES, SURFACE ROUGHNESS, AND MATERIAL HARDNEES IN TURNING 17-4 PH STAINLESS STEEL	33
Mustafa AY, Gültekin BASMACI	
MACWILLIAMS IDENTITIES OF LINEAR CODES OVER THE RING	40
Mehmet ÖZEN and Fatma Zehra UZEKMEK	
PROCESS IMPROVEMENT: AN APPLICATION AT GAZIOSMANPAŞA UNIVERSITY	45
Münevver Çiçekdağı, Kadir Ardıç	
RAISING SOCIALLY RESPONSIBLE INDIVIDUALS: MONTESSORI EDUCATION MODEL	59
Figen GÜLEŞ	
STRATEGIC MANAGEMENT GUIDANCE IN HEALTH INSTITUTIONS MANAGEMENT: DETERMINATION OF MISSIONVISION-STRATEGY SELCUK UNIVERSITY MEDICAL FACULTY HOSPITAL SAMPLE	63
Hakkı GÖKBEL, Hasan Kürşat GÜLEŞ, Zeynep ERGEN IŞIKLAR, Tuğba ŞENER	
THE INVESTIGATION OF THE RELATION BETWEEN NDVI IMAGE AND FOREST MANAGEMENT-SITE INDEX DATA, THE CASE OF BARTIN REGION OF FORESTRY, TURKEY	71

Ayhan Atesoglu, Metin Tunay, Hüseyin Simsek



THE ISSUE OF COSTS IN TEACHING ECONOMIC COURSES IN INFORMATICS	77
Mária Ďurišová, Alžbeta Kucharčíková	
USE OF PARTICIPATORY METHODS IN TEACHING AT THE UNIVERSITY	82
Alžbeta Kucharčíková, Emese Tokarčíková	
WASTEWATER TREATMENT BY ELECTRODIALYSIS SYSTEM AND FOULING PROBLEMS	91
Elif OZTEKIN, Sureyya ALTIN	



# AN APPLICATION OF ENVIRONMENTAL ECONOMIC DISPATCH USING GENETIC ALGORITHM

Özge Pınar ARSLAN Kırıkkale University Electrical and Electronics Engineering Kırıkkale, Turkey pozge.arslan@gmail.com Yağmur ARIKAN Kırıkkale University Electrical and Electronics Engineering Kırıkkale, Turkey yagmurarikan@gmail.com Ertuğrul ÇAM Kırıkkale University Electrical and Electronics Engineering Kırıkkale, Turkey camertugrul@gmail.com İbrahim EKE Kırıkkale University Electrical and Electronics Engineering Kırıkkale, Turkey eke@kku.edu.tr

**Abstract:** In the economic load dispatch, power plants are operated at minimum cost, but environmental pollution caused by fossil-fueled electric power plants is not considered. Therefore, new solution suggestions have come up due to the growing environmental problems in recent years. One of these suggestions is environmental economic load dispatch which aims to both operations of plants at minimum cost and trying to minimize the amount of emissions. In this study, 6-generator system with three load demands 500, 700 and 900 MW is tested to solve environmental economic load dispatch problem. Genetic algorithm from heuristic optimization methods is preferred for this problem. The results which transmission losses are considered are compared with the other studies in the literature. These results show the effectiveness and superiority of the method over economy and reduction of the emission.

Keywords: Environmental Economic Dispatch, Genetic Algorithm, Optimization, Emission.

# Introduction

Economic load dispatch is one of the important problems in operation of power systems. It minimizes the generation cost while meeting demand and satisfying equality and inequality constraints. However, operation at minimum cost cannot be the only basis for dispatching electric load when the pollution is considered. Thermal power plants cause high concentration of pollutants. Therefore, emissions caused by electric power plants that use fossil fuel must be considered while operating electric power systems. Environmental economic dispatch, (EED), is the problem which takes into consideration the environmental pollution and aims to reduce emissions with minimum cost. It minimizes both cost and emission together.

EED problem has two objectives consisting of minimum fuel cost and minimum emission. There are many methods that have been proposed to solve this problem in the literature. Song et al. have applied fuzzy logic controlled genetic algorithm to EED on a six-generator system (Song, 1997). Pandit et al. have proposed an improved differential evolution method for EED in multi-area power system by studying on three test cases (Pandit, 2015). Sivasubramani and Swarup have presented a new multi-objective harmony search algorithm for EED problem and tested on the standard IEEE 30 bus and 118 bus systems (Sivasubramani, 2011). Güvenç et al. have proposed Gravitational Search Algorithm to find the optimal solution for Combined Economic and Emission Dispatch problems and it has been implemented on four different test cases, having no valve point effect without transmission loss and valve point affect with transmission loss (Güvenç, 2012). Bhattacharya and Chattopadhyay have presented the combination of Biogeography-based Optimization algorithm and differential evolution to solve complex economic emission load dispatch problems (Bhattacharya, 2011).

# **Problem Formulation**

EED problem can be formulated by adding emission to the economic dispatch problem. Economic dispatch, (ED), formula is shown in Equation 1.

$$F(P_g) = \sum_{i=1}^n (a_i P_i^2 + b_i P_i + c_i)$$
(1)

In Equation 1,  $a_i$ ,  $b_i$ ,  $c_i$  are the fuel cost coefficients of the ith unit,  $F(P_g)$  is total generation cost in the system (\$/h),  $P_i$  is the power generated by ith unit and the n is the number of generating units.

Emissions can be expressed by a quadratic equation depending on the active power output of the generator. It can be formulated as Equation 2.

$$E(P_g) = \sum_{i=1}^n (d_i P_i^2 + e_i P_i + f_i)$$
(2)



In Equation 2,  $E(P_q)$  is the emission amount (lb/h or kg/h), d<sub>i</sub>, e<sub>i</sub>, f<sub>i</sub> are the emission parameters of the ith power plant.

While solving the problem, the following constraints must be satisfied.

Power Balance: The sum of the generated powers must be equal to sum of the total transmission loss and power demand.

 $\sum_{i=1}^{n} P_i = P_D + P_L$ (5) In equation 3,  $P_D$  is the demanded power and  $P_L$  is the line loss. The line loss can be found by busing B matrix and it can be expressed as (4).

$$P_L = \sum_{i=1}^n \sum_{j=1}^n P_i B_{ij} P_j \tag{4}$$

where  $B_{ii}$  is the loss coefficients.

Generator lower and upper constraint: The active power limitation of each unit is defined as follows.

$$P_{i(min)} \le P_i \le P_{i(max)} \qquad \qquad i = 1, \dots, n_g \tag{5}$$

where  $P_{i(min)}$  is the minimum power generated by ith unit and  $P_{i(max)}$  is the maximum power generated by ith unit.

EED can be formulated by using generation cost and amount of emission and converting them into the single optimization problem as seen in Equation 6.

$$T = w1 * F(P_g) + w2 * h * E(P_g)$$
(6)

In Equation 6, T is the total operation cost of the system, w1 and w2 are weight factor and h is the price penalty factor.

The price penalty factor h has some steps (Kulkarni, 2000):

(i) Firstly, h<sub>i</sub> is calculated:

$$h_{i} = \frac{FC_{i}(P_{i}(max))/(P_{i}(max))}{EC_{i}(P_{i}(max))/(P_{i}(max))}, \qquad i = 1, \dots, n \dots \$/kg$$
(7)

(ii) Secondly, arrange the values of h<sub>i</sub> in ascending order.

(iii) Thirdly, add the maximum capacity of each generator one at a time starting from the smallest  $h_i$  until  $\sum_{i=1}^{n} P_{i(max)} \ge P_D.$ 

(iv) And finally, h<sub>i</sub> calculated from last generator becomes the price penalty factor h.

When  $w_{1=1}$  and  $w_{2=0}$ , the problem becomes ED; when  $w_{1=0}$  and  $w_{2=1}$ , the problem becomes emission dispatch; when w1=1 and w2=1, the problem becomes EED.



# **Genetic Algorithm**

A genetic algorithm (GA) is a method for optimization problems and it solves both constrained and unconstrained problems. It is based on a natural selection process. The algorithm repeatedly develops a population of individual solutions. This method randomly selects individuals from the current population and produce the children for the next generation. The population move to an optimal solution over successive generations.

The genetic algorithm uses three operators to generate the next generation from the current population. These operators are selection, crossover and mutation. The individuals named as parents are selected. Crossover combines two parents to form children for the next generation. Random changes are applied to individual parents to form children by mutation.

# The Study

GA is applied on the test system and its performance is compared to other optimization methods. In the system, there are 6 generating units which have cost and emission functions with demand of 500, 700 and 900 MW. The data of this system is derived from study of Rughooputh (Rughooputh, 2003).

The value of h is calculated as 43.8983 for 500 MW demand, 47.8222 for 700 MW demand, and 43.1533 for 900 MW demand.

EED problem is solved by using GA with the help of MATLAB program. The dispatch results for 500, 700, and 900 MW demands are shown separately, see [Table 1].

Table 1. Results of LED problem by GA							
	Demand (MW)						
Unit (MW)	500	700	900				
P1 (MW)	55.3071	93.4380	123.2889				
P2 (MW)	40.1529	66.9674	116.2879				
P3 (MW)	66.5698	82.2116	98.4371				
P4 (MW)	80.2377	111.7986	134.9396				
P5 (MW)	147.4310	204.2191	263.0380				
P6 (MW)	132.9505	179.6866	228.3156				
Total generation (MW)	522.6490	738.3213	964.3011				
Losses (MW)	22.6491	38.3213	64.3011				
Fuel cost (Rs/h)	28475	39008	51139				
Emission output (kg/h)	277.4178	472.5402	764.2358				

Table 1: Results of EED problem	by GA
---------------------------------	-------

According to results of EED for the system that has 6 generating units by using genetic algorithm; fuel cost is 28475 Rs/h, emission output is 277.4178 kg/h, transmission loss is 22.6491 MW for 500 MW load; fuel cost is 39008 Rs/h, emission output is 472.5402, transmission loss is 38.3213 MW for 700 MW load; fuel cost is 51139 Rs/h, emission output is 764.2358, transmission loss is 64.3011 for 900 MW load.

The results of GA are compared with other methods. These methods are Newton-Raphson, (NR), (Song, 1997), Fuzzy Controlled Genetic Algorithm, (FCGA), (Song, 1997), Biogeography based Optimization, (BBO), (Roy, 2010), and Non-dominated Sorting Genetic Algorithm, (NSGA), (Roy, 2010). The comparison results are showed, see [Table 2]. It is explicitly seen from Table 2 that GA is the best method in terms of emission output.

Table 2: Results of EED problem by methods						
Load	Method	Total Cost (Rs/h)	Amount of			
(MW)			Emission (kg/h)			
500	GA	28475	277.4178			
	NR [1]	28550.15	312.513			
	FCGA [1]	28231.06	304.90			
	NSGA [8]	28291.119	284.362			
	BBO [8]	28318.5060	279.3092			
700	GA	39008	472.5402			
	NR [1]	39070.74	528.447			
	FCGA [1]	38408.82	527.46			
	NSGA [8]	38671.813	484.931			
	BBO [8]	38828.266	476.408			



900	GA	51139	764.2358
	NR [1]	50807.24	864.060
	FCGA [1]	49674.28	850.29
	NSGA [8]	50126.059	784.696
	BBO [8]	50297.271	765.087

# Conclusions

Power systems have some serious environmental problems. EED problem aims to decrease fuel cost and also emission. In this paper, GA has been successfully applied to EED problem. It is tested on six generator system. The results of GA is compared with the other studies in the literature. It has seen that GA provides improved results at cost and emission output.

# References

- Bhattacharya A. & Chattopadhyay P.K. (2011). Solving economic emission load dispatch problems using hybrid differential evolution. (pp.2526-2537). Applied Soft Computing 11.
- Güvenç U., Sönmez Y., Duman S., & Yörükeren N. (2012). Combined economic and emission dispatch solution gravitational search algorithm (pp.1754-1762). Scientia Irenica, Transactions D: Computer Science & Engineering and Electrical Engineering 19(6).
- Kulkarni P.S., Kothari A.G., & Kothari D.P. (2000). Combined economic and emission dispatch using improved backpropagation neural network (pp.31-44). Electr. Power Compon. Sys. 28.
- Pandit M., Srivastava L., & Sharma M. (2015). Environmental economic dispatch in multi-area power system employing improved differential evolution with fuzzy selection. (pp.498-510). Applied Soft Computing 28.
- Roy P.K., Ghoshal S.P., & Thakur S.S (2010). Combined economic and emission dispatch problems using biogeography-based optimization. (pp. 173-184). Electr. Eng 92.
- Rughooputh H.C.S., & Ah King R.T.F. (2003). *Environmental/economic dispatch of thermal units using an elitist multiobjective evolutionary algorithm* (pp. 48-53). ICIT Maribor, Slovenia, IEEE conference.
- Sivasubramani S. & Swarup K.S. (2011). *Environmental/economic dispatch using multi-objective harmony search algorithm* (pp. 1778-1785). Electric Power Systems Research 81.
- Song Y.H., Wang G.S., Wang P.Y., & Johns A.T. (1997). Environmental/economic dispatch using fuzzy logic controlled genetic algorithms (pp. 377-382). IEE Proc. Gener. Transm. Distrib. 144(4).



# ANALYZING EFFICIENCIES AND TOTAL FACTOR PRODUCTIVITIES OF STAR ALLIANCE MEMBER AIRLINES

Yağmur ÖZ, Can Deniz KÖKSAL

Akdeniz University, Faculty of Economics and Administrative Sciences Department of Business Antalya – TURKEY

yagmuroz@akdeniz.edu.tr, candeniz@akdeniz.edu.tr

**Abstract:** Comparing the efficiency levels and productivities of domestic and international airline companies is an active research area in services sector and has lots of interests in business administration field. In this study, Data Envelopment Analysis and Total Factor Productivity Analysis are used to compare the efficiencies and productivities of Star Alliance member international airline companies. Eight variables, including both inputs and outputs named as Number of Annual Passengers, Daily Departures, Number of Countries Served, Number of Airports Served, Revenue Passenger (Km), Sales Revenue (\$), Number of Employees and Fleet of 26 airline companies are taken place in analysis for the years 2013 and 2014. Because of price differences in access the resources of services and goods that the companies used, the Variable Returns to Scale Method of Data Envelopment Analysis is used instead of Constant Returns to Scale Method to figure out efficiencies in years. Results show that there are differences in efficiencies and productivities of airline companies by the means of using their inputs to produce outputs while some of them are wasting their resource and some others are not.

Keywords: Airlines, Total Factor

# Introduction

Efficiency in the services sectors is getting much more significant issue in global trade year by year. As one of the most and rapid growing establishments in global service sector, the domestic and international airline companies have the pioneering role as in Turkey and in the world. Airline companies which are operated singular or operated as the member of an alliance group still are in the competition in locally and globally. The growing demand to this service sector creates the difficulties and makes the expenses of operating facilities higher under the competitive stress. Therefore, yearly and continuously, the efficiencies of these companies have growing importance by investors, creditors, business partners, and the governments. It is also have great importance from the view point of the airline's management, so they can gauge their own performance and compare it against other airline companies. Operated domestic or/and international, it is the responsibility of every organization to allocate, monitor and evaluate their annual expenditure and service delivery.

For this reason, in this study, Data Envelopment Analysis (DEA) and Total Factor Productivity Index (TFPI) are the generating mechanisms for efficiency scores and methodology for seeking sources of inefficiency of each and following operating year. Numerous studies have adopted DEA technique in the field of airline operations, mainly focusing on airline management and airport operation (Chiou and Chen, 2006). The main reason to select DEA technique is that it is easily applicable in many situations where the inputs and outputs cannot be converted to a common scale, as is the case here (Barros and Peypoch, 2009). And as a computational detail, the Variable Returns to Scale (VRS) Method of Data Envelopment Analysis is used instead of Constant Returns to Scale (CRS) Method to figure out efficiencies in years, because of price differences in access the resources of services and goods that the companies used. This study aims to identify the inputs which are used inefficient by the inefficient airlines and to advice them how to be efficient by adopting the scales of efficient airlines. The structure of the study is organized as follows: Airline Industry as an Alliance, Literature Survey, Data Envelopment Analysis for Efficiency Measurement, Theoretical Model, Data and Results, Conclusion and References.

# The Study

**Airline Industry as an Alliance:** Domestic and International passenger airlines are a critical mode of transportation and play an important role in modern society. As an alliance within the concept of airline industry, the Star Alliance network is the leading global airline network, with the highest number of member airlines, daily flights, destinations and countries flown to. It was established in 1997 as the first truly global airline alliance to offer customers convenient worldwide reach and a smoother travel experience. In 1997, a group of five world-class airlines united to create something never seen before - an alliance that brings together networks, lounge



access, check-in services, ticketing and dozens of other services to improve the travel experience for customers, wherever they are in the world. Star Alliance Services GmbH was created to manage the Star Alliance network on behalf of its members. It was the first alliance in the world to create this type of organization. The team is based in Frankfurt, Germany and is made up of around 70 employees from over 20 different countries. Having the mission of "Executing leadership in managing a portfolio of alliance products and services using an agreed process" Star Alliance member airlines fly to more destinations than any other airline alliance in the world – which means easier travel and quicker connections. The main goal has always been to make your travel experience smoother. To achieve this, Star Alliance member airlines are located closer together in airports and connections teams are installed for faster transfers. Common airport facilities, coordinating schedules and a range of new technologies are also frequently introduced.

The member airlines of the Star Alliance network are among the most respected in the world. In order to become members, all airlines must comply with the highest industry standards of customer service, security and technical infrastructure. Together, they offer convenient and comfortable travel to almost any destination in the world. Its acceptance by the market has been recognized by numerous awards, including the Air Transport World Market Leadership Award and Best Airline Alliance by both Business Traveller Magazine and Skytrax. The member airlines are: Adria Airways, Aegean Airlines, Air Canada, Air China, Air India, Air New Zealand, ANA, Asiana Airlines, Austrian, Avianca, Avianca in Brazil, Brussels Airlines, Copa Airlines, Croatia Airlines, EGYPTAIR, Ethiopian Airlines, EVA Air, LOT Polish Airlines, Lufthansa, Scandinavian Airlines, Shenzhen Airlines, Singapore Airlines, South African Airways, SWISS, TAP Portugal, Turkish Airlines, THAI and United (http://www.staralliance.com/en/about/organisation).

Total revenue	179.05 BUSD		Revenue Passenger Km	1,364.83 bn	
Daily departures	More than 18.500		Annual Passengers	641.10 m	
Countries served	192		Number of employees	432,603	
Airports served	1330		Fleet (Number of Aircraft)	4,657	
Lounges More than 1000					

**Table-1:** Some Statistical Figures of Star Alliance as Combined by the End of 2014

Source: http://www.staralliance.com/en/about/member\_airlines/

Literature Survey Related with the Airline Industry Efficiencies: Up to now, many studies on Airline Industry have been conducted and published with academic purposes. Some most recent of them published by the year 2010 are listed as given chronological order including author, number of Decision Making Units (DMU's), study periods, methodology used, remarks and focuses: Hong and Zhang (2010): 29 international airlines, 1998-02, Standard DEA, Airlines with high share of cargo business are significantly more efficient. Merkert and Hensher (2011): 58 international airlines, 2007-09, Standard DEA and Bootstrapped Tobit Regression, Size of airlines and fleet mix decisions have an impact on technical efficiency. Zhu (2011): 21 US airlines, 2007-08, Two-stage network DEA Multi-stage network DEA models provide deeper insight into functioning of an airline. Assaf and Josiassen (2012): 31 European and US airlines, 2001-08, Bayesian Distance Frontier Model, European airlines have slightly higher efficiency and productivity growth than US airlines. Barros and Couto (2013): 23 European airlines, 2000-11, Luenberger Productivity Index and Malmquist Productivity Index, Managerial causes of technical efficiency may be due to variations in the strategies adopted by the different airlines. Barros et al. (2013): 10 US airlines, 1998-10, B-convex Model, Efficiency can be influenced by the size of the airline, mergers, and acquisitions. Choi et al. (2013): 12 US airlines, 2008-11, Service quality-adjusted DEA and Mann-Whitney test, SQ-DEA places a greater emphasis on service quality as a factor that relates to service productivity. Airlines can overcome the tradeoff between quality and productivity. Arjomandi and Seufert (2014): 48 international airlines, 2007-10, Bootstrapped DEA, Low-cost carriers are operating under increasing returns to scale. Tavassoli et al. (2014): 11 Middle Eastern airlines, 2010, Slacks-Based Measure (SBM), network DEA Deals with shared inputs and outputs with selected weights. Wu and Liao (2014): 38 international airlines, 2010, Standard DEA and Balance Score Card (BSC), Leading and lagging factors of BSC were adapted to the evaluation of operational performance of airlines along with DEA. Chang et al. (2014): 27 international airlines, 2010, Slacks-Based Measure (SBM), DEA Tradeoffs between labor and capital measures poses a challenge. Fuel consumption and revenue structure are major causes of inefficient airlines. Lee and Worthington (2014): 42 US and European airlines, 2001-05, Bootstrapped DEA and Bootstrapped Truncated Regression, DEA scores are estimated simultaneously with a bootstrapped



truncated regression model to explain efficiency drivers. Large airlines need to significantly reorganize and rescale their operations to remain competitive. Lu et al. (2014): 30 US airlines, 2010, Two-stage network DEA, Two-stage network model examines production and marketing efficiencies.

**Data Envelopment Analysis for Efficiency Measurement:** The technique, which is referred to as DEA, is able to compare the efficiency of multiple service units that provide similar services by considering their use of multiple inputs and to produce multiple outputs (Bosetti, Cassinelli & Lanza, 2003). Besides being more comprehensive and reliable than a set of operating ratios or profit measures, the DEA measure has the ability to incorporate multiple inputs and multiple outputs into both the numerator and denominator of the efficiency ratio without the need for converting to a common scale basis (Fitzsimmons & Fitzsimmons, 1998).

DEA is a linear programming model that attempts to maximize a service unit's efficiency with the performance of a group of similar service units that are delivering the same service. In the process, some units achieve 100% efficiency and are referred to as the relatively efficient units, whereas other units with efficiency scores of less than 100% are referred to as inefficient ones (Norman & Stoker, 1991). Efficiency is defined as the ratio of weighted sum of outputs to weighted sum of inputs in the model and components of this model can be explained as follows (Metters, Frei & Vargas, 1999):

Efficiency = Weighted Sum of Outputs / Weighted Sum of Inputs Efficiency of Unit ( j ) =  $(u_1.y_{1j} + u_2.y_{2j} + ...) / (v_1.x_1j + v_2.x_2j + ...)$ Variables in equation indicate;  $u_1$  = weight of output i  $y_{1j}$  = quantity of output-1 derived from unit j  $v_1$  = weight of input j  $x_{1j}$  = quantity of input-1 used by unit j

An efficiency model simplified as the above equation can be solved as a Linear Program by means of the following maximization approach (Yolalan, 1993).

DEA evaluates the relative efficiency of organizational units, called decision making units (DMUs), with multiple inputs and outputs (Charnes et al., 1978). DEA is a linear programming based non-parametric methodology and treats each DMU as a black box, focusing entirely on the DMU's inputs, outputs, and its relative efficiency. Each DMU converts a specific level of each input into a specific level of output under appropriate assumptions. The two main DEA model assumptions are model orientation and returns-to-scale (Charnes et al., 1994; Cook et al., 2014). DEA models commonly are either input or output oriented (Cook et al., 2014) and input oriented models seek to reduce inputs while the output oriented models seek to increase outputs (Sarkis, 2007). To achieve high operational



efficiency of domestic and international airlines, the airline managers must seek to reduce inputs and increase outputs simultaneously (Forsyth et al., 1986; Hirst, 2008).

Variable Returns to Scale Assumption: In economics, returns to scale and economies of scale are related but different terms that describe what happens as the scale of production increases in the long run, when all input levels including physical capital usage are variable (chosen by the firm). The term returns to scale arises in the context of a firm's production function. It explains the behavior of the rate of increase in output (production) relative to the associated increase in the inputs (the factors of production) in the long run. In the long run all factors of production are variable and subject to change due to a given increase in size (scale). While economies of scale show the effect of an increased output level on unit costs, returns to scale focus only on the relation between input and output quantities. The laws of returns to scale are a set of three interrelated and sequential laws: Law of Increasing Returns to Scale, Law of Constant Returns to Scale, and Law of Diminishing returns to Scale. If output increases by that same proportional change as all inputs change then there are constant returns to scale (CRS). If output increases by less than that proportional change in inputs, there are decreasing returns to scale (DRS). If output increases by more than that proportional change in inputs, there are increasing returns to scale (IRS). A firm's production function could exhibit different types of returns to scale in different ranges of output. Typically, there could be increasing returns at relatively low output levels, decreasing returns at relatively high output levels, and constant returns at one output level between those ranges (Zelenyuk, 2014). In mainstream microeconomics, the returns to scale faced by a firm are purely technologically imposed and are not influenced by economic decisions or by market conditions (i.e., conclusions about returns to scale are derived from the specific mathematical structure of the production function in isolation) (Gelles, Gregory M.; Mitchell, Douglas W., 1996).

**Total Factor Productivity Index:** In economics, total-factor productivity (TFP), also called multi-factor productivity, is a variable which accounts for effects in total output not caused by traditionally measured inputs of labor and capital. If all inputs are accounted for, then TFP can be taken as a measure of an economy's long-term technological change or technological dynamism. TFP cannot be measured directly. Instead it is a residual, often called the Solow residual, which accounts for effects in total output not caused by inputs. The equation below (in Cobb–Douglas form) represents total output (Y) as a function of total-factor productivity (A), capital input (K), labor input (L), and the two inputs' respective shares of output ( $\alpha$  and  $\beta$  are the capital input share of contribution for K and L respectively). An increase in either A, K or L will lead to an increase in output. While capital and labor input are tangible, TFP appears to be more intangible as it can range from technology to knowledge of worker (human capital).

# $Y = A \times K^{\alpha} \times L^{\beta}$

Technology growth and efficiency are regarded as two of the biggest sub-sections of Total Factor Productivity, the former possessing "special" inherent features such as positive externalities and non-rivalness which enhance its position as a driver of economic growth. Total Factor Productivity is often seen as the real driver of growth within an economy and studies reveal that whilst labor and investment are important contributors, Total Factor Productivity may account for up to 60% of growth within economies. TFP is more accurately measured in long term, since TFP can vary substantially from one year to another. It has been shown that there is a historical correlation between TFP and energy conversion efficiency (Machek, 2012).

**Theoretical Model:** The theoretical model of this study aims to seek the sources of inefficiency by analyzing the efficiency measurements and total factor productivity scores for each Star Alliance member airline year by year and within the upcoming time periods. The airline efficiency model consists of from four input and four output variables. Table 2 depicts the airline operating efficiency model by its input and output variables including 26 airline companies within the body of Star Alliance. The input variables used in this study are the capital assets of an airline company. By using them an airline company wants to increase the number and the value of its outputs.

Inputs (Xi)	Outputs (Yj)				
<b>X1</b> : Fleet (Number of Aircrafts)	Y1: Number of Annual Passengers (x 1.000)				
<b>X2</b> : Number of Employees	Y2: Daily Departures				
<b>X3</b> : Number of Airports Served	<b>Y3</b> : Revenue Passenger (Miles)* (x 1.000.000)				
X4: Number of Countries Served	<b>Y4</b> : Sales Revenue (\$) (x 1.000.000)				

Table 2: Input and Output Variables for Efficiency Evaluation of Airline Companies



**\*Revenue Passenger Miles**: RPM are measures of traffic for an airline flight, bus or train calculated by multiplying the number of revenue-paying passengers aboard the vehicle by the distance traveled. RPM can be considered the basic amount of "production" that an airline creates. In other words, RPM are defined as a summation of the products of available seat miles (ASM) between two destinations and the number of revenue passengers served on that trip. RPM represent the service demand of an airline. ASM and RPM are perishable quantities, meaning that they are nonstorable and must be used instantaneously. ASM and RPM are the two vital indicators that measure the relevant operational performance of an airline.

**Methodology and Data:** In this study, Data Envelopment Analysis (DEA) is used as the analysis technique for a number of reasons, including the fact that; there is no restriction on the types of variables which can be included in the analysis. In DEA studies, variables can be measured in different units and there is no need to convert them into a common scale, as is the case here. The proposed model has parameters with different units of measurement such as USA Dollar, Revenue Passenger Miles, number of aircrafts and number of passengers, etc. In this study, we also applied the VRS assumption instead of CRS while there are no fixed or standardized market prices for some of these quantities.

The data for this study was obtained from the Star Alliance web site for the years 2013 and 2014 including the 26 of 28 airline companies which's data were available for both years. In this organization the member airline companies update their basic data twice a year.

# Findings

The determination of each airline company's efficiency for year 2013 and for 2014 is done by applying input oriented and Variable Returns to Scale DEA model separately. The inputs and outputs values and technical efficiency scores are showed in Table 3 as a whole. Sectoral slacks are and annual efficiency means are also given at the bottom line of the related table. The brand names of Decision Making Units (DMU's) are named as given below;

DMU01: Adria Airways	DMU10: Brussels Airlines	DMU19: Shenzhen Airlines
DMU02: Aegean Airlines	DMU11: Copa Airlines	DMU20: Singapore Airlines
DMU03: Air Canada	DMU12: Croatia Airlines	DMU21: South African Airways
DMU04: Air China	DMU13: EGYPTAIR	DMU22: SWISS
DMU05: Air New Zealand	DMU14: Ethiopian Airlines	DMU23: TAP Portugal
DMU06: All Nippon Airways-ANA	DMU15: EVA Air	DMU24: THAI
DMU07: Asiana Airlines	DMU16: LOT Polish Airlines	DMU25: Turkish Airlines-THY
DMU08: Austrian	DMU17: Lufthansa	DMU26: United
DMU09: Avianca	DMU18: Scandinavian Airlines	

As it is seen from Table-3, which also contains input and output variables used in the analysis, 14 airline companies out of 26 were found technically efficient in years 2013 and 2014, respectively. Together with this, only 12 airline companies out of 14 efficient ones were found technically efficient in both years. This means %85 of them kept their relative efficiency for both years. Related with this, the average efficiency scores for these years are 0,919 and 0,910, respectively by showing a slight decrease from year 2013 to year 2014. According to the efficiency score means, the Star Alliance Group has % 9 inefficiency while it can be gained with a proper operational management.

Another question can be asked as; "Which airline company is more successful among all?" The answer is not clear at first but, when the results are evaluated together, the airline companies which are found efficient in both years and which's TFP index scores over 1,000 can be sorted out as the successful ones. Only three airline companies with names "All Nippon Airways-ANA", "Singapore Airlines" and "Turkish Airlines-THY" provide above-mentioned conditions. And, we need to look out their peer counts to find out the most successful one among best three. As a final decision, Singapore Airlines was chosen as the number one airline company by its operational capability, because it has more total peer counts (19) than All Nippon Airways-ANA (12) and Turkish Airlines-THY (1). Ethiopian Airlines has the worst technical efficiency scores (0,449 and 0,467 for the years 2013 and 2014, respectively) among all despite its TFP index is shown 1,161.

All in all, the airline managers can use the reference values of efficient airline companies as given the outputs of the DEA analysis to reduce their input values while keeping the volume and quantity of their output values in order to be efficient as the peer one(s). To do that, they also have to understand the policies and operating capabilities of the efficient ones. It is also mentioned that the airlines which operate in areas where the population is dense and world trade has main attraction could be the potential successful airlines in the future.



# Table 3: Data and Analysis Results of Star Alliance Member Airline Companies for the years 2013 and 2014

Airline	Year	Y1 (1.000)	Y2	Y3 (1.000.000)	Y4 (1.000.000)	X1	X2	X3	X4	TE (VRS )	Peer Counts	TFP (Index )
Adria	2013	1160	54	1220	228	13	400	18	17	1,000	5	0.986
Airways	2014	1030	54	1060	181	10	405	18	16	1,000	6	
Aegean	2013	6100	195	6990	849	30	1347	75	21	1,000	7	0.967
Airlines	2014	6900	210	7810	849	36	1357	120	33	1,000	5	0.907
Air	2013	35000	1530	89600	12100	351	27000	179	45	0,960	0	0.963
Canada	2014	35800	1500	88500	11900	364	27000	186	48	0,917	0	
Air	2013	48680	900	95230	16030	301	25269	145	29	1,000	1	1.023
China	2014	51010	900	103060	16090	316	25830	154	31	0,995	0	
Air	2013	13300	574	27000	3900	103	11000	54	16	1,000	5	0.930
New Zealand	2014	13700	523	28080	3700	104	11000	51	16	1,000	0	
All Nippon	2013	45000	1000	62500	15800	232	33000	78	14	1,000	3	1.258
AIFways-ANA	2014	46000	950	65530	16000	241	14000	87	16	1,000	9	
Asiana	2013	15000	260	31200	5080	79	10381	71	23	0,972	0	1.061
Airlines	2014	17000	260	32800	5720	84	10183	75	24	1,000	2	1.001
Austrian	2013	11500	400	17950	2690	77	6236	130	57	0,888	0	0.001
	2014	11300	370	17710	2069	80	6108	130	56	0,808	0	0.901
Avianca	2013	23100	568	29100	4300	143	15400	85	18	0,866	0	0.992
	2014	24600	710	31200	4600	165	19000	100	26	0,862	0	
Brussels	2013	6000	240	5370	1310	43	3500	70	40	0,891	0	0.060
Annies	2014	6000	240	9770	1440	45	3500	78	39	0,889	0	0.909
Copa	2013	7140	327	20100	2250	86	8240	65	29	0,732	0	0.942
Annies	2014	11600	333	25300	2600	98	9484	69	30	0,676	0	
Croatia	2013	1950	80	1440	303	12	1071	25	16	1,000	6	0.983
Annies	2014	1800	80	1320	288	12	973	32	18	1,000	5	
EGYPTAIR	2013	8300	250	17600	2000	81	8000	80	64	0,576	0	0.923
	2014	8400	128	17760	1800	81	9000	78	52	0,553	0	
Ethiopian Airlines	2013	4600	63	13200	1900	58	6557	85	52	0,449	0	1.161
T MITINGS	2014	6000	190	21300	2400	77	8066	89	63	0,467	0	
EVA Air	2013	7500	104	26000	2200	61	6292	63	18	0,910	0	1.009
	2014	5000	137	28000	2598	6/	1700	65	18	0,929	0	
Airlines	2013	5000	240	7290	1010	3/	1700	52	34	1,000	7	0.959
	2014	5000	1996	140790	22620	200	1/00	219	32	1,000	3	
Lufthansa	2013	76200	2006	149780	17260	420	40622	210	02 79	1,000	9	0.957
Saandinavian	2014	25500	2080	27800	5750	450	40022	101	24	0.005	2	
Airlines	2013	25500	785	2/800	5040	142	12549	101	24	1,000	6	1.056
Shanghan	2014	18200	105	26400	3940	142	12040	67	34	1,000	4	
Airlines	2013	21350	620	20400	3210	1/1	13660	67	5	1,000	3	0.844
Singanore	2014	18200	220	93760	11930	102	14156	62	34	1,000		
Airlines	2013	18200	621	95060	9200	102	14628	60	33	1,000	12	1.064
South African	2014	6500	150	21500	3000	51	10868	42	30	0.781	0	
Airways	2013	7000	165	23100	3000	52	9273	39	27	0.809	0	1.041
	2013	15800	420	33500	5180	92	8067	74	38	1,000	0	0 995
SWISS	2014	15970	400	35100	5170	90	8250	84	40	0.943	0	0.775
ТАР	2013	10170	320	25960	3190	71	7055	77	34	0.867	0	
Portugal	2014	10700	350	28150	3070	77	6889	88	38	0.799	0	1.010
	2013	20620	270	60680	6940	95	25412	76	34	1.000	2	
THAI	2014	21510	284	63480	6420	101	25323	79	34	1.000	1	0.970
Turkish	2013	39050	845	74400	7980	233	15857	245	105	1,000	0	
Airlines-THY	2014	46160	1168	89960	9560	260	19658	264	108	1,000	1	1.048
<b>T</b> T 1. 1	2013	140000	5300	331000	37200	1265	88000	368	62	1.000	3	1.000
United	2014	140000	5100	330000	38300	1265	85000	374	59	1,000	2	1.000



# Conclusions

The main objective of this study is to demonstrate the relative operating efficiencies of the Star Alliance group member airlines using their panel data for the years 2013 and 2014. This study also investigates whether there is a difference between consecutive years. We achieved that by applying the DEA method with its Variable Returns the Scale (VRS) assumption and Malmquist Total Factor Productivity Index (TFPI) to reveal these things mentioned. By doing that, this research intends to figure out the relative efficiency conditions of member airline companies in a competitive business environment.

The main constraint of this study is that the data issued by the companies asynchronously. Therefore, the results should be examined carefully by the operational managers and policy makers. It is also advised that the derived results should not be used immediately at the tactical levels by the management of the inefficient airline companies. Due to the panel data used in this study is limited to 2 years; it is advised to use a broader time period for a reliable study outcome for the further studies on this area.

Finally, airline companies which carry more passengers, depart more (frequent) and have more RPK, while they use aircrafts with more passenger capacity, employ fewer staff, own fewer aircraft and serve fewer number of countries are the potential candidates for efficiency.

# References

- Arjomandi, A. & Seufert, J.H. (2014). An evaluation of the world's major airlines' technical and environmental *performance* (pp. 133-144). Econ. Model 41.
- Assaf, A.G. & Josiassen, A. (2012). European vs. US airlines: performance comparison in a dynamic market (pp.

317-326). Tourism Management 33.

- Barros, C.P. & Peypoch, N. (2009). *An evaluation of European airlines' operational performance* (pp.525-533). International Journal of Production Economics 122.
- Barros, C.P. & Couto, E. (2013). *Productivity analysis of European airlines, 2000-2011* (pp.11-13). Journal of Air Transport Management 31.
- Barros, C.P., Liang, Q.B. & Peypoch, N. (2013). *The technical efficiency of US airlines* (pp.139-148). Transportation Research Part A: Policy and Practice 50.
- Bosetti, V., Cassinelli, M. & Lanza, A. (2003). Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management, Conference for Tourism and Sustainable Development.
- Chang, Y.-T., Park, H.-S., Jeong, J.-B. & Lee, J.-W. (2014). *Evaluating economic and environmental efficiency of global airlines: a SBM-DEA approach* (pp.46-50). Transportation Research Part D: Transport and Environment 27.
- Charnes, A., Cooper, W.W. & Rhodes, E. (1978). *Measuring the efficiency of decision making units* (pp.429-444). European Journal of Operational Research 2.
- Charnes, F., Cooper, W.W., Lewin, A.Y. & Seiford, L.M. (1994). Data Envelopment Analysis: Theory, Methodology, and Application. Kluwer Academic.
- Chiou, Y.-C. & Chen, Y.-H. (2006). *Route-Based Performance Evaluation of Taiwanese Domestic Airlines Using Data Envelopment Analysis* (pp.116-127). Transportation Research Part E: Logistics and Transportation Review 42(2).
- Choi, K., Lee, D. & Olson, D.L. (2013). Service quality and productivity in the US airline industry: a service quality-adjusted DEA model (pp.1-24). Service Business.
- Cook, W.D., Tone, K. & Zhu, J. (2014). Data envelopment analysis: prior to choosing a model (pp.1-4). Omega 44.
- Fitzsimons, J. A. & Fitzsimmons, M. J. (1998). Service Management Operations, Strategy and Information Technology, New York, Irwin McGraw-Hill.
- Forsyth, P.J., Hill, R. & Trengove, C. (1986). Measuring airline efficiency (pp.61-81). Fiscal Studies 7.
- Gelles, Gregory M. & Mitchell, Douglas W. (1996). *Returns to scale and economies of scale: Further observations* (pp. 259–261). Journal of Economic Education 27 (3).
- Hirst, M. (2008). The Air Transport System. Library of Flight, Virginia.
- Hong, S. & Zhang, A. (2010). An efficiency study of airlines and air cargo/passenger divisions: a DEA approach (pp. 137-149). World Review of Intermodal Transportation Research 3.
- Lee, B.L. & Worthington, A.C. (2014). Technical efficiency of mainstream airlines and low-cost carriers: new evidence using bootstrap data envelopment analysis truncated regression (pp. 15-20). Journal of Air Transport Management 38.
- Lu, W.-M., Hung, S.-W., Kweh, Q.L., Wang, W.-K. & Lu, E.-T. (2014). Production and marketing efficiencies of



*the U.S. airline industry: a two-stage network DEA approach* (pp.537-567). In: Cook, W.D., Zhu, J. (Eds.), Data Envelopment Analysis. Springer, New York.

Machek O. (2012). Data Issues in Total Factor Productivity Benchmarking: A Central European Perspective (pp.

224-230). The Annals of the University of Oradea. Economic Sciences 21.

Merkert, R. & Hensher, D.A. (2011). *The impact of strategic management and fleet planning on airline efficiency-a random effects Tobit model based on DEA efficiency scores* (pp.686-695). Transportation Research Part A: Policy and Practice 45.

Metters, R.D., Frei, F.X. & Vargas, V.A. (1999). *Measurement of multiple sites in Service Firms with Data Envelopment Analysis*. Production and Operation Management 3.

- Norman, M. & Stoker, B. (1991). *Data Envelopment Analysis, The Assessment of Performance*, John Wiley and Sons, New Jersey.
- Sarkis, J. (2007). Preparing Your Data for DEA, Modeling Data Irregularities and Structural Complexities in Data Envelopment Analysis (pp.305-320). Springer.
- Star Alliance. (2015, August 20). Star Alliance Services GmbH. Retrieved from http://www.staralliance.com/en/about/organisation
- Star Alliance. (2015, August 20). Travel the World with Star Alliance Network. Retrieved from http://www.staralliance.com/en/about/member\_airlines/
- Tavassoli, M., Faramarzi, G.R. & Farzipoor Saen, R. (2014). Efficiency and effectiveness in airline performance using a SBM-NDEA model in the presence of shared input (pp.146-153). Journal of Air Transport Management.
- Wu, W.-Y. & Liao, Y.-K. (2014). A balanced scorecard envelopment approach to assess airlines' performance (pp.123-143). Industrial Management & Data Systems Journal 114.
- Yolalan, R. (1993). Isletmeler Arası Göreli Etkinlik Olçümü, MPM Yayinlari No: 483. Ankara.
- Zelenyuk V. (2014). *Scale efficiency and homotheticity: equivalence of primal and dual measures* (pp.15-24). Journal of Productivity Analysis 42(1).

Zhu, J. (2011). *Airlines performance via two-stage network DEA approach* (pp.260-269). J. CENTRUM Cathedra 4.



# DESIGNING AND IMPLEMENTATION OF AN EXPERT SYSTEM TO BE USED TO DETERMINE THE BODY SIZE

Hakan YÜKSEL, Mehmet DAYIK, Oğuz ÇOLAK

Technical Science Vocational School, Faculty of Engineering, Faculty of Technology Süleyman Demirel University, Isparta-Turkey

hakanyuksel@sdu.edu.tr, mehmetdayik@sdu.edu.tr, oguzcolak@sdu.edu.tr

**Abstract:** In globalizing world, for available sectors finding themselves a place is getting harder economically and commercially. This situation leads them to follow the latest technology to go ahead in common market. One of the latest technologies in textile field is trying on clothes for people in virtual environment. Here the biggest problem is to measuring and determining the size of the body. The aim of this study is to develop decision support system software to determine the most suitable body size. With this study, it is enabled to give easier and quicker result for the expert system.

Key words: Measuring of the body, determining the body size, Expert system.

# Introduction

The rapid development in technology in globalizing world leads a competition environment among to available sectors. In order to be more successful in the commercial environment, they need to search new methods and apply them in their real environment.

When the market conditions changing so rapidly are taken into the consideration, in order to survive for the current sectors, it is necessary for them to offer their products or service to their customers more rapidly and desiring way. Within this period, the modern day business managers follow the strategy of taking the advantage of technology, special the information technology as a reaction to new development in competition, market, internal and exogenous environmental factors (Yıldız, 2005).

For the garment industry, which is an important sector in international economy, using the information technology methods gains favor for the sektor by making differences among their opponent and provide benefit. With the help of the development of information technology in garment industry, many applications are begun to made in otomatic systems. One of successful application in garment industry is to make the virtual fitting room for a person to try on the clothes he/she wants in the virtual environment. In virtual fitting rooms, people can try on the textile product they want by the simulation software in the virtual environment. The most important background of the virtual wearing system is the developing measuring and determining of the body size. It is needed to determine the body size and to use the right body size for people to try on the appropriate clothes .By the help of the body measuring system it is provided to determine the people's body size.

Body measuring process is one of the most important process of determing and producing of the clothes. The determining of the body size is made generally by hand. This has many disadvantages. These disadvantages are :

- Taking too much time,
- Being too tiring,
- The correctness of the process,
- The anti-hygienic of the measurement.

Today, body measuring and determining systems decrease or prevent most of these disadvantages. With the low budget, enabling personality trait on many clothes emphasizes the necessity of the rapid and automatic measuring



system (Guerlain, 2006). With this developing sytems, the high resolutation body images gotten at the end of the body scanning are analyzing correctly and completely and presenting the body sizes in standart data (Öndoğan, 2005). So more precise measurements are taken and for the target group it is provided mmeasurement standart.

In today's world, the information technology is used everywhere, it is needed to use this technology also to solve the problems in textile industry. So for the study of the determing the body size, it is used expert system which is one the techniques of artificial intelligence. In this study, it is provided designing and developing of an expert system determining the body using the body size.

This study is prepared in four parts. In the first part, there is an general introduction abaout the topic and in the secon part there is definitions about the expert system. In the third part, there is an application done in this study (the structure and proceeding) and in the forth part there are results of the study.

# **Expert System**

Expert system is a kind of computer programme which was developed by experts of artificial intelligence in 1970s and was started to practice commercially in 1980s. There has been many definitions for the expert system in literature.

- ES is a kind of software system which is modeling the reasoning and determining processes can be done by a person or many people expert in a field (Nabiyev, 2005).
- ES reaches a conclusion by making inference from the knowledge it has (Önder, 2003).
- ES is a consultant computer programme aiming to imitating the knowledge of the experts and ratiocination process in solving a special team problem (Turban, 1990).
- An ES program works as a system which is not standing for an algorithm, in its own knowledge base, making a search for the data know before and enabling the activation of the appropriate knowledge according to these data and going on searching by getting new data as a result of this activation (Allahverdi, 2002).

Expert Systems enable the defination of the real world problem not using the analtycal methods by intuitional methods and solving them. In figure 1. An expert system structure is shown (Llata vd., 2001).



Figure 1. Expert System Shema

Expert systems help the experts in these points (Uysal, 2003);

- Understanding of the problem,
- Solving of the problem,
- Explaination of the solution,
- Evaluating the solution,
- Expanding the knowledge,
- Evaluating the abilities,
- Construction of the knowledge.



# **Expert System Applications: Its Structure and Working**

The developed expert system makes body sizing according to the measures defined by the Europan Standarts (CEN; 2015). The textile products are sperated as upper and down parts. In this study, the body sizing of the upper clothes like t-shirt, sweater, shirt, jacket, dress, coat for men and women. It is available the measures of the upper parts (height, bust, waist, hip) of men and women. Apart from these measures, It is also important to involve the measures of sizes of shoulder, arm, neck, wrist and etc which are konown as side measures in the programme and evaluate them with those measures. Because a structure with an expert system gives the right answer to the needs, it is the base of this project. In this study, according to availble rule base, the body size of a person is defined and which size or sizes will be appropiate is evaluated. The general structure of the developed expert system is shown in figure 2.



Figure 2. The general structure of the developed expert system

The user; In the use part of the expert system, there are the system manager and users.

User Interface; it enables the communication between the user and the programme. With the help of the user interface, the controlling of the data base of the system, adding or taking out the rules can be done. In this developed system, while system manager can reach the parts "The New Kind Definition" and "Rule Base" in its own authority, the user can pass the field where the evaluation is done after the definition of the body size measuring. Before the part of the body size measuring, it must be selected to the users' woman or man. For men, it is enough to wear just height and waist sizes, for women, it is necessary to use the sizes of bust waist and hip (Figure 3). The men and women's sizes are evaluated in different rule bases.

After all the fields are filled, in the background the body size of the person is measured. The developed expert system can make evaluation about the body size of a person using the data entered in the background.

In the developed software, also it can be added the kind of the measure in the expert system with the help of the user interface and by using this measure kind, a measure kind group can be composed. This measure kind group enables the rebuilt of the rule base. It can be added choices for making those measure kinds.

Body Measurem	ent	
Woman		
Bust	78-81	•
Waist	63-65	•
Hip	88-91	•
		Result



### Figure 3. The form of the Application (Body Measurement)

Data Base; it composes the base data, rules and intuitive knowledge. The base of the expert system is related to the keeping the knowledge right and processing it. If the resolution of the data in the data base is strong, the developing system will be also that much strong.

Database composes of the reals presenting the problem situation and values. In this study, SQL Server database programme is used in order to keep the data safe and process them quickly.

The rule base: the expert system must have the structure of a defined size or control mechanism and work in certain situations. The sizes are structure in which the solution of available problem can be expressed properly. In this study, it is benefited from the "European Size Measures" and there are four rule bases. The first and second rule base (The rule base-1 / the rule base-2) are composed for defining of the woman and man body size and the rule base 1 has 10 and the rule base-2 has 8 rules.

Rule No:	Rule	Inference
1	If; Bust74-77, Waist 60-62, Hip: 84-87	Size: 32
2	If; Bust:78-81, Waist:63-65, Hip:88-91	Size: 34
3	If; Bust:82-85, Waist:66-69, Hip:92-95	Size: 36
4	If; Bust:86-89, Waist:70-73, Hip:96-98	Size: 38
5	If; Bust:90-93, Waist:74-77, Hip:99-102	Size: 40
6	If; Bust:94-97, Waist:78-81, Hip:103-106	Size: 42
7	If; Bust:98-102, Waist:82-86, Hip:107-110	Size: 44
8	If; Bust:103-107, Waist:87-91, Hip:111-115	Size: 46
9	If; Bust:108-113, Waist:92-96, Hip:116-120	Size: 48
10	If; Bust:114-119, Waist:97-102, Hip:121-125	Size: 50

# Table 1. Size defining rules for woman (Rule Base-1)

### **Table 2.** Size defining rules for man (Rule Base-2)

Rule no	Rule	Inference
1	If; Height:166-170, Bust: 86-89	Size: 44
2	If; Height:168-173, Bust:90-93	Size: 46
3	If; Height:171-176, Bust:94-97	Size: 48
4	If; Height:174-179, Bust:98-101	Size: 50
5	If; Height:177-182, Bust:102-105	Size: 52
6	If; Height:180-184, Bust:106-109	Size: 54
7	If; Height:182-186, Bust:110-113	Size: 56
8	If; Height:184-188, Bust:114-117	Size: 58

The third and fourth rule base (The rule Base 3 / The Rule Base-4) is composed for making comment about the size of woman and man according to the body measuring in the first and second rule base. The rule base 3 has 5 and the rule base 4 has 4 rules. (Table 4)

<b>Lubic 5</b> The fulles of defining body size of woman (fulle base 5)
---

Rule No	Rule	Inference
1	If; Size: 32 - 34	XS
2	If; Size: 36 - 38	S
3	If; Size: 40 - 42	М
4	If; Size: 44 - 46	L
5	If; Size: 48 - 50	XL



Rule No	Rule	Inference
1	If; Size: 44 - 46	S
2	If; Size: 48 - 50	М
3	If; Size: 52 - 54	L
4	If; Size: 56 - 58	XL

**Table 4.** The rules of defining body size of man (Rule Base 4)

In the developed expert system, there are 27 rules totally and all the rules are kept safe in the database.

Inference Mechanism; it is the inference of the data in the database and controlling of them. It is place of making inference with the expression of sizes in the rule base. It transmits the inferences obtained using the data and rules in the data base. Two different searching methods are used while interpreting the rules: Forward Chaining Method and Backward Chaining Method (Üstkan, 2007). In this study, "Forward Chaining Method" which is based on estimating and defining the available conditions of the rule by starting with the known data is used. In table 1, 2, 3 and 4 the inferences obtained by the rules of the application using the inference mechanism.

# **Conclusion and Recommendations**

In order to provide the success and continuity, the avible sectors must decrease the accession duration of the products and increase the quality. One of the most important steps of increasing the quality is following the current development in the technology. With these developments in the garment industry, virtual dressing rooms and the application of body scanning and sizing which is also background for virtual dressing room becomes really important.

So, in this study, an appropriate sofware was developed by taking into consederation of the Europan Size Stanstards and using expert systems. The main target of this software is to define the size of a person by using the body size of him/her and choosing the most appropriate and efficient way. It is seen that, in the example applications the needed results could be taken as a successful and desired way. But if the kind of the body sizing methods are increased, the more appropriate results can be taken.

# References

Allahverdi, N. (2002). Uzman Sistemler: Bir Yapay Zeka Uygulaması, Atlas Yayıncılık, İstanbul, 16-20.

CEN, (2015). http://www.cen.eu, (European Committee for Standardization- EN 13402).

- Guerlain, P., Durand B., (2006). Digitizing and Measuring of the Human Body for the Clothing Industry, International Journal of Clothing Science and Technology, pp. 151–165, England.
- Llata, J.R., Sarabia, E.G. ve Oria, J.P. (2001). Fuzzy Expert System with Double Knowledge Base for Ultrasonic Classification, Expert Systems with Applications, 20, ss. 347 355.
- Nabiyev, V.V. (2005). Yapay Zeka, Seçkin Yayıncılık, Ankara, 445.
- Önder, H.H. (2003). Uzaktan Eğitimde Bilgisayar Kullanımı ve Uzman Sistemler, The Turkish Online Journal of Education Technology TOJET, July, Volume 2, Issue3, Article 17, s2.
- Öndoğan, Z., Pamuk, O., (2005). 3 Boyutlu Vücut Tarayıcı Sistemler, Tekstil ve Konfeksiyon, Year:15, Vol:2, pp.114–116, Izmir.
- Öndoğan, Z., Pamuk, O., Topal, E., (2007). Giysi tasarımı, vücut ölçülendirme ve giysi pazarlaması konularında simülasyon Sistemlerinin incelenmesi, Tekstil ve Konfeksiyon 4/2007, p. 265-272.
- Turban, E. (1990), Decision Support and Expert Systems, Mac Millian Publishing Company, U.S.A.
- Uysal, Ö. and Kurban, M. (2003). Elektrik enerji sistemlerinin uzman sistemler kullanılarak işletilmesi, I. Ege Enerji Sempozyumu ve Sergisi, Pamukkale University, Enginering Faculty, Denizli, Mayıs.
- Üstkan, S. (2007). Uzman Sitemler Genel, Yönlendirilmiş Çalışma, Sakarya Üniversitesi Adapazarı Meslek Yüksekokulu, Mart.
- Yıldız, M. (2005). Bilişim Teknolojilerinin Uzman Sistem Boyutu İle Analizi, Selçuk Üniversitesi Sosyal Bilimler MYO Dergisi, Cilt 8, Sayı 1-2.



# FRENCH MANDATORY EDUCATION: THE CASE OF SANJAK (HATAY) (1920-1939)

### Yusuf KODAZ

Selcuk University, Ataturk Principles and Revolution, History Department, Konya, Turkey

### E-mail: yusufkodaz@selcuk.edu.tr

**Abstract:** Although Hatay existed in National Pact borders, it was kept out of Turkish borders with the Ankara Treaty signed on October 20, 1921 in order to stop the armed conflict with France under extraordinary conditions of Independence War. Yet, Ankara Government inserted provisions into this treaty in order that the Turks in the district could pursue their national existence. These provisions were preserved in the same way in Lausanne Peace Treaty and other treaties signed between France and Turkey. The case of Syria, mandated by France in The San Remo Conference, was also approved by The Nations League on July 24, 1922. So, Hatay was mandated by France along with Syria.

In the period of French Mandate Government, every community was educated in its own language. Formal schools were opened for non-Turkish groups in Hatay and the opening of private schools was supported. While the children belonging to these groups were formerly educated in the Turkish language, in the newly opened schools the Turkish language was not included at all. Moreover, as in Syria, France implemented educational policies in Hatay which would raise mandate government-dependent people.

Keywords: French Mandatory, Hatay

### Introduction

Hatay Province, located on the east coast of the Mediterranean sea, is surrounded by Syria on the south and east, the Mediterranean sea on the west, Adana province on the northwest, Osmaniye province on the north, and Gaziantep province on the northeast. Hatay Province, the history of which dates back to antiquity, and is a transition point geographically, has been home to many different culture until today. Alexandretta, a district of Hatay, is an important natural harbour in the Eastern Mediterranean. These features of Hatay made it a focal point for great powers in every period of the history. French tried to train individuals to practice their policies in the field of education, during the period when they mandated Hatay with Syria.

### French Occupation of Hatay and the Foundation of Mandate Government

After World War I, Sanjak (Hatay) was under the control of Turkish forces, when the armistice of Mudros was signed between Ottoman Empire and Allied Powerp. However, right after the armistice of Mudros, Allied Powers started to occupy the region based on this treaty (Akşin 1991, p.302, Sökmen 1992; p.34-35, Kuçcu 1997; p.23, Durgun 2011, p.180;Fırat-Kürkçüoğlu 2012, p.280). In parallel with the occupation, the region was handed to France in accordance with Sykes-Picot Agreement, which was one of the secret agreements made during World War I. Even it was within Misak-1 Milli (National Oath) borders, Hatay had be left out of Turkish Republic borders with Ankara Treaty signed on 20 October, 1921, due to the extraordinary conditions of the Turkish War of Independence, in order to stop the armed conflict with France. Nonetheless, Ankara government included terms in this treaty, which would protect the rights of Turks in Hatay, and pave the way for the autonomy of the region (Atay 1936 p.1; Benice 1936, p.1; Küçüka 1936, p.3; Nadi 1936; p.1; Erkal 1988 p.15; Sarınay 2001, p.23; Gönlübol-Sar 2013, p.147). These terms were also include in the Treaty of Lausanne (Başbakanlık Cumhuriyet Arşivi; 030.10/224.510-12; Akşin 1991 p.303; Ada 2005 p.104; Çatalçam 2008 p.25; Esmer 1938, p.334-335; Soysal 1985, p.80; Khadduri1945, p.406-425; Dağlıoğlu 1936, p.3). The decisions of San Remo Conference put Syria within the French Mandate on 25 April 1920, and this decision was approved by League of Nations on 23 September 1923. After that, France founded an autonomous government for Hatay region in accordance with the Treaty of Ankara (Tekin 1986; Gönlübol-Sar, 2013). With further treaties signed between Turkey and France, Turkish language was given the official language status, and the terms included in these treaties paved the way for the development of Turkish culture, and established an environment for Turkish cultural activity. Still, France didn't completely comply with these terms in Hatay during their mandate.



# French Education Policies Practiced in Hatay (1920-1939)

French didn't interfere with the cultural life in their vassal Hatay at the beginning, and allowed cultural development of the residents. This attitude of France started to change after a couple of years, and they started to intervene in the cultural life. Wanting to consolidate their place in the region, France started systematic and programmed activities in order to withstand the reforms conducted by Turkey. Until 1925, Turkish educational program was practiced in Hatay, and the course books were also brought from Turkey. However, this disturbed mandatory managements, and they started work harder to break the connections of the region with Turkey (Bilgili 1939, p.15; Payasli 2009, p.24-25).

"Divide and rule" policy was practiced in French mandated Syria in the process of establishing the domination in the area (Sander 1994, P.72; Ayranci 2006, p.21). Social structure of the country was also affective in this policy of France, as Syria was a country with the most different ethnic population in Middle East (Ayranci 2006, p.21). France tried to attain its goals by using this social structure of Syria. To this end, they started to increase the number of missionary priests. These priests worked not only to proselytize but also for the interests of France (Hourani 1997, p.298; Umar, 2002, p.291). Taking advantage of the poorness of Ottoman management and education system in the area, missionaries founded many schools. At French schools in Hatay, they tried to inculcate Arabian students with hostility against Turks, and tried to create animosity between Turks and Arabs. They tried to keep the region under control taking advantage of the upheavals to be created this way. As they did in the administration, French tried to commove any kind of racial and religious tendencies. They cut down the budget of public schools that offered Turkish education, and they also tried to reduce the number of these. On the other hand, they tried to increase the number and the budget of the schools that served for French interests. This way, they tried to train individuals loyal to mandatory government (Umar 2002, p. 303-304).

Due to their policies, French didn't only deal with non-Turkish groups. They also tried to promote the reformist and conservative attitudes among Turks, in order to create conflict within them. For this purpose, they made former primary schools semi-public schools under the name of "EcolCoranique". Teachers educated in madrasahs were assigned to these schools and financial aid was provided (Bilgili 1939, p.15;Payash2009, p. 25). Conservative families mostly sent their children to these schools. These schools offered rote learning with traditional methods. They tried to prevent the development of thinking skills of the children who attended these schools. There were many schools founded in constitutional period in Hatay, when French occupied the area. These were 1 high school with five classes, 1 girls' junior high school, 1 boys' junior high school in Antakya, and one junior high in Alexandretta and Belen. Additionally, there were a total of 41 primary schools in various places in Hatay. Even these schools were closed during World War I, France allowed the re-opening of them right after the war. In order to maintain their cultural inheritance, Hatay residents followed the developments in Turkey closely. French mandatory government was totally disturbed by this attitude of Hatay people. In this context, they introduced the educational developments in Turkey as alienation from Islam, and tried to keep religious-traditional institutions active. (Payash 2009, p.23-25).

Primary schools opened in Hatay during constitutional period were 3 grade schools, and mostly offered religious education. These schools continued their education this way until 1928, and they were re-organized as 5 grade schools in that year. These schools taught in French and Arabic as of first grade, and their objective was to train students for colleges. At schools in Turkey, a standard programmed curriculum was followed in classes, though Hatay schools offered un-programmed education for groups. After 5<sup>th</sup> grade of primary schools, students were given certificates according to their proficiency in French, regardless of their achievement in other courses.

French mandatory government started to increase the number of these schools as of 1928, and in 1938 there were 26 of these schools. The same education of the same of the purpose was also given in schools in villages (K1ymat 2007,p.12).

In his book titled Mandatory Government: Cultural Life in Hatay, Mesut FaniBilgili provided this information about the education of Turkish children during mandatory government: "Of the 21000 Turkish children at school age between 6-14, only 2600 could learn to read. Compared to children of other ethnic groups, cultural condition of Turkish children was a disaster. While Turkish children were in such a bad situation, of the 3800 Armenian children at school age 2873, of the 1909 eastern orthodox children 1181, of 1272 catholic children 826, of 244 protestant children 216, and of 79 Jewish children 57 followed schools regularly. Additionally, Christian children in Hatay were educated under the aegis of missionaries. Today, while 75-80% of Christian children are literate, while only 10% of Turkish children are".



# Conclusion

Hatay, is an area where different ethnic groups have lived in peace and tolerance for centuries. France tried to maintain its dominance in Hatay making use of this cultural diversity. Educational policies were also set accordingly. In spite of all these policies, France couldn't settle in Syria easily. Divide and rule policy and the pressure policies of France resulted in a reaction to France by local residents. France faced many rebellions in its vassal Syria. Yielding to independence requests from the nationalist groups, France signed an independence agreement on 9 September 1936. After Syria-France Independence Agreement, Turkey carried Hatay dispute to international grounds bringing up the terms of Ankara Treaty. As a result of successful policies, Hatay first separated from Syria, and gained independence. Then, on 23 June 1939, Hatay Assembly decided to become part of Turkey.

# References

Ada, Serhan, (2005), Türk-Fransız İlişkilerinde Hatay Sorunu (1918-1939), İstanbul: Bilgi Üniversitesi Yayınları. Akşin, Aptülahat (1991), Atatürk'ün Dış Politika İlkeleri ve Diplomasisi, Ankara: Türk Tarih Kurumu Yayınları. Ayrancı, Zişan Şirin (2006), Türkiye-Suriye İlişkileri, Eskişehir: Anadolu Üniversitesi Sosyal Bilimler Enstitüsü

Yayınlanmamış Yüksek Lisans Tezi.

Atay, Falih Rıfkı, Fransa ve Sancak, Ulus, 22 Kasım 1936.

Başbakanlık Cumhuriyet Arşivi, 030-10-224-510-12.

Benice, Etem İzzet, Antakyalılar İntihaba Zorla Götürülemezler, Açıksöz, 16 Kasım 1936.

Bilgili, Mesud Fani,(1939), Manda İdaresinde: Hatay Kültürel Hayatı, Antakya: İktisat Basımevi.

Çatalçam, Aytekin, (2008), 1923-1938 Atatürk Dönemi Türk Dış Politikası'nda Lozan'ın Etkisi, İstanbul: Beykent Üniversitesi Sosyal Bilimler Enstitüsü Yayınlanmamış Yüksek Lisans Tezi.

Dağlıoğlu, Hikmet Turhan, Antakya Anadolu Kadar Eski ve Anadolu Kadar Halis Bir Türk Yurdudur!, Cumhuriyet, 7 Ekim 1936.

Durgun, Sezgi,(2011), Memalik-i Şahane'den Vatan'a, İstanbul: İletişim Yayınları.

Erkal, Şükrü, (1988), Atatürk ve Hatay, Atatürk Haftası Armağanı (Ölümünün 50inci Yılında Atatürk), Ankara: 1988.

Esmer; A. Şükrü,(1938), *Cumhuriyet ve Dış PolitikamızLozan-Montrö-Hatay*, Siyasi İlimler (Mülkiye) Mecmuası, Ekim 1938, No:91, s.334-335.;

Fırat, Melek-Kürkçüoğlu, Ömer,(2012), *Sancak (Hatay) Sorunu*, Türk Dış Politikası Kurtuluş Savaşı'ndan Bugüne Olgular, Belgeler, Yorumlar (Cilt:I 1919-1980), Editör: Baskın Oran, İstanbul: İletişim Yayınları.

Gönlübol, Mehmet -Sar, Cem,(2013) Atatürk ve Türkiye'nin Dış Politikası (1919-1938), Ankara: Atatürk

Araştırma Merkezi Yayını.

Hourani, Albert, (1997), Arap Halkları Tarihi, (Çeviren: Yavuz Alagon), İstanbul: İletişim Yayınları.

Khadduri, Majid,(1945), *The Alexandretta Dispute*, The American Journal of International Law, Wol.39, No:3. Kıymat, Zeynep,(2007), Hatay'ın Anavatana Katılmasından Sonra İskenderun İlçesinde Eğitim Alanında Gelişmeler (1939-2000), Konya: Selçuk Üniversitesi Sosyal Bilimler Enstitüsü, Yayınlanmamış Yüksek Lisans Tezi.

Kuşcu, Samet,(1997),*Hatay'ın Kurtuluşu ve Kurtarılışı Konusunda Özet Bir İnceleme II*, Güney'de Kültür, Cilt:9, Sayı:96.

Küçüka, Necibali, Davamız Milletler Cemiyeti Konseyinde, Ulus, 13 Aralık 1936.

Nadi, Yunus, Sancak Meselesinde (Er Nuvel) Gazetesini Tenvir İçin, Cumhuriyet, 7 Aralık 1936.

Payaslı, Volkan, (2009), Atatürk Dönemi Eğitim-Kültür Politikalarının Hatay'a Yansımaları (1921-1938), Ankara: Ankara Üniversitesi Türk İnkılap Tarihi Enstitüsü Yayınlanmamış Yüksek Lisans Tezi.

Sander, Oral, (1994), Türk Siyasi Tarihi 1918-1994, Ankara: İmge Kitapevi Yayınları.

Sarınay, Yusuf, (2001), *Atatürk Dönemi Türk Dış Politikası ve Hatay*, Anavatana Katılışının60. Yıldönümünde Hatay, (Yayına Hazırlayan: Berna Türkdoğan), Ankara: Atatürk Araştırma Merkezi Yayını.

Soysal, İsmail; (1985), Hatay Sorunu ve Türk-Fransız Siyasal İlişkileri (1936-1939), Belleten, Cilt:XLIX, Sayı:193.

Sökmen, Tayfur, (1992), Hatay'ın Kurtuluşu İçin Harcanan Çabalar, Ankara: Türk Tarih Kurumu Yayını.

Umar, Ömer Osman,(2002), Suriye'de Fransız Emperyalizmi, Elazığ: Fırat Üniversitesi Sosyal Bilimler Dergisi, Cilt:12, Sayı:1.



# INVESTIGATION OF BEHAVIOR OF STRUCTURES ACCORDING TO DIFFERENT LOCAL SITE CLASSES FOR L TYPE REINFORCED CONCRETE FRAME BUILDING HAVING A1 AND A3 IRREGULARITIES

Rıfat SEZER, Ceyhun AKSOYLU, Nail KARA

Selcuk University, Civil Engineering Department, Konya, Turkey, rsezer@selcuk.edu.tr ceyhunaksoylu@selcuk.edu.tr nkara@selcuk.edu.tr

**Abstract:** In this study, a series of investigation was carried out considering Z1, Z2, Z3 and Z4 type soils stated in Turkish Earthquake Code 2007 (TEC-2007) for the reinforced concrete frame model having torsional irregularity (A1) and plan irregularities (A3) with high ductility level of L type central floor load-bearing system designed in accordance to TEC-2007. The investigated structure is an 8-floor school building having the building importance factor of I = 1.4 and existing in 1<sup>st</sup> degree Seismic Zone. The earthquake analyses were performed with SAP2000 v.16.1.1. computer program by considering the Equivalent Seismic Load Method (ESLM) and Mode Combinaion Method (MCM). Base shear force, torsional force, overturning moment, effective mass participation ratio, building period, floor displacement and effective relative floor projection were calculated considering the commonly used calculation methods and the boundary conditions of TEC-2007 for different soil classes in terms of structure-soil interaction and compared according to commonly used calculation methods.

Keywords: Reinforced Concrete, Structure, Class

# Introduction

Three elastic calculation methods are defined to be used in earthquake calculation in the buildings to be constructed according to the Turkish Earthquake Code-2007 (TEC-2007). These are "Equivalent Seismic Load Method (ESLM)", "Mode Combination Method (MCM)" and "Time History Analysis (THA)". It is stated in the regulation that all three calculations methods can be used in the event that specific conditions are fulfilled. The obligation of conducting three dimensional structure analyses has been imposed in all of these methods. In addition, whereas the regulation has imposed specific limitations for the application of ESLM, no limitation has been imposed on other two methods. As our country is located on a seismic belt, big earthquakes tend to occur from time to time and many structures are either damaged or destroyed. When the buildings which are damaged or destroyed due to earthquakes are examined, it is observed that not attaching the necessary importance to structure-soil interaction has mostly been very influential (Livaoğlu and Doğangün 2002). Nonetheless, in the calculations which are made to determine the behavior of buildings to earthquake, the structure-soil interaction has been ignored for a long time and the abutments of structures have been assumed to behave according to the pre-defined earthquake movement. First of all, all abutments have been accepted to be attached to the soil with a single rigid block and a single component of the movement has effect on this block (Korkmaz and Demir 2012). With this consideration, solutions have been reached by generally accepting that the foundations are fixed and there is no change of location or rotary motion in foundations. However, the complexity of structure systems have increased in time and the fact that the earthquake movement needs to be taken into consideration in two and three dimensional coordinate systems also have come to the fore due to the detection of collapses and rotary motions in foundations even in the analysis of structure systems under static loads. The structure-soil interaction is traditionally defined as the mutual interaction of structure and soil in the framework of a model in which soil environment and super structure are taken into account together under the effect of earthquake (Aydınoğlu 2011).

There are numerous studies in the literature examining the effect of structural irregularities on earthquake performance. Related studies have particularly focused on the issues of poor bearing story, soft story and torsion irregularity (İnan and Korkmaz, 2011, Özmen and Unay, 2007., Tezcan, 1998). Moreover, there are other studies



containing flooring discontinuities and the protrusions included in the plan (Öztürk et all., 2015 and Arslan, 2007).

It is known that in damages observed in reinforced concrete structures after earthquakes, structures which did not receive engineering services have been heavily damaged or completely destroyed (Arslan and Korkmaz, 2007., Sezen et.al, 2003., Doğangün, 2004., Inel et. al, 2008). In addition, the fact that damage increases in buildings and the total collapse of the building is facilitated with structural irregularities stated in earthquake Code has been observed in field works (Tezcan and Alhan, 2001., Arnold and Reitherman, 2002.,Gülay and Calim, 2003., Inan and Korkmaz, 2011).

In this study, contrary to the analysis of a single irregularity in structures in the literature, the effect of an L-type reinforced concrete frame system, in which torsion irregularity (A1) and the existence of protrusions in the plan irregularity (A3) co-exist in the scope of irregularities in plan, on structural behavior towards 4 different soil classes (Z1, Z2, Z3, Z4) has been examined through a case analysis study by taking the structure-soil interaction according to ESLM and MCM into consideration as well. As a result of this examination, base shear force, torsional moment, overturning moment, effective mass participation ratio, building period, story displacement and relative story displacement have been calculated for different soil classes and have been compared with the used calculation methods.

# Methods using in Earthquake Calculations

The selection criteria of the calculation method to be used in earthquake calculation has been stated in the 2.6 section of the TEC-2007. According to this section, whereas ESLM can only be used after meeting certain conditions, MCM can be used in all buildings in the scope of the regulation. Analyses have been carried out according to ESLM and MCM which have been allowed in the earthquake calculation of building and building-type structures in TEC-2007.

### **Equivalent Seismic Load Method**

For the application of ESLM in buildings where earthquake calculations will be made, conditions presented in Table 1 must be met.

Earthquake Zone	Type of Structure	Total Height Limit (meter)
1,2	Structures that do not have torsion irregularity of A1, if they have, it is needed to provide (η <sub>bi</sub> )≤2 ratio for each floor	H <sub>N</sub> ≤25m
	Structures that do not have torsion irregularity of A1, if they have, it is needed to provide (η <sub>bi</sub> )≤2 ratio for each floor and structures that do not haveB2 irregularity	25m< H <sub>N</sub> ≤60m
3,4	All Structures	$H_N \leq 75m$

Table 1. Buildings that are suitable for applying equivalent seismic load method

While the first mode of the building is taken as a basis in the ESLM method, the earthquake forces which affect the stories are accepted as being proportional to the mass of each story and to the height of stories from the foundation (Uçar and Merter 2012). This method is considered as a dynamic method based on the building's first degree of freedom as it also takes the mass of the building into account in the period calculation and distribution of earthquake load (Celeb and Kumbasar 2004).

In line with the earthquake which is taken into account, the equivalent earthquake load (base shear force) which effect the whole building is determined by calculating it as  $V_t$  (TEC-2007)

$$V_t = \frac{W * A(T_1)}{R_A(T_1)} \ge 0, 1 * A_0 * I * W$$
(1)

In Equation (1), W indicates building total weight,  $A(T_1)$  indicates spectral acceleration coefficient taken as a basis in the determination of earthquake load,  $R_a(T_1)$  indicates earthquake load reduction coefficient,  $A_0$  indicates efficient ground acceleration coefficient and I indicates building importance coefficient.

The obtained base shear force  $(V_t)$  is distributed as horizontal static single forces in line with the appropriate dynamic degrees of freedom along the height of the building. This distribution is mostly accepted as linear in



Code and the horizontal force affecting the 1st story in line with the dynamic degree of freedom  $(F_i)$  is calculated by using Equation (2) (TEC-2007).

$$F_i = V_t - \Delta F_N * \frac{w_i * H_i}{\sum_{j=1}^N w_j * H_j}$$

$$\tag{2}$$

In this equation,  $w_i$  is the weight of the building's 1st story and  $H_i$  is the height of the building's 1st story which is measured as from the top of the foundation. The additional equivalent earthquake load affecting the top story of the building ( $\Delta F_N$ ) value is determined by utilizing Equation (3) (TEC-2007).

$$\Delta F_N = 0,0075 * N * V_t \tag{3}$$

### **Mode Combination Method**

Maximum internal forces and transposition in MCM is obtained by the statistical combination of the maximum contributions calculated for each of the natural vibration mode in sufficient number in the building. The reason behind the statistical combination lies in the fact that these maximum contributions occur at different times (Uçar and Merter 2012). Moreover, this method can also be considered at the assessment for each of the mode types delivering the behavior of systems with multitude degrees of freedom (Celeb and Kumbasar 2004).

The reduced acceleration spectrum ordinate to be taken into consideration in any  $n^{th}$  vibration mode is determined through Equation (4) below (TEC-2007).

$$S_{aR}(T_n) = \frac{S_{as}(T_n)}{R_a(T_n)} \tag{4}$$

In the equation above,  $S_{aR}(T_n)$  indicates reduced spectral acceleration for the n<sup>th</sup> natural vibration mode,  $S_{ae}(T_n)$  indicates elastic spectral acceleration and  $R_a(T_n)$  indicates the earthquake load reduction coefficient calculated for the n<sup>th</sup> natural vibration mode.

The sufficient vibration mode which needs to be taken into consideration will be determined according to the rule that the total effective mass which is calculated for each mass in each of the perpendicular horizontal earthquake directions can never be less than the 90% of the building's total mass (Taşan 2012). This condition has been presented in Equation 5 and 6.

$$\sum_{n=1}^{Y} M_{xn} = \sum_{n=1}^{Y} \frac{L_{xn}}{M_n} \ge 0,90 * \sum_{\tilde{I}=1}^{N} m_i$$
(5)

$$\sum_{n=1}^{Y} M_{yn} = \sum_{n=1}^{Y} \frac{L_{yn}}{M_n} \ge 0,90 * \sum_{\tilde{I}=1}^{N} m_{\tilde{I}}$$
(6)

In these equations,  $M_{xn}$  and  $M_{yn}$  are the effective mass in the building's n<sup>th</sup> natural vibration mode for the calculated earthquake direction,  $M_n$  is the modal mass of natural vibration mode,  $m_i$  is the mass of the building's 1st story. The calculation of  $L_{xn}$  and  $L_{yn}$  with  $M_n$ , indicated with Equation 5 and 6 for buildings in which floorings serves as rigid diaphragm has been presented in Equation 7,8 and 9.

$$L_{xn} = \sum_{i=1}^{N} m_i * \Phi_{xin} \tag{7}$$

$$L_{yn} = \sum_{i=1}^{N} m_i * \Phi_{yin} \tag{8}$$

$$M_n = \sum_{i=1}^N m_i * \Phi_{xin}^2 + m_i * \Phi_{yin}^2 + m_{ei} * \Phi_{ein}^2$$
(9)

Here,  $\Phi_{xin}$  and  $\Phi_{yin}$  are the horizontal component of the n'th mode type in line with the perpendicular x and y axis on the first story,  $\Phi_{oin}$  is the rotation component around the horizontal axis of the n'th mode type on the first story.  $m_{oin}$  indicates the building's mass moment of inertia according to the horizontal axis which pass through the non-displaced mass center of the first story.

There are some rules in the MCM method for the statistical combination of non-concurrent maximum contributions which are calculated for each vibration mode to be applied separately for each of the magnitudes such as the total earthquake load, story shear force, internal force components, transposition and relative story



displacement affecting the building. On the condition that the natural periods of any two vibration modes taken into account meet the requirement of  $T_m/T_n<0.8$  with  $T_m<T_n$ , the Square Root of the Sum of the Squares (SRSS) rule can be applied for the combination of maximum mode contributions. In case of the non-fulfillment of the conditions in question, the Complete Quadratic Combination (CQC) rule will be applied in the combination of maximum mode contributions (TEC-2007).

In line with the earthquake taken into consideration, in the event that the ratio of  $V_{tB}$ , which is the total earthquake load obtained as a result of the combination of above-stated conditions, to the total earthquake load which is calculated from ESLM ( $V_t$ ) is lower than the  $\beta$  value defined below ( $V_{tB} < \beta * V_t$ ), all internal force and translocation magnitudes which have been found according to MCM will be amplified by utilizing Equation 10 (Ünsal 2013).

$$B_D = \frac{\beta * \nabla_t}{\nabla_{tB}} * B_B \tag{10}$$

In the equation above,  $B_D$  is an amplified value which belongs to the  $B_B$  magnitude and  $B_B$  is any magnitude which is found with the combination of mode contributions in RSM (Uçar and Merter 2012). In case of the existence of at least one A1, B2 or B3 irregularity in the building, the  $\beta$  value to be taken into account in Equation 10 will be assumed as 0.90 whereas in the existence of none of these irregularities, the  $\beta$  values will be assumed as 0.80.

# **Analytical Study**

In this study, a reinforced concrete frame model in L-type which does not contain other irregularities has been created for the analysis of buildings with A1 and A3 irregularities. The storey heights have been selected as 3 meters in the designed model. The axle intervals of the building whose total length is 25 meters in both directions have been determined as 5 meters. The designed reinforced concrete building in L-type with eight stories has been modeled in SAP2000 (V.16.1.1).

The building has been thought to be located on a 1st degree seismic earthquake zone and its efficient ground acceleration has been considered as 0.4g as stated in TEC-2007. The soil on which the building is located has been accepted as Z1, Z2, Z3 and Z4 type soil class which is stated in TEC-2007 respectively. On these type of soils, corner periods (spectrum characteristic periods) varies between 0.10 seconds and 0.90 seconds.

In load-bearing system, sections have been determined as 50/50 cm for columns and as 25/50 cm for beams. The sections have been selected as fixed on each story. Base slab foundation thickness has been assumed as 50 cm and the slab thickness designed with beams has been assumed as 15 cm. In the system whose structure geometry has been identified, C30 class concrete and S420 type reinforcement have been used. In addition, the fixed and mobile load in flooring has been accepted as  $g=0.150 \text{ t/m}^2$  ve  $q=0.200 \text{ t/m}^2$ to unit area according to TS-498 (TS-498,1997) and TS-500-2000 (TS-500,2000). 20 cm thick exterior load has been defined as  $g_d=0.625 \text{ t/m}$  and 10 cm thick interior wall load has been defined as 0.4375 t/m.

The plan, horizontal, three dimensional geometry of the related building have been presented in Figure 1 and the parametered which have been taken into account have been presented in Table 2. The investigation of beams and columns have been conducted according to TS-500-2000 and TDY-2007 which are parallel to ACI 318 (ACI 318, 1995). In the earthquake calculation of the building, the reduction coefficient for systems which have high earthquake load ductility levels applicable to frame-type structures has been accepted as 8. In TEC-2007 it is stated that ESLM can be used in buildings with torsion irregularity whose height does not exceed 25 m on the condition that torsion irregularity coefficient  $\eta_{bi} \leq 2$  rule is met. As no condition about MSM exists in the related regulation, earthquake loads have been affected on the building according to these two calculation methods. In modellings, base slab has been ties to the foundation soil with horizontal springs. Column beam connection areas have been selected as rigid. While finding internal force values in TEC-2007, Ex and Ey loadings have been taken as a basis for ESLM and Response SpectrumX (RS<sub>x</sub>)and Response SpectrumY (RS<sub>y</sub>) have been taken as a basis for MCM.





Figure 1. Plan, vertical section and 3 dimensional view of designed structure

Table 2. Parameters that were taken into account for designing L type structure
---

Determination Method and Acceptances for L Type Structure		Equivalent Seismic Load Method	Mode Combination Method
Earthquake Zone		1. Zone	1. Zone
Structure Significance R	atio (I)	1.4	1.4
Behavior Ratio of Load Bearin	g System (R)	8	8
Ductility Level		High	High
Concrete Unit Weight (t/m <sup>3</sup> )		2.54	2.54
Soil Ratio (t/m <sup>3</sup> )	C <sub>z1</sub>	10,000	Soil Ratio (t/m <sup>3</sup> )
	C <sub>z2</sub>	3,000	
	C <sub>z3</sub>	1,500	
	$C_{z4}$	1,000	
	Z1	$T_A = 0.10$ $T_B = 0.30$	
Periods Related to Soil Type			Periods Related to Soil Type(Second
(Second)	Z2	$T_{\rm A} = 0.15$ $T_{\rm B} = 0.40$	
	Z3	$T_A = 0.15$ $T_B = 0.60$	



	Z4	$T_A = 0.20$ $T_B = 0.90$	
Concrete Type		C30	C30
Reinforcement Type		S420	S420
Reduction Ratio of Living Loads		0.6	0.6
Concrete Safety Ratio		1.5	1.5
Reinforcement Safety Ratio		1.15	1.15

The elastic design acceleration spectrums which are stated in the earthquake regulation and determined according to soil groups are obtained with the help of Table 3 and Table 4 below (Urtimür 2012).

51			
Local Soil Types		$T_A(s)$	$T_B(s)$
Z1	A class soils		
	B class soils where	0.10	0.30
	$h_1 \leq 15m$		
Z2	B class soils where h <sub>1</sub> >15m	0.15	0.40
	B class soils where $h_1 \leq 15m$		
Z3	C class soils where15m<	0.15	0.60
	h₁≤50m		
	D class soils where $h_1 \leq 10m$		
Z4	C class soils where h <sub>1</sub> >50m	0.20	0.90
	D class soils where h <sub>1</sub> >10m		

Table 3. Characteristic Periods related to Local Soil Types
---

Table 4. Elastical Acceleration Ratio for Relevant Gaps in Designing

Tuble 4. Elustical / Receleration Ra	tio for Relevant Sups in Designing
Period Gap	$S(T_i)$
$0 \le T \le T_A$	$1+1.5*T/T_{A}$
$T_A \leq T \leq T_B$	2.5
T>T <sub>B</sub>	$2.5^* (T_B/T)^{0.8}$

Elastic acceleration spectrums for each soil class can be obtained as in Figure 2 by putting the characteristic periods presented in Table 3 into the related intervals presented in Table 4 (Livaoğlu and Doğangün 2002).





### **Results of Analytical Study**

The 8-story reinforced concrete frame structure in L type which has torsion irregularity A1 and protrusions in the plan irregularity A3 have been modeled in the study for four different soil classes and its analyses have been conducted. In the case of existence of these two irregularities in the structure for analysis, the change in internal forces which occurs in the face of different soil classes has been analyzed.



The change in internal forces has been grouped as figures and tables according to the data obtained from SAP2000(V.16.1.1) in modellings. Base shear force, base tipping moment and base torsion moment changes have been demonstrated for four different soils in Figure 3,4 and 5 respectively.



Figure 3. Shear Force in Basement Related to Soil Class



Figure 4: Momentum of Basement Over turn Related to Soil Class





Figure 5. Momentum of Basement Torsion Related to Soils Class

As can be seen from the figures above, the change in internal forces which has been calculated by utilizing ESLM and MCM varies according to soil type. Whereas the minimum value in terms of the base shear force and base tipping moment has been calculated with ESLM-Z1, the maximum value has been obtained with ESLM-Z4. While the minimum value in terms of the base torsion moment is in MCM-Z1, the maximum value has been found in MCM-Z4.

As only the structure with A1 and A3 type irregularities is analyzed, it will be appropriate to conduct an investigation for the soft story formation mentioned in earthquake Code (referred to as B<sub>2</sub>in TEC-2007) as well. The rigidity irregularity coefficient ( $\eta_{ki}$ ) according to the equation presented in Table 5 for the formation of soft story in TEC-2007 is indicated as the reduced relative story displacement on the first story of the building  $\Delta_i$  and the story height of the building's first story ( $h_i$ ). For the occurrence of soft story irregularity, the rigidity irregularity coefficient ( $\eta_{ki}$ ) needs to be higher than 2.0.As this value has not been reached in any of the models, it is not possible to mention the formation of soft story. However, it has been observed that this coefficient has been obtained from Reinforced Concrete Frame (BAC8 Z4) the most according to soil class.

Table 5.	Soft Store	v Control
I uble c.	Don Dione	y control

Rigidity Irregularity Between adjecent floors	Model Type Name			
B <sub>2</sub> (Soft Storey)	BAC8 Z1	BAC8 72	BAC8 Z3	BAC8 74
$\left(\frac{\Delta_i}{h_i}\right)_{i=1}$	<u></u>	Ditço_22	<u> </u>	Ditço_24
$\eta_{ki} = \frac{1}{\left(\frac{\Delta_{i+1}}{h_{i+1}}\right)_{ort}} > 2$	1.05	1.06	1.065	1.07

In the event that  $\eta_{bi}$ , which is the torsion irregularity indicating the ratio of the biggest relative story displacement in any story for any of the two perpendicular earthquake directions to the mean relative displacement in the same direction on that story, is higher than 1.2, the existence of A1 irregularity is detected. Whereas in the event that both dimensions of the protrusions in building story plans in two perpendicular directions exceed the 20% of the total plan dimensions in the same directions of that story of the building, the existence of A3 irregularity can be discussed. It has been observed that in all models, the related value has been exceeded for both of the irregularities stated above. While demonstrating the existence of torsion irregularity in Table 6, the fact that this coefficient has been obtained from Reinforced Concrete Frame (BAÇ8\_Z4) the most has been detected.
Torsion Irregularity (A1)	Model Type Name			
	BAÇ8_Z1	BAÇ8_Z2	BAÇ8_Z3	BAÇ8_Z4
$\eta_{bi} = \frac{(\Delta_i)_{max}}{(\Delta_i)_{max}} > 1.2$	1.66	1.72	1.75	1.77

Tablo 6. Torsion Irregularity Control

As the torsion irregularity coefficient is in  $1.2 < \eta_{bi} < 2$  interval in the conducted analyses, the ±%5 additional eccentricity has been amplified by being multiplied with the D<sub>i</sub> coefficient calculated in Equation 11 for both earthquake directions in the calculation of relative story displacements.

$$D_i = \left(\frac{\eta \text{bi}}{1.2}\right)^2 \tag{11}$$

As the rigidity of the system will decrease with the change of the soil class from good to be bad, the increase of the first mode period must be expected. In analyses, the lowest period values have been found for the Z1 class while the highest period values have been found for the Z4 class. The first three mode periods of four different soils have been demonstrated in Figure 6.



Figure 6. First Mod Values Determined for 4 Different Soil Types

Considering the mode periods of four different soil classes, the sufficient vibration mode number has been determined as 5 by taking the effective mass participation ratios into account. The total effective mass participation ratios for different soil classes have been presented in Figure 7.





Figure 8. Alteration of floor displacement values concerning different soil class

5

Number of Floors

6

7

5

Number of Floors

8





Figure 9. Alteration of floor offset values concerning 4 different soil class

## **Results and Discussions**

In this study, the analyses of the A1 and A3 type irregularities, which affect the earthquake performance of structures adversely and cause plan irregularity in plan, for four different soil classes according to EELM and MSM have been examined in line with the conditions stated in TDY-2007. In Accordance with this purpose, an L-type reinforced concrete building with 8 stories has been taken as a model. Models have been created in the plan according to discontinuous different soil class (BAÇ8\_Z1, BAÇ8\_Z2, BAÇ8\_Z3, BAÇ8\_Z4) to be able to observe the irregularities occurring in the plan and the internal force differences these created. In the event that A1 and A3 irregularities exist when the concluded analytical studies for the L-type building stated in Figure 3, 4 and 5 are examined, the occurring change in internal forces has been obtained. Following conclusions have been reached as a result of the conducted analytical study:

- In the analyses conducted according to different soil classes, base shear force, base tipping moment and base torsion moment values have been found. The total design earthquake load (base shear force) and base tipping moment calculated from EELM is higher than the value calculated from MSM. Whereas this value occurs on the Z4 type soil the most, the ration of EELM to MSM is at a 10% level in the base shear force and 9.8% level in the base tipping moment.
- In terms of base torsion moments, however, the value found from MSM is 38.91% higher than the value of EELM. The reason behind this lies in the fact that in EELM, a conclusion is reached by taking all the mode conditions and particularly the distortion mode into consideration contrary to horizontal load which affect as earthquake load.
- Whereas the highest value in terms of the base shear force and base tipping moment in the L-type reinforced concrete structure with A1 and A3 irregularities has been obtained from EDDYY-Z4\_FY, the lowest value has been obtained from MSM-Z1\_FX.
- In terms of the base distortion moment, the highest value has been obtained from MSM-Z4\_Mz while the lowest has been obtained from EELM-Z1\_Mz.
- ✤ As the rigidity of the system will decrease with the change of the soil class from good to be bad, the increase of the first mode period must be expected. Thus, analyses have also found the lowest period values for the Z1 class with 0.939 second and the highest period values for the Z4 class with 1.033 classes.
- Considering the effective mass participation ratio for four different soil classes, the sufficient vibration mode number has been determined the fifth mode as a value which exceeds the 90% value.
- Whereas the model in which the L-type reinforced concrete building exhibited displacement the most in terms of story displacements and effective relative story displacement has been obtained in Z4<sub>x</sub>EELM



and the least displacement has been observed in  $Z1_YMSM$ . While 0.093 meter displacement occurred in the  $Z4_XEELM$  model in terms of story displacement, 0.002760 meter displacement occurred in the  $Z1_YMSM$  model. It is evident that the structure with low period exhibits less displacement.

Lastly, in structures which have been analyzed in this study, no problems which could prevent story floorings from safely transferring earthquake forced to horizontal load-bearing system components has occured. However, the analysis of different structures with A3 irregularity condition in which such a problem may occur is aimed at in future studies.

## References

Arslan, M.H. and Korkmaz, H.H. (2007) "What is to be learned from damage and failure of reinforced concrete structures during recent earthquakes in Turkey?", *Engineering Failure Analysis*, 14.

- Aydınoğlu, M.N. (2011) Zayıf Zeminlerde Yapılan Binalarda Dinamik Yapı Kazık Zemin Etkileşimi İçin Uygulamaya Yönelik Bir Hesap Yöntemi, Boğaziçi Üniversitesi Kandilli Rasathanesi Ve Deprem Araştırma Enstitüsü Deprem Mühendisliği Anabilim Dalı, Rapor No. 2011 / 1.
- Arnold, C. andReitherman, R. (2002) "Building Configuration and Seismic Design", John Wiley&Sons.Inc., New York, USA.
- ACI 318-95, Building Code Requirements for Reinforced Concrete.
- Celep Z., Kumbasar N., (2004) "Deprem Mühendisliğine Giriş ve Depreme Dayanıklı Yapı Tasarımı" İstanbul, Beta Dağıtım.
- Dogangun, A. (2004) "Performance of reinforced concrete buildings during the May 1, 2003 Bingol Earthquake in Turkey", *Engineering Structures*, 26, 841–856.
- Gulay, F.G. and Calim, G. (2003) "A comparative study of torsionally unbalanced multi-storey structures under seismic loading", *Turkish Journal Engineering Environment Science*, 27, 9-11.
- Inan, T. and Korkmaz, K. (2011) "Evaluation of structural irregularities based on architectural design considerations in Turkey", *Structural Survey*, 29, 303-319.
- Inel, M.,Ozmen, H.B. and Bilgin H. (2008) "Re-evaluation of building damage during recent earthquakes in Turkey", *Engineering Structures*, 30, 412–427.
- Korkmaz, A. K. ve Demir, F. (2012) "Yapı-Zemin Etkileşiminin Yapıların Deprem Davranışına Etkileri", Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 3 (1):
- Livaoğlu, R., Doğangün, A., (2002) "Deprem Yönetmeliğindeki Farklı Zemin Sınıflarına Göre Yapı Davranışlarının Irdelenmesi, Gümüşhane ve Yöresini Kalkındırma Sempozyumu", Gümüşhane, **1**, 142-152.
- Ozmen C. and Unay, A.I. (2007) "Commonly encountered seismic design faults due to the architectural design of residential buildings in Turkey", Building and Environment, 42, 1406–1416.
- Öztürk, O., Aksoylu, C., Arslan, M.H. (2015). Frame Type Reinforced Concrete Buildings On The Vertical Load-Bearing System To Address Discontinuity Of Reconstructing. International Burdur Earthquake and Environment Symposium, 7-8-9 May 2015, page: 113-123.
- Sezen, H., Whittaker, A.S., Elwood, K.J. and Mosalam, K.M. (2003), "Performance of reinforced concrete buildings during the August 17, 1999 Kocaeli, Turkey earthquake, and seismic design and construction practise in Turkey", *Engineering Structures*, 25, 103–114.
- Taşan, Z. A., (2012). Comparation Turkish Earthquake Code-1998 (TdY-98) with Turkish Earthquake Code-2007 (TDY-2007), Master's tThesis, Çukurova University. Graduate School Of Natural Sciences. Adana.
- Tezcan, S. (1998) "An Architect's Log Book for Earthquake Resistant Design", Turkish Earthquake Foundation Press, Istanbul, Turkey.
- Tezcan, S. and Alhan, C. (2001), "Parametric analysis of irregular structures under seismic loading according to the New Turkish Earthquake Code", *Engineering Structures*, 23, 600–609.
- TEC. 2007. Turkish Earthquake Code. Ministry of Environment and Urban. Ankara.
- TS500. (2000). Reinforced concrete Structures design and construction Rules. Turkish Standards Institute, Ankara.
- TS 498. (1997). Design Loads for Buildings. Turkish Standards Institute, Ankara.
- Uçar, T. ve Merter, O. (2012) "Binaların Deprem Hesabında Kullanılan Doğrusal Elastik Hesap Yöntemleriyle İlgili Bir İrdeleme", Ordu Üniv. Bil. Tek. Derg.,Cilt:2,Sayı:2,2012,15-31/Ordu Univ. J. Sci. Tech.,Vol:2,No:2,2012,15-31.
- Ünsal, İ. (2013). Regulation Of The Turkish Earthquake Seismic Analysis Methods Of Structures Depending On Examining Geometrisine. Master's Thesis. Çukurova University. Graduate School Of Natural Sciences. Adana.
- Urtimür, S. (2012). Equivalent to using the method of Earthquake Load effects of Earthquake Regions Earthquake Buildings regulation on Buildings to be done shera wall of 2007 According to the Investigation.Master's thesis. Çukurova University. Graduate School Of Natural Sciences. Adana



# INVESTIGATION OF THE EFFECTS OF CONVENTIONAL AND WIPER COATED CARBIDE TOOLS WITH DRY CUTTING ON CUTTING FORCES, SURFACE ROUGHNESS, AND MATERIAL HARDNEES IN TURNING 17-4 PH STAINLESS STEEL

Mustafa AY<sup>1</sup>

<sup>1</sup>Marmara University, Faculty of Technology, Department of Mechanical Engineering, Istanbul-Turkey e-mail:muay@marmara.edu.tr

Gültekin BASMACI<sup>2</sup>

<sup>2</sup>Mehmet Akif Ersoy University, The Faculty of Engineering and Architecture, Istanbul-Turkey e-mail:gbasmaci@mehmetakif.edu.tr

**Abstract:** In this study, an experimental investigation on cutting forces, surface roughness and the hardness of material after machining in turning of 17-4 PH stainless steel using wiper and conventional insert cutting tools with dry cutting condition were presented. The influences of feed rate, depth of cut, and corner radius on surface roughness, cutting force and material hardnesswere examined. In order to optimize the turning process, Taguchi optimization method has been used. The influence of each parameter on obtained results was determined by using analysis of variance (ANOVA). The relationship between dependent parameters and independent parameters were modeled by Regression analysis. The optimal machinability of 17-4 PH stainless steel with coated carbide insert was successfully determined in this study.

**Keywords:** Anova, Taguchi method, wiper and conventional tools, Surface roughness, cutting force, Hardness,

## Introduction

Machining has maintained its importance for years and the researches in this field have been closely followed by the manufacturers. Every act of manufacturing has a cost and there are some factors which determine them. The cost of cutting tools and the cost of the work-piece can be considered as the two important factors in question. Thus, to lower the manufacturing cost and buy the product on cheap, those factors should be taken into consideration.

For the cutting tools to be long lived and to prevent the waste of the raw material by producing the work-piece at the required level of quality, the need for the optimization of the cutting performance and conditions has arisen. To achieve that, the factors which affect the life of the cutting tools and the determination of the quality of the work-piece have been searched by the scientists. The researches have revealed the fact that there are a number of parameters and conditions in turning, which affect the above-mentioned points (Shaw,1984, Cakır,2000). These are geometric properties of the cutting tool, tip angles, approach angle, feed, cutting speed, depth of cut, coatings, cooling liquid, chip breaker form, work-piece, rigidity of the cutting tool etc (Shaw,1984, Cakır,2000, Kurt,2006, Lin,2001). These parameters' being selected suitable to the property of work-piece material reduces the cost of manufacturing and the applied energy with lengthening the life of the cutting tool and the surface quality of the manufactured product (Lin, 2001, Saglam, 2007, Gokkaya, 2006, Field,1989). When all these are taken into consideration, it is obvious that the selection of the cutting parameters in turning is very essential.

The machining of stainless steel inherently generates high cutting temperature, which not only reduces tool life but also impairs the workpiece surface quality (Kumar, 2006, Noordin, 2007). Obtaining the desired surface quality is very important for the functional maintenance of a part. One of the stainless steel family materials most commonly used in the production facility is steel with austenitic structure. The austenitic stainless steels structure is a combination of good mechanical properties and good corrosion resistance (Korkut, 2004, Elbah, 2013, Grzesik, 2006).

In this study, an experimental investigation on cutting forces, surface roughness and the hardness of material after machining in turning of 17-4 PH stainless steel using wiper and conventional insert cutting tools were presented. The influences of feed rate, depth of cut, corner radius, dry cutting condition on surface roughness, cutting force and material hardness were examined. In order to optimize the turning process, Taguchi optimization method was used. The influence of each parameter on obtained results was determined by using analysis of variance (ANOVA). The relationship between dependent parameters and independent parameters were modelled by regression analysis. The optimal machinability of 17-4 PH stainless steel with coated carbide insert was successfully determined in this study.



#### **Materials and Methods**

The samples used in the experimental study were in the shape of stick. Their length was 130 mm and diameter was 25 mm. Chemical composition of 17-4 PH stainless steel were presented in Table 1. A JOHNFORD TC 35 CNC Fanue 0T CNC lathe was used.

Table 1. Chemical composition						
С	Mn	Cr	Mo	Ni	Co	Cu
0.04	0.78	15.9	0.40	4.69	0.06	3.4

In the experimental study, KENNAMETAL KC5010 PVD TiAlN coated conventional (FF) and wiper (FW) inserts were used. The surface roughness value and hardness on the work-piece obtained after the machining process was measured by MAHR-Perth meter and three measurements were performed on the machined surfaces determine the Ra values. For the force measurements, KISTLER 9121 force sensor, KISTLER 5019b charge amplifier and DynoWare analysis program were used.



Figure 1. Experimental set up

## **Experimental Design**

For the experimental design Taguchi method was employed.

$$S / N(\eta) = -10x \log\left(\frac{1}{n} \sum_{i=1}^{n} y_{i^2}\right)$$
 (1)

Experimental factors and their levels were presented in Table 2 and L9 experiment design in Table 3. Schematic drawing of the experimental set up is given in Figure 1.

Table 2. Experimental Factors and Their Levels					
	(A)	(B)	(	(C)	
Parameters	Feed	Depth of cut	Corne	r Radius	
	(mm/rev)	(mm)	(r	nm)	
Level I	0.1	0.4	(	0.4	
Level II	0.2	0.8	(	0.8	
Level III	0.3	1.2		1.2	
<b>Table 3</b> . Taguchi $L_9$ experiment design					
Euronimont		(A)	(B)	(C)	
Experiment	Variables	f	d	r	
INO.		(mm/rev)	(mm)	(mm)	
1	$A_1B_1C_1$	1	1	1	
2	$A_1B_2C_2$	1	2	2	
3	$A_1B_3C_3$	1	3	3	
4	$A_2B_1C_2$	2	1	2	
5	$A_2B_2C_3$	2	2	3	
6	$A_2B_3C_1$	2	3	1	



7	$A_3B_1C_3$	3	1	3
8	$A_3B_2C_1$	3	2	1
9	$A_3B_3C_2$	3	3	2

## **Results and Discussion**

#### **Evaluation of surface roughness results**

In general, the obtained roughness value has been between 0.55-2.37  $\mu$ m, which meets the expectations. The surface roughness values obtained as a result of those 18 experiments are shown in Figure 2.



Figure 2. The surface roughness results

#### **Evaluation of Cutting Forces Results**

In general, the obtained cutting force value has been between 153.42- 390.53 N, which meets the expectations. The cutting force values obtained as a result of those 18 experiments are shown in Figure 3.





#### **Evaluation of Hardness Results**

In general, the obtained hardness value has been between 32.17- 39.67 HRC, which meets the expectations. The material hardness values obtained as a result of those 18 experiments are shown in Figure 4.





Figure 4. The material hardness results

## **Evaluation of ANOVA Results**

In turning of 17-4 PH stainless steel, nine experiments have been carried out using three different factors at three different levels and different Ra, N, and HRC values have been obtained from each experiment. Whether these differences are only a coincidence or result from the factors and the influence of each factor in this answer will be determined by the analysis of variance.

The ANOVA results of the average values of surface roughness are presented in Table 4 and 5. As a result of the machining of 17-4 PH stainless steel with wiper and conventional insert cutting tools, the feed with a proportion of 51.70% and 48.88% has been the most effective factor in the formation of the roughness on the machined surface.

Notations	Degree of freedom	Sum of Squares	Variables	F Ratio	Percentage Ratio (%)
A	2	0.75709	0.37854	25.73	51.70
В	2	0.13016	0.06508	4.42	8.88
С	2	0.57696	0.28848	19.61	39.40
Error (e)	2	0.02942	0.01471		0.02
Total	8	1.49362			100

N.T	E é	a ŝ	** * 1 1		
Notations	Degree of	Sum of	Variables	F Ratio	Percentage
	freedom	Squares			Ratio (%)
A	2	1.03740	0.51870	20.39	48.88
В	2	0.17407	0.08703	3.42	08.19
С	2	0.87927	0.43963	17.9	42.91
Error (e)	2	0.05087	0.02543		0.02
Total	8	2.14160			100

The ANOVA results of the average values of cutting forces are presented in Table 6 and 7. As a result of the machining of 17-4 PH stainless steel with wiper and conventional insert cutting tools, the depth of cut with a proportion of 73.6% and 49.76% has been the most effective factor in the formation of the cutting force on the machining.

## Table 6. ANOVA versus cutting forces for wiper insert



Notations	Degree of freedom	Sum of Squares	Variables	F Ratio	Percentage Ratio (%)
А	2	9712.5	4856.2	40.44	21.06
В	2	33957.7	16978.9	141.38	73.64
С	2	2443.6	1221.8	10.17	05.29
Error (e)	2	240.2	120.1		0.01
Total	8	46354.0			100

Notations	Degree of freedom	Sum of Squares	Variables	F Ratio	Percentage Ratio (%)
A	2	22815.0	11407.5	12.61	45.57
В	2	24914.5	12457.3	13.77	49.76
С	2	2339.6	1169.8	1.29	04.66
Error (e)	2	2339.6	120.1		0.01
Total	8	1809.6			100

The ANOVA results of the average values of material hardness are presented in Table 8 and 9. As a result of the machining of 17-4 PH stainless steel with wiper and conventional insert cutting tools, the corner radius with a proportion of 62.48% and 71.58% has been the most effective factor in the formation of the material hardness on the machined surface.

Table 8. ANOVA versus material hardness for wiper insert

Notations	Degree of freedom	Sum of Squares	Variables	F Ratio	Percentage Ratio (%)
А	2	11.7807	5.8903	11.48	35.30
В	2	0.7406	0.3703	0.72	02.21
С	2	20.8588	10.4294	20.32	62.48
Error (e)	2	1.0263	0.5131		0.01
Total	8	34.4063			100

 Table 9. ANOVA versus material hardness for conventional insert

Notations	Degree of freedom	Sum of Squares	Variables	F Ratio	Percentage Ratio (%)
Α	2	8.9384	4.4692	4.75	25.66
В	2	0.9606	0.4803	0.51	02.75
С	2	24.9444	12.4722	13.25	71.58
Error (e)	2	1.8827	0.9413		0.01
Total	8	36.7261			100

## **Evaluation of Regression Analysis Results**

Regression models aim to determine the relationship between variables where a cause and effect relationship is estimated. In this context, in application of the regression model, estimating that there is a conceptual relationship between independent factors and dependent factors is highly important for the model developer. To formulate a predictive equation between the control factors used during chip removal (feed rate, depth of cut and corner radius) and the result (average surface roughness, cutting force, material hardness) and to define this relationship, linear regression analysishas been used. A represents the feed rate, B cutting depth and C corner radius. In addition,  $\varepsilon$  stands for inaccuracy.

Linear regression coefficients were obtained using equations 2 to 7, where  $\varepsilon$  indicates error. R<sup>2</sup> is the coefficient expressing the appropriateness of the equation. Although an acceptable value of R<sup>2</sup> can vary depending on the



relationships between dependent and independent variables used in each discipline or model, the optimal value is the one that is closest to 1. As  $R^2$  gets closer to 1, it is considered that statistical approximation of the regression model to the real relationship increases. A regression model represents the relationship between the dependent and independent variables. According to Pearson coefficient, If  $R^2$  has a value of 0.80 and greater, it is considered a strong relationship, while 50-70% is considered to be a moderate relationship. In this case, when the modeled statistical regressions (Equations 2 to 7) are analyzed, it is understood that they are within acceptable limits. There is a particularly strong relationship between the variables in Equation 6. Based on this finding, it is concluded that the factors (independent factors) selected in the experimental study as having a strong effect on dependent variables (surface roughness, cutting force, material hardness) were accurately estimated. In this case, it is concluded that the regression model provides a good estimation of reality.

The Ra equation formulated for this experimental study is represented below wiper and conventional insert: Surface Roughness (Wiper Insert) =  $0.748 + 0.353 \text{ A} + 0.0850 \text{ B} - 0.285 \text{ C} + (\varepsilon)$  (2)

$$R^2 = 0.857$$

In this equation, the coefficient of determination of the equation is 0.857.

Surface Roughness (Conventional Insert)= $1.00+0.415 \text{ A} + 0.062 \text{ B} - 0.348 \text{ C} + (\epsilon)$  (3) R<sup>2</sup> = 0.833

In this equation, The coefficient of determination of the equation is 0.833.

The cutting force equation formulated for this experimental study is represented below wiper and conventional insert:

Cutting Force (Wiper Insert) = 55,0 + 38,3 A + 73,1 B + 14,1 C +( $\epsilon$ ) (4) R<sup>2</sup> = 0.907

In this equation, The coefficient of determination of the equation is 0.902.

Cutting Force (Conventional Insert) =  $39,4 + 59,3 \text{ A} + 64,4 \text{ B} - 19,3 \text{ C} + (\varepsilon)$  (5)

$$R^2 = 0.929$$

In this equation, The coefficient of determination of the equation is 0.929.

The Material Hardness equation formulated for this experimental study is represented below wiper and conventional insert:

Material Hardness (Wiper Insert) =  $30,0 + 1,39 \text{ A} + 0,342 \text{ B} + 1,85 \text{ C} + (\epsilon)$  (6) R<sup>2</sup> = 0.954

In this equation, The coefficient of determination of the equation is 0.954.

Material Hardness (Conventional Insert) = 29,1 + 1,21 A+ 0,208 B + C +( $\varepsilon$ ) (7) R<sup>2</sup> = 0.924

In this equation, The coefficient of determination of the equation is 0.924.

## Conclusion

This study of the machinability of 17-4 PH stainless steel alloy material with KENNAMETAL KC5010 PVD TiAlN coated conventional (FF) and wiper (FW) inserts have produced some useful results. The criteria for the machinability are surface roughness, cutting force and material hardness. Three control factors which were considered to be effective in creating the most suitable conditions for the criteria (feed rate, depth of cut and corner radius) were chosen at three different levels and applied in the experimental study. Below is the summary of the results:

- The most effective control factor on the surface roughness value on the machined surface is feed rate. It has also been observed that feed is the most serviceable factor, still depth of cut and cutting speed play a role as well.
- The effective parameters for the increase of cutting forces are depth of cut, cutting speed and feed rate.
- The most effective control factor on the surface material hardness is in the direct proportion with corner radius and wiper insert.
- Taguchi method is beneficial for the experimental design of the machinability of 17-4 PH stainless steel alloy material. Having optimized the parameters, it is also fruitful for keeping the response values at required levels.
- The analysis of variance (ANOVA) is helpful in determining which control factor has how much importance in the determination of the results obtained from the experimental study.
- The test results prove the effectiveness of the wiper inserts in providing excellent surface roughness. The results also suggest that the use of the wiper insert is an effective way that significantly increases cutting efficiency without changing the machined surface roughness in high feed turning operations.

## Acknowledgments



The authors would like to express their gratitude to the University of Marmara for the financial support Under Project No. FEN-D-110815-0384.

#### References

Shaw M.C. (1984). Metal cutting principles. Oxford University pres.

Cakır MC (2000). Modern Machining Methods. VIPAS A.S. 349-410.

Kurt A., (2006). Cutting Forces Generated During Machining and Mechanical Stresses The Creation of Mathematical Models and Experimental Investigation. *Gazi University Institute of Pure and Applied Sciences Mechanical Education Branch PhD. Thesis.* 

Lin W.S., Lee B.Y., Wu C.L., (2001). Modelling the surface roughness and cutting force for turning, *International Journal of Materials Processing Technology*. 108: 286-293.

Saglam H., Yaldiz S., Unsacar F., (2007). The effect of tool geometry and cutting speed on mail cutting force and tool tip temperature. *Materials and Design. 28: 101-111*.

Gokkaya H., Nalbant M., (2006). Formation and Distribution of Temperature During Chip Removal Cutting. *Electronic Journal of Machine Technology.* 2: 33-43.

Field M., Kahles J.F., Koster W.P., (1989). Surface finish and surface integrity. *Metals Handbook-Machining-16*. *Ninth Edition. ASM International Materials Park-Ohio.* 19-36.

Kumar, A. S. Durai, A. R. Sornakumar, T. (2006) The effect of tool wear on tool life of alumina-based ceramic cutting tools while machining hardened martensitic stainless steel, *Journal of Materials Processing Technology*, *vol. 173, p.p. 151-156*.

Noordin, M.Y. Venkatesh, V.C. Sharif, S. (2007). Dry turning of tempered martensitic stainless tool steel using coated cermet and coated carbide tools, *Journal of Materials Processing Technology, vol. 185, p.p. 83-90.* 

Korkut, I. Kasap, M. Çiftçi, I. Şeker, U. (2004) Determination of optimum cutting parameters during machining of AISI 304 austenitic stainless steel, *Materials and Design, vol. 25, pp 300-305*.

Noordin, M. Y., Kurniawan, D. and Sharif, S. (2007). Hard turning of stainless steel using wiper coated carbide tool. *International Journal of Precision Technology1.1:* 75-84.

Jawahir, I. S., et al. (2011). Surface integrity in material removal processes: Recent advances. CIRP Annals-Manufacturing Technology 60.2: 603-626.

Elbah, M. et al. (2013) Comparative assessment of wiper and conventional ceramic tools on surface roughness in hard turning AISI 4140 steel. *Measurement*. *Volume 46, Issue 9, Pages 3041–3056*.

Grzesik, W., and Wanat. T. (2006) Surface finish generated in hard turning of quenched alloy steel parts using conventional and wiper ceramic inserts. *International Journal of Machine Tools and Manufacture* 46.15: 1988-1995.



## MACWILLIAMS IDENTITIES OF LINEAR CODES OVER THE RING



Mehmet ÖZEN and Fatma Zehra UZEKMEK

Department of Mathematics, Sakarya University, Turkey

ozen@sakarya.edu.tr, zehra.uzekmek@hotmail.com

Abstract: Linear codes are considered over the ring  $\frac{\mathbb{Z}_4 \lfloor u \rfloor}{\langle u^2 - 1 \rangle}$ . The Lee weight enumerators,

the complete weight enumerators and the symmetrized weight enumerators for the linear codes over the ring  $R = \frac{\mathbb{Z}_4 \lfloor u \rfloor}{\langle u^2 - 1 \rangle}$  are defined and Gray map  $\Phi$  from  $R \to \mathbb{Z}_4$  is constructed.

Then, MacWilliams identities for these weight enumerators are proved.

Keywords: Weight enumerator, MacWillims identities

## **Introduction and Motivation**

involved.

Attracted the attention of many coding theory researchers in the last two decades are codes over rings. So, codes over the ring have been a common research topic in coding theory. The interest in codes over rings started with the seminal work in 1994 (Hammons, Kumar, Calderbank, Sloane and Sole) and expanded in many directions. Because decoding algorithm is more quickly, linear codes are more useful than other codes, especially. So, linear codes are an important and intensely studied class of codes. Another research topic in coding theory is MacWilliams identity which relates the weight enumerator of linear code to the weight enumerator of its dual code. Yildiz and Karadeniz analysed for MacWilliams identity, projections and formally self dual codes over  $\mathbb{Z}_4 + u\mathbb{Z}_4$  in the linear codes. Consequently, they found optimal code. Using Gray map, R. Bandi and M. Baintwal determined MacWilliams identity for Lee and Gray enumerator over the ring  $\mathbb{Z}_4 + u\mathbb{Z}_4$ , where  $v^2 = v$ . There is a connection between  $\mathbb{Z}_4$  and  $F_2 + uF_2$  which has generated a lot of among coding researchers starting with Dougherty, Gaborit, Harada and Sole's work in 1999. Considered by this similarity (and difference) between two  $\mathbb{Z}$  [u]

rings and Yildiz and Karadeniz's works at references, we study codes over the ring  $\frac{\frac{\omega_4 \mathbf{L}^* \mathbf{J}}{\langle u^2 - 1 \rangle}}{\langle u^2 - 1 \rangle}$ . In 2006, Yu and Zhu investigated MacWilliams identity over the ring  $F_2 + uF_2$ . In Yildiz and Karadeniz's article (2010), the researchers discussed the linear codes over  $F_2 + uF_2 + vF_2 + uvF_2$ , as well as MacWilliams identity for the complete and Lee weight enumerator over the ring. In 2015, J. Gao studied linear codes over the ring  $F_p + uF_p + u^2F_p$ , where p is an odd prime and also defined Gray map and MacWilliams identity of linear codes.

In this article, mainly focused on  $\mathbb{Z}_4 + \mathbb{Z}_4$ , where  $u^2 = 1$ . In Section II, we are considered linear codes over the ring  $\mathbb{Z}_4 + u\mathbb{Z}_4 = \{b + (a - b)u \mid a, b \in \mathbb{Z}_4\}$ , where  $u^2 = 1$ , we define linear Gray maps from  $\mathbb{Z}_4 + u\mathbb{Z}_4$  to  $\mathbb{Z}_4^{2n}$ and we give definitions of Lee distance and dual code of linear code. In Section III, we have studied complete, symmetrized and Lee weight enumerators and proved MacWilliams identity for all the weight enumerators



Lee Weight and Gray Map of Linear Codes Over the Ring  $\frac{\mathbb{Z}_{4}[u]}{\langle u^{2}-1\rangle}$ 

**Definition 1** A linear code *C* of length *n* over  $R = \frac{\mathbb{Z}_4[u]}{\langle u^2 - 1 \rangle}$  is an *R*-submodule of *R<sup>n</sup>*. Elements of *C* are called codewords.

**Definition 2** For any  $z = b + (a - b)u \in R$  and  $a, b \in \mathbb{Z}_4$ , we define the Gray map  $\phi: R \to \mathbb{Z}_4^2$  by  $\phi(z) = (b, a + b)$ .

**Definition 3** The Lee weight  $w_L(z)$  of  $z \in \mathbb{Z}_4$  is min  $\{x, 4-x\}$ . The Lee weight of a vector in  $v \in \mathbb{Z}_4^n$  is then defined as the rational sum of the Lee weight of its coordinates. So, we can define the Lee weights of an element of  $z = b + (a-b)u \in R$  as  $w_L(z) = w_L(b+(a-b)u) = w_L((b,a+b))$ . For any  $z_1, z_2 \in \mathbb{R}^n$ , the Lee distance is given by  $d_L(z_1, z_2) = w_L(z_1 - z_2)$ .

The minimum Lee Distance of C is defined by  $d_L(C) = \min_{c_1, c_2 \in C} d_L(c_1, c_2)$  and the minimum Lee weight of C

is defined by  $w_L(C) = \min_{\substack{c_1, c_2 \in C \\ c_1 \neq c_2}} w_L(c_1, c_2)$ . So, if C is a linear code, then the minimum Lee weight is equal to

minimum Lee distance.

**Theorem 4** The map  $\phi$  is a distance preserving linear isometry from  $R^n$  to  $\mathbb{Z}_4^{2n}$  with Lee weight.

**Corollary 5** If C is linear code over R of length n, then  $\phi(C)$  linear code over  $\mathbb{Z}_4$  of length 2n.

**Definition 6** For  $x = (x_1, x_2, ..., x_{n-1})$ ,  $y = (y_1, y_2, ..., y_{n-1}) \in \mathbb{R}^n$ , the Euclidean inner product on  $\mathbb{R}^n$  by defining

$$\langle (x_0, x_1, \dots, x_{n-1}), (y_0, y_1, \dots, y_{n-1}) \rangle = x_0 y_0 + x_1 y_1 + \dots + x_{n-1} y_{n-1}$$

where the operations are performed in  $\mathbb{Z}_4 + u\mathbb{Z}_4$ .

**Definition 7** Let C be a linear code over  $\mathbb{Z}_4 + u\mathbb{Z}_4$  of length n. Then, the dual code of C is defined as follow:

$$C^{\perp} = \left\{ x \in \mathbb{R}^n : \left\langle x. y \right\rangle = 0, \ \forall \ y \in C \right\}$$

## Weight Enumarators and MacWilliams Identities 3.1 The Complete Weight Enumarators and MacWilliams Identities $\mathbb{Z}_4 + u\mathbb{Z}_4 = \{s_1, s_2, \dots, s_{16}\}$ be given as

 $\mathbb{Z}_{_4} + u\mathbb{Z}_{_4} = \left\{0, u, 2u, 3u, 1, 1+u, 1+2u, 1+3u, 2, 2+u, 2+2u, 2+3u, 3, 3+u, 3+2u, 3+3u\right\}.$ 

**Definition 8** Let  $n_{s_i}(\overline{c})$  be the number of  $s_i(\overline{c})$  in the vector  $\overline{c}$ . The complete weight enumerator of a linear code over  $\mathbb{Z}_4 + u\mathbb{Z}_4$  is defined as



$$cwe_{C}(x_{1}, x_{2}, \dots, x_{16}) = \sum_{\bar{c} \in C} \left( x_{1}^{n_{s_{1}}(\bar{c})} x_{2}^{n_{s_{2}}(\bar{c})} \dots x_{16}^{n_{s_{16}}(\bar{c})} \right).$$

Because  $\mathbb{Z}_4 + u\mathbb{Z}_4$  is a Frobenius ring, the MacWilliams identities for the complete weight enumerator is preserve. Now we define the character on  $\mathbb{Z}_4 + u\mathbb{Z}_4$  to find the exact identities.

**Definition 9** Define  $\chi: \mathbb{Z}_4 + u\mathbb{Z}_4 \to \mathbb{C}^{\times}$  by  $\chi(b + (a - b)u) = i^{a+b}$ . Let the 16×16 matrix is *T*, by giving  $T(i, j) = \chi(s_i, s_j)$ . Then, *T* is defined as follows:

**Theorem 10** Let C is a linear code over  $\mathbb{Z}_4 + u\mathbb{Z}_4$  of length n and  $C^{\perp}$  is a dual code of C.

$$cwe_{C^{\perp}}(x_1, x_2, \dots, x_{16}) = \frac{1}{|C|} cwe_{C}(T.(x_1, x_2, \dots, x_{16})^{t})$$

where T is the  $|R| \times |R|$  matrix and  $T(i, j) = \chi(s_i, s_j)$ .

(Here  $()^{t}$  denotes the transpose.)



## 3.2 The Symmetrized Weight Enumarator and Lee Weight Enumarator

Firstly, we define the Lee weights of the elements of  $\mathbb{Z}_4 + u\mathbb{Z}_4$ .

1 4010	$3.11 \pm 4$ $10 \pm 4$ total often	amarin 200 agrinklari
d	d nin Lee Ağırlığı	Değişken Karşılıkları
0	0	<i>X</i> <sub>1</sub>
и	1	X <sub>2</sub>
2 <i>u</i>	2	X <sub>3</sub>
3и	1	X 4
1	3	X <sub>5</sub>
1 + <i>u</i>	2	X <sub>6</sub>
1+2 <i>u</i>	1	X <sub>7</sub>
1+3 <i>u</i>	2	X <sub>8</sub>
2	2	X,,
2 + <i>u</i>	3	$X_{_{10}}$
2 + 2 <i>u</i>	4	X <sub>11</sub>
2 + 3 <i>u</i>	3	X <sub>12</sub>
3	3	X <sub>13</sub>
3 + <i>u</i>	2	X 14
3 + 2 <i>u</i>	1	X <sub>15</sub>
3 + 3 <i>u</i>	2	X 16

Tablo 3.1:  $\mathbb{Z}_4 + u\mathbb{Z}_4$  teki elemanların Lee ağırlıkları

Now we can define the symmetrized weight enumerator as follow:

**Definition 11** Let *C* be a linear code of length *n* over  $\mathbb{Z}_4 + u\mathbb{Z}_4$ . Then, the symmetrized weight enumerator of *C* as

$$swe_{c}(X, Y, Z, W, S) = cwe_{c}(X, Y, Z, Y, W, Z, Y, Z, Z, W, S, W, W, Z, Y, Z)$$
.

Here X represents the element have weight 0, Y represents the element have weight 1, Z represents the element have weight 2, W represents the element have weight 3, S represents the element have weight 4.

**Theorem 12** Let C be a linear code of length n over  $\mathbb{Z}_4 + u\mathbb{Z}_4$  and let  $C^{\perp}$  be its dual. Then, we have

$$swe_{c^{\perp}}(X, Y, Z, W, S) = \frac{1}{|C|} \cdot swe(X + 4Y + 4W + 6Z + S, X - 2Y + 2W - S, X - 2Z + S, X + 2Y - 2W - S, X - 4Y + 6Z - 4W + S)$$



**Definition 13** Let *C* be a linear code of length *n* over  $\mathbb{Z}_4$ . Then, the Lee weight enumerator of *C* is defined as follow:

$$Lee_{C}(Y, X) = \sum_{\overline{c} \in C} Y^{4n - w_{L}(\overline{c})} X^{w_{L}(\overline{c})}$$

**Definition 14** Let *C* be a linear code of length *n* over  $\mathbb{Z}_4 + u\mathbb{Z}_4$ . Then,

$$Lee_{c}(Y, X) = swe_{c}(Y^{4}, Y^{3}X, Y^{2}X^{2}, YX^{3}, X^{4}).$$

Lee weight and n of C is defined as follow:

1) 
$$w_{L}(c) = \alpha_{1} + 2\alpha_{2} + 3\alpha_{3} + 4\alpha_{4}$$

2)  $n = \alpha_0 + \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4$ 

Here  $\alpha_i$  is the number of weight *i*, where i = 0, 1, 2, 3, 4.

**Theorem 15** Let C be a linear code of length n over  $\mathbb{Z}_4 + u\mathbb{Z}_4$  and let  $C^{\perp}$  be its dual. Then,

$$Lee_{C^{\perp}}(Y,X) = \frac{1}{|C|} Lee_{C}(Y+X,Y-X).$$

#### Conclusions

In this paper we searched linear codes over the ring  $\frac{\mathbb{Z}_4[u]}{\langle u^2 - 1 \rangle}$ . Lee weights, Gray maps and all weight enumerators for these codes are defined and MacWilliams identities for the complete, symmetrized and Lee weight enumerators proved.

#### References

S.T. Dougherty, P. Gaborit, M. Harada & P. Sole (1999). Type II Codes over  $F_2 + uF_2$ , IEEE Trans. Inform. Theory, 45, 32-45.

B. Yildiz & S. Karadeniz (2014). Linear Codes over  $\mathbb{Z}_4 + u\mathbb{Z}_4$ : Macwilliams Identities, Projections and Formally Self-Dual Codes, Finite Fields Appl., 27, 24-40.

Yu H. & Zhu S. (2006). Identities of linear codes and their Codes over  $F_2 + uF_2$ , Journal of University of Science and Technology of Chain, 36 (12): 1285-1288.

R.K. Bandi &M. Baintwal, Codes over  $\mathbb{Z}_4 + u\mathbb{Z}_4$ , IEEE.

B. Yildiz & S. Karadeniz (2010). Linear Codes over  $F_2 + uF_2 + vF_2 + uvF_2$ , Des. Codes Crypt., 54: 61-81.

J. Gao (2015). Some Results on Linear Codes over  $F_p + uF_p + u^2F_p$ , J. Appl. Math. Comput., 47:473-485.

A.R. Hammons, P.V/ Kumar, A.R. Calderbank, N.J.A. Sloane & P. Sole (1994). The  $\mathbb{Z}_4$  Linearity of Kerdock, Preparata, Goethals and Related Codes, IEEE Transactions on Information Theory, Vol. 40, No.2, pp. 301-319.



## PROCESS IMPROVEMENT: AN APPLICATION AT GAZIOSMANPAŞA UNIVERSITY

<sup>1</sup>Münevver Çiçekdağı, <sup>2</sup>Kadir Ardıç

<sup>2</sup>Sakarya Üniversitesi, İşletme Fakültesi, İşletme Bölümü, Serdivan, Sakarya

<sup>1</sup>munevverylmz@gmail.com, <sup>2</sup>kadirardic@sakarya.edu.tr

Abstract: The importance society, which well analyzes its past and wants its future with the better living standards, gives to quality increased as much as the importance it gives to education that a business provides a competitive advantage is very closely related to at what degree the scientific methods are applied in it, because these scientific methods emerged from the specialists' analyzing the concept quality and the ways of increasing quality coming into their faces as a result of their discussing on the customer expectations over years. In many businesses producing goods and services, in order to reach the competitive conditions, although it is seen that process improvement techniques similar to this are utilized, it is a disputable issue at what level the applicability of this information taught in high education institutes is. In this study, it is aimed that it is seen that the statistical process improvement techniques, mentioned in the theory, are easily applicable at the application point and that its results will serve the increase of quality, even if at the long term. In the study, examining the basic statistical process control techniques with a group consisting of the students of Faculty of Economic and Administrative Sciences, Gaziosmanpaşa University, the processes, where it is seen that there are some deficiencies, were discussed via the technique of brain storming and, for the processes selected, constituting the fishbone diagrams, the sub-causes were descended. Then, the main process enabling to improve was selected. This process was examined by means of workflow charts and it was studied what will be able to do about improvement and the new flow schemes were drawn. Thanks to this, it became possible to take the quality under control, provide high quality, increase productivity, increase customer satisfaction, and reduce time loss.

Keywords: Statistical Proses Control, Process Improvement, Quality

## Introduction

Today, the developing international competition and approach of business and management have urged the institutes to search for perfection. The main esprit of new approach is that it does not regard to anything as occurred and disappeared and accepts everything in the state of occurring. As a result of this search, one of the points reached is also Total Quality Management (TQM) ((Özdemir, 2002: 253).)

TQM approach, instead of result oriented management like classical management approaches, prefers a process and result oriented management. In turn, the controls to be done reveal a state as sorting the defects out and increasing costs. If the result is not only kept under control but also processes, as a result, predicting and preventing the defects faced will be under consideration (Milli Eğitim Bakanlığı, 2007: 21).

TQM approach becomes widespread every passing days and it is recently discussed to implement it in the educational institutes. As in manufacturing businesses, universities have also the inputs, processes, outputs and customers. Universities, due to the conditions introduced by competition, in the direction of the satisfaction, desires, and expectations the internal and external customers, are obliged to increase qualities of the inputs, outputs, and processes (Serin and Aytekin, 2009: 83).

Approach of continuous development, the main philosophy of TQM, constitutes the core of "Developing Process Performance and Process Management. Today, "quality, cost, and speed" are the main elements determining that organizations compete in the national and international areas. This situation inherently forces the institutes to rapidly change and continuously modify their processes. If we adapt this logic to education, instead of supervising the success of education in the last stage of education, in an educational institute, it will be necessary to control (in the more correct expression, to manage) each process that will affect the achievement of student such as (Milli Eğitim Bakanlığı, 2007: 77-78)

➢ Management,

- Selection and education of human resource,
- Preparation of educational environment,
- Course tools and equipment
- Educational programs



- Education activities
- Counselling services
- Measurement and Assessment etc.

This will bring the possibility to see the deficiencies, if available, and take action in the management before the graduation of student.

Determining, defining, and having, and continuously monitoring the business processes of an organization can be defined as "process management". However, the point that is important is: If process management incorporates "improvement", it cannot be called "process management" (Karapınar, 2006: 88) In education, TQM means meeting the needs and expectations of the internal and external customers i.e.

In education, TQM means meeting the needs and expectations of the internal and external customers i.e. Students, teachers, school employees, guardians, society, and public and private organizations. These expectations are that the internal customers are proud of the education and activities carried out in the school, while the external customers enjoy from the aspect of that the students and graduates gain the behaviors in the desired qualities (Kwan, 1996: 25).

While the educational business provide quality, they have to use the resources effectively without wasting and, in this context, to limit the costs. Measurement of quality has importance as much as forming the conditions of quality. About defining and measuring the quality of products, statistical methods of quality controls were developed. In the businesses producing products, defining and measuring the quality of products can easily materialize, depending on the quantitative criteria and methods. However, due to the idiosyncratic features of service, it becomes difficult to measure it in terms of product (Eleren, 2007: 4-5).

In the study, for the process of educational service in the university to be managed well, beginning from selecting the process to be improved, it was examined what should be done on the name of becoming high quality of output and sustainability of this quality. The main techniques used in the management of processes are brain storming, fishbone diagram, and other process flowcharts. With these techniques, taking under control the changes in the service formation, it is targeted to provide the compatibility of service with the previously determined quality standards, to minimize the defects and cost resulted from this, to provide time saving, and to increase the competitive power, bringing the new and useful skills in the business.

In selecting Gaziosmanpaşa University, established in 1992, as implementation region of the study of process improvement, the aim of contributing the continuation of the success it shows increasingly until today also plays role in the following years. In this improvement study, it was decided that the main techniques of statistical quality control were the most convenient method that can be used in data collecting and measuring.

The identifications conducted in the study are considered to make guidance for the post graduate studies that will be carried out after that. With this study, it is considered that the deficiencies about the quality of education and service in Gaziosmanpaşa University will be noted and it will be a light about improving it.

## The Instruments and Methods of Process Improvement

The main aim in developing process performance, reducing the operation steps, with the expression of Bill Gates, is to realize to produce service in the light speed and, eliminating the defects in the operation on the process basis, to reach to zero defect. In this approach, processes are continuously questioned and defined; the variability is measured; whether or not the variability is normal is identified; and, if necessary, applying the corrective operations, the process is developed. Thus, making dominant a process oriented approach, not result oriented, on the system, realizing managerial approach of a zero defect production becomes possible (Milli Eğitim Bakanlığı, 2007: 21).

In total quality management, instruments of statistical process control, one of the instruments used to problem solving and continuous improvement, analyze the abilities of the processes and machinery. The main instruments, utilized in statistical process control, are widely known as seven quality instruments. Especially, in determining and solving the problems that do or will emerge in the application process, and forming the necessary data, it can be said that they are very useful. Statistical methods were designed to facilitate smoothly uncovering the data and provide these data to be evaluated with a systematic approach (Gümüşoğlu, 2000: 139).

#### Main Statistical Methods

In this section, main seven instruments, emphasized with by Ishikawa, among the instruments and methods of quality improvement, and technique of brain storming ere mentioned. These techniques are divided into three categories according to those used in problem defining and problem analyzing.



Techniques of Problem Defining	Techniques of problem defining and analyzing	Techniques of Problem Analyzing
Grouping data	Pareto analysis	Histogram
Brain Storming	Cause-Effect Scheme	Distribution Diagram
Control Table		Control Chart

Table 1. Graphical Techniques Used in Problem Solvin
--

Resource: Bozkurt, 1998: 173

#### Cause-Effect Diagram (Fishbone Diagram) (Ishikawa Diagram)

Recognition of diagram as an analysis method, its becoming widespread, and adaptation to the activities of quality circle had been thanks to Professor Kaoru Ishikawa. Therefore, the method, known in the literature as Ishikawa diagram and fishbone diagram, due to its shape, is an important instruments the quality circles have used to detect and monitor the causes of quality problems. The points, on which the members of circle generally study related to each factor, are (Simşek, 2004: 279-280):

• The quality levels of materials, defect rates, and their effects on the production works, elements that should be corrected in the supply works;

• The scopes of documents related to method, their clearance degrees, their sufficiency levels;

• The problems in the use of machinery and equipment and the possibilities to be able to improve;

• Whether or not it is possible to supervise oneself; if available, the way of improving this, identification of the acceptable defects and necessary correction rates; and the time and possibilities that should be provided for labor force;

• The productivity insufficiencies and defects resulted from labor force; elimination of the needs such as education and innovation to be able to continuously improve the quality;

• Fishbone diagram should be used to detect the possible main causes, to relate and pot in order the interactions, and to analysis the existing problems (Genel Kurmay Başkanlığı, 1999: 6-1).

#### **Brain Storming**

Brain storming was first developed and applied by Greeks. In those ages, brain storming is known as "heuristics". In 1940s, Dr. Alex Osborn, used brain storming in advertisement, his own job. Later, the technique has been begun to be used for the industrial aims (Bozkurt, 1998: 174).

Brain storming is a method serving to detect the problem and solution of problem. It aims to uncover the remained hidden views and think of differently. Everybody participates in brain storming The problems are put in order. The person wanting to speak about these suggests his/her views in order. For brain storming to be able to apply successfully, it is necessary for the problem to be understandable, to avoid the repetition in the solution of problem, and not to be entered the detail while examining the problem (Doğan, 2002: 51).

During brain storming (Doğan, 2002: 51-52),

- The thoughts verbalized cannot be criticized.
- At the beginning stage, any discussion cannot be made related to any thought.
- It is not worried due to the thoughts verbalized.
- Everybody listens to each other carefully.
- Confliction environment cannot be formed.
- Each thought is written onto paper or blackboard. While being written, the name of opinion's owner is not written.
- Everybody is obliged to talk at least one time.



#### The difficulties Faced in Applying the Instruments and Methods of Process Improvement

In application of total quality management, some difficulties are faced.

Lack of Quality Policies and their Aims           Deficiency of Coordination           Data Insufficiency           That quality cannot be thought of a function of management           That quality cannot be thought of a function of management           That the management makes an assessment according to the amount of product produced; that quality responsibility cannot be thought of at the business level           Participation in the seminars about quality and deficiency of reading           Educational deficiency about the basic statistical methods           Not being able to apply the new procedures on quality           Not being able to sufficiently utilize from the motivational methods           High employee turnover rates           Giving responsibility to those having inadequate educational level           Technological and Economic Difficulties           Difficulties Resulted from the External Factors           The effect of government policy on producing high quality product           The delayed and disconnected relationships between TSE, MPM, DPT, university and industry           Nor quality in raw material and industry		Difficulties of Total Quality Management
Deficiency of Coordination           Data Insufficiency           That quality cannot be thought of a function of management           That quality cannot be thought of a function of management           That the management makes an assessment according to the amount of product produced; that quality responsibility cannot be thought of at the business level           Participation in the seminars about quality and deficiency of reading           Educational deficiency about the basic statistical methods           Not being able to apply the new procedures on quality           Not being able to sufficiently utilize from the motivational methods           High employee turnover rates           Giving responsibility to those having inadequate educational level           Technological and Economic Difficulties           Difficulties Resulted from the External           The effect of government policy on producing high quality product           Difficulties Resulted from the External           Factors		Lack of Quality Policies and their Aims
Data Insufficiency           Difficulties Resulted from the Management         That quality cannot be thought of a function of management           That quality cannot be thought of a function of management         That the management makes an assessment according to the amount of product produced; that quality responsibility cannot be thought of at the business level           Human –Education Difficulties         Participation in the seminars about quality and deficiency of reading           Educational deficiency about the basic statistical methods         Not being able to apply the new procedures on quality           Not being able to sufficiently utilize from the motivational methods         High employee turnover rates           Giving responsibility to those having inadequate educational level         Insufficiency of the material, equipment, and the other facilities used in quality control and development           The effect of government policy on producing high quality product         The delayed and disconnected relationships between TSE, MPM, DPT, university and industry		Deficiency of Coordination
Difficulties Resulted from the Management       That quality cannot be thought of a function of management         That the management makes an assessment according to the amount of product produced; that quality responsibility cannot be thought of at the business level         Participation in the seminars about quality and deficiency of reading         Human –Education Difficulties       Educational deficiency about the basic statistical methods         Not being able to apply the new procedures on quality       Not being able to sufficiently utilize from the motivational methods         High employee turnover rates       Giving responsibility to those having inadequate educational development         The effect of government policy on producing high quality product       Insufficiency in applying industrial methodology and measurements         Difficulties Resulted from the External Factors       The effect of government policy on producing high quality product         Difficulties Resulted from the External Factors       The delayed and disconnected relationships between TSE, MPM, DPT, university and industry		Data Insufficiency
Difficulties Resulted from the Management         management           That the management makes an assessment according to the amount of producet produced; that quality responsibility cannot be thought of at the business level         Participation in the seminars about quality and deficiency of reading           Human –Education Difficulties         Participation in the seminars about quality and deficiency of meading           Educational deficiency about the basic statistical methods         Not being able to apply the new procedures on quality           Not being able to be understood the concept and policy of quality         Not being able to sufficiently utilize from the motivational methods           High employee turnover rates         Giving responsibility to those having inadequate educational level           Technological and Economic Difficulties         Insufficiency in applying industrial methodology and measurements           Difficulties Resulted from the External Factors         The effect of government policy on producing high quality product           Difficulties Resulted from the External Factors         The delayed and disconnected relationships between TSE, MPM, DPT, university and industry		That quality cannot be thought of a function of
Human -Education DifficultiesThat the management makes an assessment according to the amount of product produced; that quality responsibility cannot be thought of at the business levelHuman -Education DifficultiesParticipation in the seminars about quality and deficiency of readingHuman -Education DifficultiesEducational deficiency about the basic statistical methods Not being able to apply the new procedures on quality Not being able to be understood the concept and policy of quality Not being able to sufficiently utilize from the motivational methodsHigh employee turnover rates Giving responsibility to those having inadequate educational levelTechnological and Economic DifficultiesInsufficiency of the material, equipment, and the other facilities used in quality control and developmentDifficulties Resulted from the External FactorsThe effect of government policy on producing high quality productDifficulties Resulted from the External FactorsThe effect of government policy on producing high quality product	Difficulties Resulted from the Management	management
Participation in the seminars about quality and deficiency of readingHuman –Education DifficultiesEducational deficiency about the basic statistical methods Not being able to apply the new procedures on quality Not being able to be understood the concept and policy of qualityNot being able to sufficiently utilize from the motivational methodsHigh employee turnover rates Giving responsibility to those having inadequate educational levelTechnological and Economic DifficultiesDifficulties Resulted from the External FactorsFactorsDifficulties Resulted from the External FactorsTechnological and Economic DifficultiesTechnological and Economic DifficultiesThe effect of government policy on producing high quality productThe delayed and disconnected relationships between TSE, MPM, DPT, university and industryUnconscious consumer and shortsightedness Low quality in raw material and industry		That the management makes an assessment according to the amount of product produced; that quality responsibility cannot be thought of at the business level
Human –Education Difficulties       Educational deficiency about the basic statistical methods         Not being able to apply the new procedures on quality         Not being able to be understood the concept and policy of quality         Not being able to sufficiently utilize from the motivational methods         High employee turnover rates         Giving responsibility to those having inadequate educational level         Technological and Economic Difficulties         Difficulties Resulted from the External Factors         The effect of government policy on producing high quality product         The delayed and disconnected relationships between TSE, MPM, DPT, university and industry         Unconscious consumer and shortsightedness         Low quality in raw material and industry	Human –Education Difficulties	Participation in the seminars about quality and deficiency of reading
Human –Education DifficultiesNot being able to be understood the concept and policy of qualityNot being able to sufficiently utilize from the motivational methodsHigh employee turnover ratesGiving responsibility to those having inadequate educational levelTechnological and Economic DifficultiesDifficulties Resulted from the External FactorsFactorsThe delayed and disconnected relationships between TSE, MPM, DPT, university and industry Unconscious consumer and shortsightedness 		Educational deficiency about the basic statistical methods Not being able to apply the new procedures on quality
Notbeing able to sufficiently utilize from the motivational methodsHigh employee turnover rates 		Not being able to be understood the concept and policy of quality
IncludesHigh employee turnover ratesGiving responsibility to those having inadequate educational levelInsufficiency of the material, equipment, and the other facilities used in quality control and developmentTechnological and Economic DifficultiesInsufficiency in applying industrial methodology and measurementsDifficulties Resulted from the External FactorsThe effect of government policy on producing high quality productThe delayed and disconnected relationships between TSE, MPM, DPT, university and industryUnconscious consumer and shortsightedness Low quality in raw material and industry		Not being able to sufficiently utilize from the motivational methods
Ingr employ to tamover factsGiving responsibility to those having inadequate educational levelTechnological and Economic DifficultiesInsufficiency of the material, equipment, and the other facilities used in quality control and developmentTechnological and Economic DifficultiesInsufficiency in applying industrial methodology and measurementsDifficulties Resulted from the External FactorsThe effect of government policy on producing high quality productDifficulties Resulted from the External FactorsThe delayed and disconnected relationships between TSE, MPM, DPT, university and industry Unconscious consumer and shortsightedness Low quality in raw material and industry		High employee turnover rates
Insufficiency of facilities used in quality control and developmentTechnological and Economic DifficultiesInsufficiency in applying industrial methodology and measurementsDifficulties Resulted from the External FactorsThe effect of government policy on producing high quality productThe delayed and disconnected relationships between TSE, MPM, DPT, university and industryUnconscious consumer and shortsightedness Low quality in raw material and industry		Giving responsibility to those having inadequate educational level
Technological and Economic Difficulties       Insufficiency in applying industrial methodology and measurements         Difficulties Resulted from the External Factors       The effect of government policy on producing high quality product         The delayed and disconnected relationships between TSE, MPM, DPT, university and industry       Unconscious consumer and shortsightedness         Low quality in raw material and industry       Insufficiency in applying industrial methodology and measurements	Technological and Economic Difficulties	Insufficiency of the material, equipment, and the other facilities used in quality control and development
Difficulties Resulted from the External Factors  The effect of government policy on producing high quality product  The delayed and disconnected relationships between TSE, MPM, DPT, university and industry  Unconscious consumer and shortsightedness Low quality in raw material and industry		Insufficiency in applying industrial methodology and measurements
DifficultiesResulted from the ExternalproductFactorsThe delayed and disconnected relationshipsbetween TSE, MPM, DPT, university and industryUnconsciousconsumer and shortsightednessLowquality in rawmaterial and industry	Difficulties Resulted from the External Factors	The effect of government policy on producing high quality
Difficulties Resulted from the External The delayed and disconnected relationships between TSE,         Factors       MPM, DPT, university and industry         Unconscious consumer and shortsightedness         Low quality in raw material and industry		product
Unconscious consumer and shortsightedness Low quality in raw material and industry		The delayed and disconnected relationships between TSE, MPM, DPT, university and industry
Low quality in raw material and industry		Unconscious consumer and shortsightedness
		Low quality in raw material and industry

**Table 2**. Application Difficulties of Total Quality Management

Resource : Efil, 1995: 47-48

## Application

In order to prove the applicability of the theoretical information in the studies of process improvement, in this section of study, an application study has been carried out. Application study in the Faculty of Economic and Administrative Science (FEAS), Gaziosmanpaşa University (GOU). The procedure of data collecting was predominantly in the Department of Health, Culture, and Sports (DHCS). In this section, information has been given about GOU and DHCS and, reporting that from which stages are passed until arriving the subject of process flows belonging to DHC, flow charts have been discussed.

## **Importance of the Study**

Nowadays, an intensive competition is experienced in the global market. In this competition, raising the students having quality that can meet the expectations of business world is increasingly gaining importance. If the educational system fails in providing the qualified graduates (outputs), either businesses will pay for the price of this unsuccessfulness, sending billions for education, or society, bearing poor quality goods and services (Yıldız and Ardıç, 1999: 73). In view of this, the importance given to education by society analyzing well its past and wanting to shape its future with the better living standards has also increased as much as the importance given to quality by it.



The fact that high education institutes are not profit-oriented does not mean that they cannot also be managed with business management rules like economic businesses. Just as in the other businesses, also in businesses, professionalism and forming a good infrastructure became obligatory, because that a business provides a competitive advantage depends on its presenting good products and services as well as its being managed by means of the scientific methods (Karapınar, 2006: 171).

In this study, in high education institute, the applicability of the thought to increase the quality by improving process was shown.

## The Aim of the Study

The aim of application study is to encourage for the individuals to carry out their jobs with a continuously increasing quality and, teaching the techniques they can use in this direction, to help them maintain the flow in the most efficient way. In many businesses producing the goods and services, although it is seen that improvement techniques and, etc. were utilized, in high education instituters, it is a discussable issue that the applicability this information they taught is at what level. With this study, in the university having the educational process following the primary education, it is aimed

- to increase the student satisfaction, providing improvement in the processes the students desired;
- to reveal the effect of Statistical Process Control Techniques on quality improvement process;
- to enable employees to recognize their processes, making the process maps, where they can see that the works reach them, passing from which stages
- to identify and eliminate the undue activities leading tine loss by analyzing work processes;
- to enable employees to realize their works in a TQM based order; and

• to provide to be seen that some techniques applied in theory are also readily applicable at the application and that its results will provide benefit even if in long period.

## Material and Method of Study

While the theoretical data of study are formed, the various domestic and foreign authors and internet resources were utilized. The application data were first begun to be formed in a meeting held with the students of GOU. The other data were obtained from DHCS. In the scope of quality improvement process, due to the fact that the methods of quality improvement are numerous and comprehensive, the study was limited with Techniques of Statistical Process Control (SPS). In examination process, first of all, brain storming was made with the student group and then, the subjects selected for improvement in brain storming are divided into their causes by means of fishbone diagram. With work flowchart, the current flow of process was examined and the solution suggestions toward the improvement of process were developed. Lastly, the new flowcharts containing suggestions were formed. For drawing of fishbone diagrams, RFFlow Program was used, while for drawing of flowcharts, Microsoft Office Visio 2007 Program (Yılmaz, 2011).

## Results

#### Simple Process Development Model

#### Step 1: Forming the suitable team

The suitable team was determined by the team leader. Some interviews were carried out with a group of 8 people, which consist of the students of the senior students of department of economics, also including the students representative as well as a group of 10 people consisting of the students of business management and economics club. After the suitable day and hour for interview was determined by the team leader, the students were informed about the subject of thesis and the study that will be carried together in the direction of Power Point presentation prepared. Giving information lasted about 45 minutes. During presentation, the short and brief information was given about the approach to problem solving, sorts of problems, how to be the process of problem solving, old and new quality definitions, PUKÖ cycle, quality circle, how to be able to the effective teamwork, brain storming, and 7 main techniques of statistical process control. After informing, the stage of brain storming was passed and this stage also lasted about 1 hour. During brain storming, the students expressed the various ideas they want to be exchanged or improved without remaining any press. As a result of brain storming performed, about the first three headings receiving the highest vote in voting, the diagrams of fishbone were formed. In turn, a single process was selected for improvement. The meeting lasted about three hours and it was finished by agreeing on again meeting, if necessary.



#### Step 2: Selection of Process and Determination of Target of Process Development

As the scope of the process to be improved, Faculty of Economics and Administrative Science was selected. Together with the team, formed in this direction, the technique of brain storming was applied and the problem of "Lengthiness of Process to Take Permission for Social Activities". The technique of brain stormed realized was shown below stage by stage.

In the first stage of the technique of brain storming carried out with a group of 8 people from the students of department of economics and business management and a committee of 10 people from the students of club of business management and economics, the following headings emerged.

- a) That classroom size is large and that the equipment in class is insufficient
- b) That the cleanness of school is inadequate
- c) That the working salons of faculty is small
- d) That canteens are insufficient both as food and as area
- e) The rough behaviors exhibited by the research assistants against the students
- f) The lengthiness and difficulty of the process to take permission for social activities
- g) Insufficiency of professional seminar
- h) Insufficiency of technical travel
- i) That summer school continues at only Faculty of Economics and Administrative Science
- j) Insufficiency of academics

k) In the periods of enrollment, due to the fact that the approvals of supervisor and deliveries of bank receipt correspond to vocation periods, to be obliged to arrive earlier to the school

- 1) That academic members cannot see the pictures of students in the student information system
- m) That the computers in computer labs are broken
- n) Deficiency of bank to sit down in front of the faculty building
- o) Lack of garbage can in front of the faculty building
- p) Lack of activity area for the different sportive branches
- q) Insufficiency of coverage area of wireless internet

In the second stage, voting was passed and the students had right to vote for each heading. As a result of voting, the vote each heading has is:

Headings		Votes
a)	That classroom size is large and that the equipment in class is insufficient	13
b)	That the cleanness of school is inadequate	9
c)	That the working salons of faculty is small	1
d)	That canteens are insufficient both as food and as area	12
e)	The rough behaviors exhibited by the research assistants against the students	18
f)	The lengthiness and difficulty of the process to take permission for social activities	7
g)	Insufficiency of professional seminar	6
h)	Insufficiency of technical travel	2
i)	That summer school continues at only Faculty of Economics and Administrative Science	18
j)	Insufficiency of academics	13
k)	In the periods of enrollment, due to the fact that the approvals of supervisor and deliveries of bank receipt correspond to vocation periods, to be obliged to arrive earlier to the school	10
1)	That academic members cannot see the pictures of students in the student information system	1
m)	That the computers in computer labs are broken	5
n)	Deficiency of bank to sit down in front of the faculty building	14
0)	Lack of garbage can in front of the faculty	11
p)	Lack of activity area for the different sportive branches	10
q)	Insufficiency of coverage area of wireless internet	3

#### **Table 3**. The distribution of votes taken in the second stage



In the third stage, each student has the right to use only one vote for each heading.

Headings		Votes
a)	That classroom size is large and that the equipment in class is insufficient	
b)	That the cleanness of school is inadequate	
c)	That the working salons of faculty is small	
d)	) That canteens are insufficient both as food and as area	
e)	) The rough behaviors exhibited by the research assistants against the students	
f)	The lengthiness and difficulty of the process to take permission for social activities	2
g)	Insufficiency of professional seminar	
h)	) Insufficiency of technical travel	
i)	That summer school continues at only Faculty of Economics and Administrative Science	9
j)	Insufficiency of academics	0
k)	In the periods of enrollment, due to the fact that the approvals of supervisor and deliveries of bank receipt correspond to vocation periods, to be obliged to arrive earlier to the school	1
1)	That academic members cannot see the pictures of students in the student information system	0
m)	) That the computers in computer labs are broken	
n)	Deficiency of bank to sit down in front of the faculty building	
o)	Lack of garbage can in front of the faculty	0
p)	) Lack of activity area for the different sportive branches	
q)	) Insufficiency of coverage area of wireless internet	

#### **Table 4**. Distribution of votes received in the third stage

As a result of brain storming, 3 problems arouse. These are:

1) That summer school continues in only Faculty of Economics and Administrative Science

2) The rough behaviors exhibited by the research assistants against the students

3) The lengthiness and difficulty of the process to take permission for social activities Although the students of Club of Business Management And Economics said that they did not suffer from the issue taking place in the third place, the other students said that they suffered from it. As the cause of that the club students did not complain about it, the opinion that the clubs cooperating with academic supervisor can take permission more easily.

#### Step 3: Identifying the Causes of Inadequcy

In the third stage, for the first three headings selected for improvement by means of brain storming, the fishbone diagram was drawn together with the team. Thanks to this, identifying the main reasons was aimed. While the fishbone diagram was used, the main reasons vary according to the sort of problem. The main reasons that will constitute in this problem were classified as Administration, Human, and Method.





Figure 1. Fishbone Diagram of that summer school continues in only Faculty of Economics and Administrative Science:



Figure 2. Fishbone Diagram of the rough behaviors exhibited by the research assistants against the students





Figure 3. Fishbone Diagram of the lengthiness and difficulty of the process to take permission for social activities

It is seen that from the diagram drawn, two processes i.e. the headings of "Elimination of Summer School" and "the rough behaviors exhibited by the research assistants against the students" will not be the subject of application in this thesis study. The reason for this is that the rough behaviors of research assistants is a problem of organizational behavior and that its improvement only becomes possible with long termed educational studies and institutional culture. That the issue of summer school is a legal issue and that it is in the scope of school administration show that these are out of the scope of application study. When these three problems are examined, the problem that is appropriate for carrying out the study of process improvement was determined as "the lengthiness and difficulty of the process to take permission for social activities"

As will be seen from Figure 3, in the process "the lengthiness and difficulty of the process to take permission for social activities", while the causes resulted from management were determined as that the people in enough number cannot meet for committee, that committee cannot be met in time, and that the decisions are made late, the causes resulted from human emerged as indifference of process employees, busy works, and delay of works. In addition to this, that the students, as individuals, do not follow the conclusion that will turn out from commission was also shown as one of the reasons that will extend the process. Finally, the causes resulted from the method were specified as that bureaucracy slowly runs, that there are some steps making the process slower, that the way of announcing the decision to the students are not enough, and that the announcement to the students are reported

#### Step 4: Forming the flowchart of the process selected

In this step, the data were sought from the website and the flowcharts of some sample universities were examined. Later, it was interviewed with Head of Department of Culture and Sports, Gaziosmanpaşa University, and the people he directed to and the sample processes were compared to the processes applied in Gaziosmanpaşa University. However, it was seen that the although process steps in Gaziosmanpaşa University are carried out in similar way to the other universities, they do not have a flowchart, on which the process steps can be followed. It was understood that the flowcharts that will be drawn in the application in this direction will not only improve the process but also a document will emerge that will provide a benefit to Department of Health, Culture, and Sports. As a result of interviews, the flowchart of one sample processes, applied in of GOU, were drawn. Although DHCS is intertwined with many processes, the reason for selecting the only one processes is that they are the processes closely concerning the students and that they complain about them.





Figure 4. Work Flowchart of the Process for Guest Inviting

Step 5: Simplification of the process and making modifications

When three flowcharts are investigated drawn above, reducing some operation steps that may cause the permission decisions to turn out late in guest inviting, the way of process simplification was gone. These operation steps reduced were generally the most approved decisions. Besides this, in the new formed flowcharts, the staff, who serves in these steps, and the relevant legislation and regulations were given place. This will also give information regarding to who performs which task, when new staff was recruited in the relevant unit and, provided that any disagreement occurs about the decisions made, it will enable the relevant legislations and rules to be easily reached.





Figure 5. Work Flowchart of the Process For Guest Inviting after Improvement



## **Conclusion and Suggestions**

Statistical Process Control cosmists of techniques many employees, whatever whose educational level are, who provide the process control in a simple expression and, with its underlying real aim, to make improvement, can apply to the work process in the businesses, whether they produce goods or services. In this study, of main 7 main statistical process control techniques, using the fishbone diagram and flowcharts as well as brain storming, the process selected was analyzed and suggestions were presented toward improving them.

At the beginning stage of study carried out, although the issue of improvement are considered to be performed on the subject concerning the students of Faculty of Economics and Administrative Sciences, the direction of the study turned into the issue concerning all students of GOU, because Department of Health, Culture, and Sports is an institute supporting the club activities of all faculties and vocational high schools in GOU. This, an improvement made in DHCS processes will affect all of the students. Moreover, it not only affects the students but also it will also an easiness for the employees of DHCS and enable their works to improve more systematically. Since DGCS is an institute subjecting to GOU, for the exact consciousness of quality, which is in interest area of Total Quality Management, to place, the participation of all employees in the institute will become provided.

The study of process improvement passed through the following stages.

After the team consisting of the students selected was informed about the subject, the subjects they wanted to be improved by means of brain storming were put in order and, with a voting system of 3 rounds, the three headings receiving the most votes were determined.

For the three headings determined, again together with the team, fishbone diagrams were drawn and the sub-problems causing these three headings to become a problem were examined.

After fishbone diagrams were examined, the first one of the first two headings were understood to be a subject on the legislation and school regulation and it was seen that exchanging it would not be in these subject of thesis. It was also seen that the other heading is a problem of organizational behavior and improving it was possible with educational studies taking long time, which is in the initiative of university administration.

The remaining third subject was determined as the application subject of thesis study and, for the course that is currently going on to understand better, the interviews were made with both students and head of DHCS and the other employees directed by him. As a result of interviews, it was seen that "Process For Guest Inviting", which affect the students, were also carried out in DHCS as in the other universities, but flowcharts are of sin qua none of process improvement are not present within institute. Again, in the interviews, in this study, it was talked about that forming flowcharts are useful to the institute and, with the support of head of DHCS, the necessary information was easily reached. Firstly, for DHCS, the flowcharts of this work process were drawn. Later, GOU flows were compared with flows of another university, taken as a basis, as a result of web searches and the new flowcharts, where optimum effectiveness will be provided. In these flowcharts, just as operational steps take place, the staff, who is responsible for these steps, and that these tasks were also carried out in the scope of which regulations can be clearly seen. In the new flowcharts drawn, reducing the undue bureaucracy and accelerating the process, reducing the extra operational steps, were provided so that this also became a result the students making brain storming exactly wanted. In the process of the students' taking permission for the social activities, for the time to wait for the decision to be shortened, it is also considered that announcing the permission announcement through web address of university will facilitate the follow of decision by the students and it is a simpler way in terms of administration to report to whom may concern.

The study carried out has of course an importance in terms of process improvement; however, this is not seen enough. For GOU to be able sign the bigger successes in the sharp competitive environment, it is necessary for the studies like this study to increase and to be supported by the academics and administration; because quality improvement is a state requiring continuity and concerning all the employees in the institute.



#### References

- Akın, B. ve Öztürk, E., (2005), "İstatistik Proses Kontrol Tekniklerinin Bilgisayar Ortamında Uygulanması", Marmara Üniversitesi, İ.İ.B.F., Ekonometri Bölümü, Sakarya Üniversitesi, Gebze Meslek Yüksekokulu
- Al-Turki, U. ve Andijani, A., (1997), "Quality Control Practices in Saudi Arabia: Survey Result", <u>Production</u> <u>Planning & Control</u>, Volume <u>8</u>, Issue <u>8</u>, Pages 726 - 730
- Aslan, T., (2007), *Toplam Kalite Yönetimi: Kamu Alanındaki Uygulamaların Değerlendirilmesi*, yayınlanmamış yüksek lisans tezi, Kahramanmaraş Sütçü İmam Üniversitesi, Sosyal Bilimleri Enstitüsü, İşletme Anabilim Dalı
- Bengisu, M., (2007), "Yüksek Eğitimde Toplam Kalite Yönetimi", Journal Of Yaşar University, 2(7), 739-749
- Bircan, H. ve Gedik, H., (2003), "Tekstil Sektöründe İstatistiksel Proses Kontrol Teknikleri Uygulaması Üzerine Bir Deneme", *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi, Cilt 4, Sayı 2*
- Bozkurt, R., (1998), Kalite İyileştirme Araç ve Yöntemleri, Milli Prodüktivite Merkezi Yayınları, No:630, Ankara
   Cheng, P.C.-H., Dawson, S. D., (1998), "A Study of Statistical Process Control: Practice, Problems and Training Needs", Total Quality Management & Business Excellence, Volume 9, Issue 1 February, Pages 3 20
- Corbett, C.J. ve Pan J., (2002), "Evaluating Environmental Performance Using Statistical Process Control Techniques", *European Journal of Operational Research 139*, 68–83
- Deros, B. M., Rahman, M. N., Ismail, A. R., Yee, L. W. ve Zain, R.M., (2010),
- "Application of Statistical Process Control Technique for Evaluating Machine Capability: A Case Study", AIJSTPME 3(1): 15-22, King Mongkut's University of Technology North Bangkok Press, Bangkok, Thailand
- Doğan, E., (2002), Eğitimde Toplam Kalite Yönetimi, Academyplus Yayınevi, Ankara
- Efil, İ., (1995), Toplam Kalite Yönetimi ve Toplam Kaliteye Ulaşmada Önemli Bir Araç İSO 9000 Kalite Güvencesi Sistemi, Uludağ Üniversitesi Basımevi, Bursa
- Eleren, A., (2007), "Eğitim Başarısının Artırılmasında Süreç Geliştirme Yöntemlerinin Kullanılması ve Bir Uygulama", Afyon Kocatepe Üniversitesi, İ.İ.B.F. Dergisi (C.IX, S II, 2007)
- Elevli, S., ve Behdioğlu, S., (2006), "İstatistiksel Proses Kontrolü Teknikleri İle Kömür Kalitesindeki Değişkenliğin Belirlenmesi", *Madencilik, Cilt 45, Sayı 3, Sayfa 19-26, Eylül 2006 Vol.45, No.3, Pp 19-26, September 2006*
- Erişim: "Etkin Süreç Yönetimi ve İSO 9001:2000", 12.01.2011. Standart Bm Trada Belgelendirme A.Ş.
- (www.ormanendustri.net/wp-content/uploads/.../etkin\_sarec\_yonetimi.pdf)
- Eroğlu, C., (2006), *Süreç İyileştirme ve Bir Uygulama*, yayınlanmamış yüksek lisans tezi, Marmara Üniversitesi, Sosyal Bilimler Enstitüsü, İşletme Anabilim Dalı, Uluslararası Kalite Yönetimi Bilim Dalı, İstanbul
- Fuhrmeister, E., (1996), "Statistical Process Control Application on Customer Order Forecasting Techniques at a Dairy Company", Production Scheduler, Dairy Company, Bachelor of Science, Chemical Engineering University of Colorado
- Gencel, U. (2001), "Yükseköğretim Hizmetlerinde Toplam Kalite Yönetimi ve Akreditasyon", Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, Cilt 3, Sayı 3, ss. 164-213.
- Genel Kurmay Başkanlığı, Deniz Kuvvetleri Komutanlığı, APGE Başkanları, (1999), *Temel Süreç Geliştirme El Kitabı*, Dz. K. K. Basımevi, Ankara
- Gümüşoğlu, Ş., (2000), İstatistiksel Kalite Kontrolü ve Toplam Kalite Yönetimi Araçları, Beta Basım Yayım Dağıtım A.Ş., İstanbul
- Joelianto, E. ve Kadarusman L., (2010), "Industrial Control Quality Improvement Using Statistical Process Control: Tennessee Eastman Process Simulation Case", *Internetworking Indonesia Journal, Vol.2/No.1*
- Imai, M., (1999), Kaizen, Japonya'nın Rekabetteki Başarısının Anahtarı, Kalder Yayınları, No:21, İstanbul
- Karapınar, S., (2006), İş Akışı Analizi Yoluyla Bir Hastane İşletmesinde Süreç İyileştirme Çalışması, yayınlanmamış yüksek lisans tezi, Gazi Üniversitesi, Sosyal Bilimler Enstitüsü, İşletme Anabilim Dalı, Hastane İşletmeciliği Bilim Dalı, Ankara
- Kayaalp, İ. D. ve Erdoğan M. Ç., (2009), "Konfeksiyon İşletmesinde Dikiş Hatalarının İstatistiksel Proses Kontrol Yöntemlerini Kullanarak Azaltılması", *Tekstil ve Konfeksiyon 2/2009*
- Kwan, P.Y.K. (1996), "Application of Total Quality Management in Education: Retrospect and Prospect", Division of Commerce, City University of Hong Kong, Hong Kong
- Laosiritaworn, W. ve Bunjongjit, T., (2010), "Visual Basic Application for Statistical Process Control: A Case of Metal Frame for Actuator Production Process", *Proceedings of the International Multi Conference of Engineers and Computer Scientists, Vol III, March17-19, Hong-Kong*
- Madan, A.K. ve Mishra, R.S., (2011), "Application of Statistical Process Control for Quality Management in Technical Education", *Global Journal of Finance and Management, ISSN 0975 - 6477 Volume 3, Number* 1, pp. 25-33
- Milli Eğitim Bakanlığı, Personel Genel Müdürlüğü, (2007), Eğitimde Kalite Ödülü El Kitabı, Ankara



- Mohammed, M. A., (2004), "Using Statistical Process Control to Improve the Quality of Health Care", *Qual Saf Health Care 13:243–245. Doi: 10.1136/Qshc.011650*
- Özcan, S., (2003), "İstatistiksel Proses Kontrol Tekniklerinden Pareto Analizi ve Çimento Sanayiinde Bir Uygulama", *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi, Cilt 2, Sayı 2*
- Özdemir, S., (2002), "Eğitimde Toplam Kalite Yönetimi", *Kırgızistan-Türkiye Manas Üniversitesi Sosyal Bilimler* Dergisi, Sayı 2: ss.253-270.
- Özkan, Y., (2000), Toplam Kalite, Sakarya Üniversitesi, İktisadi İdari Bilimler Fakültesi
- Pamir, G., (1997), *Süreç Yönetimi ve Bir Süreç Geliştirme Uygulaması*, yayınlanmamış yüksek lisans tezi, İstanbul Teknik Üniversitesi, İstanbul
- Rita, S. and Lakshmi, K., (2009), "Mechanics of How to Apply Deming's PDCA Cycle to Management Education",
- (SSRN: http://ssrn.com/abstract=1353763)
- Saraç, Ö., ve Özdemir, G., (2003), "Mermer Fayanslarının Boyutlandırmasında İstatistiksel Kalite Kontrolü", Türkiye IV. Mermer Sempozyumu (Mersem'2003) Bildiriler Kitabı 18-19 Aralık
- Scordaki, A. ve Psarakis, S. (2005), "Statistical Process Control in Service Industry an Application with Real Data in a Commercial Company", *Proc. 7th Hellenic European Conference on Computer Mathematics and Its Applications*
- Serin, H., ve Aytekin, A., (2009), "Yüksek Öğretimde Toplam Kalite Yönetimi", Bartın Orman Fakültesi Dergisi, Cilt: 11, Sayı: 15, 83-93 ISSN: 1302-0943 EISSN: 1308-5875
- Smeti, E.M., Thanasoulias, N.C., Kousouris, L.P. ve, Tzoumerkas, P.C., (2007), "An Approach for the Application of Statistical Process Control Techniques for Quality İmprovement of Treated Water", *Elsevier*, *Desalination 213 (2007) 273–281*
- Şimşek, M., (2004), Toplam Kalite Yönetimi, Alfa Basım Yayım Dağıtım Ltd. Şti., İstanbul
- Tan, T., (2008), İlaç Sektöründe Kalite İyileştirme Teknikleri ve Bir Uygulama, yayınlanmamış yüksek lisans tezi, Marmara Üniversitesi, Sosyal Bilimler Enstitüsü, İşletme Anabilim Dalı, Uluslararası Kalite Yönetimi Bilim Dalı, İstanbul
- Thareja, P., (2008), "Deming Metrics to Measure the Quality of World (D(R)E(A)Ming for a Quality World", 20.03.2011. Head, Metal Engineering Deptt Punjab Engineering College, Chandigarh.
- (http://ssrn.com/abstract=1495043)
- Uryan, B., (2005), "Toplam Kalite Yönetimi", Mevzuat Dergisi, Yıl 5, Sayı 55
- Woodall, W., (2000), "Controversies and Contradictions in Statistical Process Control", Journal of Quality Technology Session at the 44th Annual Fall Technical Conference of the Chemical and Process Industries Division and Statistics Division of the American Society for Quality and the Section on Physical & Engineering Sciences of the American Statistical Association in Minneapolis, Minnesota, October 12–13
- Yıldız, G., ve Ardıç, K., (1999), "Eğitimde Toplam Kalite Yönetimi", Sakarya Üniversitesi, Sosyal Bilimler Dergisi 1999, Sayfa: 73-82
- Yiğit, M., (2009), Altı Sigma' da Kullanılan İstatistiksel Yöntemlerin İncelenmesi, yayınlanmamış yüksek lisans tezi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, İstatistik Anabilim Dalı, Adana
- Yücel, Ö., (2003), "Dikimde Hata Oluşturan Nedenlerin Belirlenmesine Yönelik İstatistiksel Bir Araştırma", Pamukkale Üniversitesi, Mühendislik Fakültesi, Mühendislik Bilimleri Dergisi, Sayı : 3, sayfa: 327-332
- Yücel, M., (2007), "Toplam Kalite Kontrolü Açısından İstatistiksel Süreç Kontrol Tekniklerinin Önemi", 8. Türkiye Ekonometri ve İstatistik Kongresi, İnönü Üniversitesi Malatya
- Zeyveli, M. ve Selalmaz, E., (2008), "İstatistiksel Proses Kontrol Yöntemlerinden Pareto Analizi ve Sebep-Sonuç Grafiğinin Zincir İmalatına Uygulanması", *Teknoloji, Cilt 11(4)*, 267-274
- Yılmaz, M. (2011). Süreç iyileştirme (Gaziosmanpaşa Üniversitesi'nde bir uygulama). Yüksek lisans tezi Gaziosmanpaşa Üniversitesi Sosyal Bilimleri Enstitüsü; 101 (unpublished).



# RAISING SOCIALLY RESPONSIBLE INDIVIDUALS: MONTESSORI EDUCATION MODEL

Figen GÜLEŞ

Selcuk University Faculty Of Health Sciences, Konya-Turkey

fgules@selcuk.edu.tr

**Abstract:** To fulfill the social responsibility of the person or institution is directly related with to be trained as an individual with responsibility awareness. Here is education that will make the biggest impact. Although there are many training methods that contribute to the formation and development of responsibility cosnciousness, Montessori education is an educational model that stands out in the formation of this consciousness. This paper is a literature review which aims to describe the understanding of Montessori education on growing socially responsible individuals. The paper draws attention the important role of Montessori education model in creating "social responsibility consciousness" on people.

KeyWords: Social Responsible Individuals, Montessori Education Model

## Introduction

Social responsibility, defined as that private sector and non-governmental society go toward a common life, bringing together around an aim, requires to be made actions that will develop and protract not only their own interest bit also the general interests of society ((www.siviltoplumakademisi.org.tr,2012). That the people or institutes perform their social responsibilities is directly related to their being raised as individuals having this consciousness. Here, what that will create the largest effect is educational area. As a result of education, individuals having "social responsibility" hold the qualities of

- being able to well know himself/herself and their roles in society;
- having the different qualities;
- being able to unite on a common aim;
- valuing the work he/she makes;
- judging the collective work and success;
- giving importance to the culture to share and cooperate;
- participating in the decisions;
- actively listening to his/her friends and making open communication;
- equally behaving to each other and moving together;
- respecting the person in his/her face and accepting him/her as he/she is; and
- having the consciousness to become "we". (Yeşilyurt, 2010)

In the various countries contributing to the developmental processes of the individuals having these gains, there are numerous educational methods, formed in the direction of the different understandings. Each educational method has the different educational program, content, instruction principles, methods, teacher raising systems, material selection, and classrom order. The schools, selecting one or some of these educational methods for themselves, realize their educational applications (Güleş and Öngören, 2008). Montessori Educational Model, one of these models and developed by Maria Montessori in 1907, with the content of its program, is an educational model targeting the development of "social responsibility consciousness" in children. In this education, the responsibility children begin to feel to each other, one of the most important elements in the development of social life, emerges with the independent efforts, carried out in the classroom. In education giving freedom to each child in the social relationship, it is only intervened, when the rights of others are violated. Thanks to this freedom, in child, the natural interest toward others and desire to help spontaneously develops (Lillard, 2013).

## Social Responsibility in Montessori Education

M.Montessori, saying that the primary interest area of education should be "humanity and culture", because all humans have a single land called "world; underlines that all humankind should be viewed as a single nation. She sees the way that will take to this point on child (Çakıroğlu Wilbrandt, 2009). According to



Montessori, the aim of education, beginning from the birth, should be to provide benefit for life and unite for a peaceful structure and a common aim. Therefore, the contents of Montessori Education Program is based on the features of

1-Education for life,

2-Universal education,

- 3-Holistic education,
- 4-Peace education,
- 5- Ethics education
- 6-Disposiition education, and
- 7-Spiritual education(Korkmaz,2012).

Due to her vision and efforts to achieve world peace through education, M.Montessori, presented candidates, for Nobel Peace Prize in the years of 1949, 1950, and 1951, argues that education should be rearranged and attributed to the rules of nature. For achieving this, she accounts for the answer of what should be done in her "cosmic theory" The thought that "every humans depends on to the other and that every individual should make contribution to the existence of other" is important here. For this thought to be able to reach its target, it is important to stimulate the sense of "gratitude and affinity" in children (Çakıroğlu Wilbrandt, 2011).

Even though Montessori education is toward preschool in the years, when it first began, in the following years, in the direction of the demands of educators and families, were enlarged in such a way that it will include the educational periods of primary schools and over. When all schools in the worlds are considered, it is seen that the number of Montessori schools providing education at this level is not very much. However, research indicates that that the features of Montessori education create the desired change on individual reached to the maximum level with that family supports Montessori education and that the number of Montessori educational year increases (Korkmaz, 2005).

Montessori primary school program encourages children to the spontaneous activity, self-education and exclusive motivation, development in cultural experience and knowledge, sufficiency via the repeated experience; and cooperative learning through peer education and social interaction. In addition, for intangible thoughts, fostering the emotional education, creativity, and imagination, aim it provides learning opportunities by physical activities and outdoor activities. The most important element of program curriculum is 5 courses, called "the Great Lessons" depending on to each other. These courses includes stories about "how the world appears, development of life in the world, humankind history, development of script, and development of mathematics". The courses are planned to provide a viewpoint about taking place of world and humankind in universe to children and to develop "an universal consciousness". Students are encouraged to examine the subjects acquiring their imaginations. They rarely use textbooks. The children collect and form information, report, portfolio, and handmade books. They transmit the knowledge and skills to their friends (Lillard, 2014; Korkmaz, 2005; www.montessoriegitimi.org 2008; www.cosmiceducation.org, 2009).

Secondary education model of M. Montessori is based on the tendencies and developmental needs of preadolescents. The adolescents, who are enrolled to these programs, using the cases of cooperative learning requiring multi-disciplinary subjects, skills of critical thinking skills, and real life experiences, work in mixed age groups. Their levels of achievement are high, because most of students come from Montessori primary schools and early childhood programs (Korkmaz, 200) Montessori, in secondary education, mentions about adolescents as "Erdkinder" or "land children". The target of Erdkinder, for being able to live in the real world, is to raise individuals, who equipped themselves with the real skills and confidence. (w.montessoriforeveryone.com/Erdkinder,2010) The support point of this program of age period is the necessity to make conscious the world belonging to primary school and ethical viewpoint. [In that period], philosophical thoughts about information on nature and culture are begun to be used. "The Great Lessons" slowly develops toward the opinions, obtained from a serious approach toward humanitarian sciences (Korkmaz, 2005).

## **Developmental Results of Montessory Education**

M.Montessori expresses education in the way that "*it either contributes to universal freedom movement, viewed as a way for escalating and defending humankind or becomes an organ, which is not used or which dried throughout the evolution of organism*". She emphasizes that reality is to see whole, considering on details; on the one hand, that human is a part of an universal order; and on the other hand, thanks to his/her intelligence, that he/she is in a specific position.

According to Montessori, education should raise "citizens modifying the world to correct it" in an universal order. In the direction of this aim, as a result of education provided in the range of 6-12 ages, it is expected that



- the child is sociable and ready for social interaction;
- he/she comprehends a relationship between action of a person the needs of others and that the concept justice emerges; and
- he/she recognizes the elements of his/her culture.

At the end of education in the range of 12-18 ages, it is expected that

- the child approaches to the problems of humans with an investigative viewpoint;
- he/she knows how to make contribution to social structure;
- he/she comprehends the necessity of making cooperation and solidarity with his/her relatives and adult people for the peace of world;
- social consciousness begins;
- he/she comprehends working as a product necessary for social life;
- he/she enjoys contributing to group; and
- the gains form in the direction of that he/she serves for universal needs of humankind (Korkmaz,2012).

According to P.Oswald, specialist for Montessori education, in the period of 12-18 ages, children not only show sensitivity toward this case, but also can realize the discovery of the gaps between demanding and being able to success, between to be able to do and to oblige to do, and between the rights and duties. Thus, children discover that they should hold responsibility for everything i.e. their own life and others', when its time comes (Çakıroğlu Wilbrandt, 2009).

#### **Conclusion and Suggestions**

The most important factor is education in forming "**social responsibility consciousne**ss", which requires to be made the actions that will develop and protect general interests of society as much as the self-interests of persons or institutes.

As a natural result of Montessori education, environment, health, and education that are main subjects related to social responsibility are the subject areas child is interested in all over the world, not only in the city and country he/she lives. The individuals raising with this understanding view this as a life style with the conscious of social responsibility that are internalized, rather than realizing their social responsibilities for the reasons such as a sponsorship activity, enhancing the personal or social credibility, and raising brand value. As will be foreseen, the individuals or institutes having this understanding will be more diversified their activities and services regarding "their social responsibilities and will be in effort to become widespread them.

It is possible to make the following suggestions related to this study:

- In Turkey, the number of the preschool educational institutes and basic educational institutes (according to the existing situation, 1 school) should be increased.

-. In Turkey, secondary education institutes applying Montessori Education

- For our educators to be made conscious about Montessori Education applications in our country and the other countries, in-service training courses, seminars, and meetings should be held.

- In Turkey, the scarcity in the number of scientific studies, carried out on Montessori Education throughout history, is a noticeable state. Therefore, scientific studies on the subject should be supported.

In the content of course programs of the primary and secondary schools that subject to Ministry of National Education and school activities, the arrangements developing social responsibility should be made.
Via education, the subject of study, and with the different educational models toward developing social responsibility consciousness, also carrying out studies, the results can be evaluated.

#### References

Çakıroğlu Wilbrandt, Emel. "Maria Montessori Yöntemiyle Çocuk Eğitimi Sanatı" Sistem Yayıncılık, İstanbul, Mayıs, 2009.

Çakıroğlu Wilbrandt, Emel. "Okul Öncesi Eğitimde Montessori Yaklaşımı" Kök Yayıncılık, Ankara, Mart, 2011.

Güleş, Figen ve Sema Öngören. "Okul Öncesi Dönem Montessori Eğitim Uygulamalarında Öğretmen-Çocuk-Veli İletişiminin Değerlendirilmesi." 5.Uluslararası Çocuk ve İletişim Kongresi, İstanbul, 2008.

Korkmaz, Eylem. "Montessori Metodu: Özgür Çocuklar İçin Eğitim" Algı Yayın, 2.Baskı, İstanbul 2012.

Korkmaz, Eylem. "Montessori Metodu ve Montessori Okulları: Türkiye'de Montessori Okullarının Yönetim ve Finansman Bakımından İncelenmesi." Yayımlanmamış Yüksek Lisans Tezi, <u>Marmara</u> <u>Üniversitesi Eğitim Bilimleri Enstitüsü</u>, 2005.

Lillard, Paula Polk. "İlk ve Ortaokulda Montessori Eğitimi". Kaktüs Yayınları, İstanbul, 2014. Lillard, Paula Polk. "Montessori Modern Bir Yaklaşım". Kaktüs Yayınları, İstanbul, 2013. www.montessoriforeveryone.com/Erdkinder (2010).



<u>www.siviltoplumakademisi.org.tr</u> (2012) <u>www.montessoriegitimi.org</u> (2008) <u>www.cosmiceducation.org</u> (2009) Yeşilyurt, Ethem. "Öğretmen Adayları Niteliklerinin İşbirliğine Dayalı Öğrenme Yöntemine Uygunluğunun Değerlendirilmesi" Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 14, 2010.



## STRATEGIC MANAGEMENT GUIDANCE IN HEALTH INSTITUTIONS MANAGEMENT: DETERMINATION OF MISSION-VISION-STRATEGY SELCUK UNIVERSITY MEDICAL FACULTY HOSPITAL SAMPLE

#### <sup>1</sup>Hakkı GÖKBEL, <sup>2</sup>Hasan Kürşat GÜLEŞ, <sup>3</sup>Zeynep ERGEN IŞIKLAR, <sup>4</sup>Tuğba ŞENER

<sup>3</sup>Selcuk University Faculty of Economics and Administrative Sciences, Konya-Turkey <sup>4</sup>Selcuk University Faculty of Art and Design, Konya-Turkey

 $^{1}hakkigk@selcuk.edu.tr,\ ^{2}hkgules@selcuk.edu.tr,\ ^{3}ergen\_zeynep@windowslive.com,\ ^{4}tugbamerve@hotmail.com,\ ^{4}tugbam$ 

m

**Abstract:** As the nature of the services they offer and areas in which they operate health care institutions are always in the process of change. Especially with the impact of technological advances, new techniques are constantly emerging in health care presentation, in parallel to innovation in health care change is also becoming necessary in the way of health care management. On the other hand today, research conducted in hospitals has reached a holistic and administrative size with the understanding that the development of institutions are connected with improvements not only in a sub-unit in all subunits in an integrated way. For a holistic assessment and progress accurate determination of mission-vision statement adopted by all stakeholders and strategies which will serve this purpose is very important. In this study <sup>1</sup> mission, vision and core strategies have been identified for the strategies.

In this study<sup>1</sup> mission, vision and core strategies have been identified for the strategic management process planning of Selcuk University Medical Faculty Hospital. In this context at first, keywords which are intended to be absolute in the hospital's mission and vision are determined by the focus group discussions with managers and content analysis method. Secondly main strategies that will shape the hospital's future have been identified in the balanced scorecard concept. The focus group interviews and content analysis results are summarized and made some evaluations and suggestions.

Keywords: Strategic Management in Health, Mission-Vision Determination, Strategy Determination

## Introduction

In health services, with standing out of strategic management and an service approach creating value, the studies toward maximizing value for all parts in health institutes increasingly gain importance at the present days. These studies are adapted to health sector in the scope of strategic management scope in health institutes in the way of determining mission-vision-strategy and targets, identifying the existing situation, analyzing shareholders in health sector, and calculating concrete indicators such as effectiveness, profitability, and performance, and reporting.

The subject of this study is to determine the mission –mission, and main strategies for Medical Faculty Hospital, Seljuk University. It is considered that this study can make a support to health managers, through the design and application of strategic management process, in shaping the future of management in health institutes.

## **Theoretical Framework: Importance of Strategic Management in Health Institutes**

Quality, whose important increases, as an instrument of providing the competition and advantage, has become obligation today. Businesses wanting to increase quality should first of all gain ability to be able to respond in time and at the expected level to the desires and expectations of customers Awareness increasing on this issue, as in many sectors, also in health sector, led the importance of measuring service quality to use (Gökbel, 2014).)

Today, with the effect of factors such as population increase, gradually aging of population, and negativities in nourishing habits, health problems and, in parallel with this, the expenditures of health institutes increase and this also forces the countries about lowering costs. The expectations of patients from health institutes and competition between institutes presenting health services increase every passing days. All of these developments make obligatory to measure and raise the service quality provided, to provide the quality and service with the most convenient cost, and to utilize the suitable models in this

<sup>1</sup> This study is taken from the doctoral thesis work (it's name is "Strategic Performance Management in Healthcare Institutions: A Model Proposal for Selcuk University Medical Faculty Hospital) that is still ongoing.



process. All of these development in health area and continuously changing structure of sector face health managers with strategic management techniques.

The basis of today's health approach consists of the target that health businesses are managed with the elements of strategic management and planning, and maximum effectiveness is obtained from this process. In addition, it also becomes effective on the development of Turkish Health System, and increase of reliabilities of the people receiving service from these businesses to the institutes

For enabling health institutes to be managed in the scope of increasing the efficiency of health institutes in managerial meaning and institutional management principles, several changes were made in the scope of reform and, especially with integration of strategic management models to health institutes, it was provided that health institutes are managed more efficiently and effectively at the present days, compared to past (§eremet, 2013:40).

The way of increasing the efficiency and performance in health management pass through acting in compatible with the principles of strategic management. According to this, in health institutes, instead of making short termed decisions, long termed planning toward future has become obligatory.

Strategic management system, providing the rapidity and flexibility in the changing competition environment, increases the efficiency of the decision made. Thanks to this, top level managers reach the ability to make effective decisions toward future. Thus, they can become stronger compared to their competitors.

Strategy, in terms of an organization, can be defined as the movements and approaches determined earlier. Strategy is related to differentiating the business from their competitors. Beyond that the business is better in the work it carried out, this is that it is different from the others.

In fact, it can be said that strategy is the continuously updated form of vision under the internal and external conditions. From this aspect, strategy is the whole of the decisions and acting styles, on which the managers undertake responsibility to succeed the performance that is at top level and the most effective (Özer,2009)



In businesses, strategic management process consists of the main stages such as case study (SWOT Analysis), determination of institutional vision, organizational policy, aim, target, and strategies. In Figure 1, the relationships between the strategic management process and stages for a business are summarized. In this context, for Medical Faculty Hospital, Seljuk University, being in active in health sector and one of the important health resources of region, applications including forward strategic planning are highly important. In this study, mission –vision and strategies, which will enable hospital to operate more efficiently and effectively and give direction to the future of hospital, were attempted to be identified, according to the views of the managers and specialists.


### Methodology

### Method of the Study and Sample

The universe of study consists of all hospitals taking place in Turkey. However, Medical Faculty Hospital, Seljuk University, is the sample area of the study. The processes of strategic management design on Medical Faculty Hospital, Seljuk University, were carried out by the method of content analysis. Method of content analysis is, in literature, a preferable method for applications of strategic management in both health institutes and other institutes, In this scope, the data obtained by means of survey method, were subjected to analysis, with the method of content analysis, by the specialists.

Medical Faculty Hospital, Seljuk University, is basically an hospital having the medical and administrative sections. In hospital, health services are carried out with 10 main scientific branch under Basic Medical Sciences, 19 main scientific branches under Internal Medical Sciences, and 13 scientific branch under Surgical Medical Science. In addition, for carrying out the health services provided to be carried out in high quality and without problems, in hospital, 17 administrative units are continuing their activities. Educational unit, quality management unit, statistics unit, and public relations unit being in active in the administrative part emphasize that with their activities, presenting high quality service, and enabling this service to continue with continuous improvements are important for managers.



Figure 2: Systemic Structure of Medical Faculty Hospital, Seljuk University,

In the scope of the study, the people in the position of manager, who serve in Medical Faculty Hospital, Seljuk University since its founding, trained in their domains, and in directly relationship with the managerial processes, were identified. In order to carry out the survey, total 30 managers were identified, who are appropriate for the desired conditions. But, because 2 of 30 managers identified were in holiday in the application period of survey, data were collected by means of face to face interview with 28 managers. The interviews with managers were carried out face to face by getting an appointment earlier between the dates of June 1-15, 2015. Some explanations, in written text and verbally were made to the managers at the beginning of interview about the aim of study, content of interview, and main heading to be interviewed (vision-mission -strategy). The managers, stage of the first the interview, are asked for specifying, taking into consideration the position they have, their activities, existing structure of hospital, the vision and mission definitions, and expressions they consider that they should be absolutely in the vision and mission declaration. In the second stage of interview, the managers are asked what the managerial strategies should be, which will take the hospital to the future they target, taking into consideration they identify.

The data obtained at the end of interviews were subjected to the content analysis by 3 academics studying on the domain of strategic management and health institutes management. First of all, the specialists examined the expressions of vision and mission and the expressions were coded according to the main headings determined. Then, calculating the frequencies of use of each code in expressions, the main codes forming the expressions of vision and mission were put in order according to their priorities. Specialists, secondly, considered the strategies and, grouping each strategy, suggested by the managers, according to their subjects, brought together the similar strategies and, the main strategies for hospital were determined. While the main strategies are grouped, the dimensions of balanced scorecard were taken into consideration, which is of the actual headings, and provides an holistic approach to the



managerial processes. In this scope, strategies were individually determined for the customer patient and staff) dimension, financial dimension, learning/developing dimension, and internal processes

### Results

### Results of Content Analysis of Mission-Vision Declaration

Hospital, Seljuk University (S:U), the main codes that will form the expressions of vision and mission, which were determined by means of the method of content analysis, were shown in Figure 2.



Figure 3: Mission-Vision Main Codes

Note: The values within parentheses show the frequency to be mentioned in the relevant female surveys

According to Figure 2, in the expression of mission of S.U. Medical Faculty, there are 15 subjects, considered that they should be existent by the managers. Of these codes, high quality service and high quality staff were suggested by 75% of participants; providing patient satisfaction (being patient oriented, protecting patient rights) by 50%; and fullness of the physical and technical competency of the hospital by 39.3%. However, R&D studies, use of advanced technology, that the region has health security, that there are good-humored and positive staff, being trustable, having the ethical principle, and caring employee satisfaction are of the other headings that stand out.

According to Figure 2, in the expression of vision of S.U. Medical Faculty, there are 12 subjects, considered that they should be existent by the managers. Of these codes, becoming pioneer hospital were suggested by 50% of participants; presenting the equal and high quality service by 50%; and that the hospital is known, by 39.3%. However, becoming dominant patient satisfaction, that the staff is competent and qualified, becoming innovative, supporting the medical development, caring the activities of research and technological development, and providing employee satisfaction are of the other headings that stand out.

### Determination of strategies according to the dimensions of Balanced Scorecard

According to the interviews carried out with the managers of S.U. Medical Faculty Hospital, the main strategies determined by means of method of content analysis according to the four basic dimensions of balanced scorecard are shown from Table 1 through Table 5.

In S.U. Medical Faculty Hospital, there are two parts as that presenting service and that receiving service in providing health service: The patients qualified as external customer receiving health service and staff qualified as internal customer presenting health service. In this context, in the scope of customer dimension of balanced scorecard, strategies were discussed in two sections toward patient and staff.



# Table 1: Strategies for dimension customer of patients

	CUSTOMER DIMENSION				
P	ATIENT				
1	To prioritize patient and patient relative satisfaction and take actions increasing satisfaction				
2	To employ staff having the ability to make dialogue according to the psychological state of patient and patient relative and enable the relationship of patient-physician at the top level				
3	To prioritize the needs for patient in the presentation of service				
4	To provide the security of patient				
5	Among alternative health providers, for the procedures of diagnosis and treatment, to take in the first order of ordering of patiens				
6	To increase the number of patient and patient relatives, to whom qualified service is presented				
7	To present high quality health service, which the patients can easily reach, and continues for 24 hours without interruption				

According to the results in Table 1, in the direction of content analyses carried out and the views of specialists, 7 main strategies toward patients were set. In these strategies, generally the subjects such as providing satisfaction of the patient and patient relatives; making a strong positive relationship between patients and relatives; presenting high quality service the people will prefer in prioritized way, and etc. stand out.

### Table 2: Strategies For Dimension Customer Of Staff

S	TAFF
	To employ enough number of health provider, who can apply quality standards and increase the
1	number of employees
2	To prioritize staff satisfaction and take actions increasing satisfsction
	To have physicians, nurses, and auxiliary staff, who make good communication from psychosocial
2	aspect, whose social aspect are strong, who has empathy ability, and who are respectful for ethcal
3	values.
	To employ enough number of professional, academic, and administrative staff, who are qualified,
4	talent, self-sacrificing, foresighted who makes his job by enjoying,
5	To provide staff to trust the institute and increase the safety of employees
	To have managers, who have high knowledge and skills about hospital management, health
6	management, and administrative issues
	To enhance the communication power of staff working in the unites (particularly information desk,
7	patient rights, and policlinic secretaries) directly making communication with patients

According to the results in Table 2, in the direction of content analyses carried out and the views of specialists, 7 main strategies toward staff were set. In these strategies, generally the subjects such as providing satisfaction of the staff and patient relatives; employment of qualified staff, providing the institutional engagement of staff, and etc. stand out.



### Table 3: Financial Dimension Strategies

	FINANCIAL DIMENSION						
	With the fiscal actions such as reducing insurance deduction, to be able to make the sufficient						
1	amount of extra payment						
	With a long termed and realist viewpoint, to prepare hospital budget in the direction of aims and						
2	targets						
	To make allocations of recourses according to andering of importance and micrity						
3	To make anocations of resources according to ordering of importance and priority						
	To provide a satisfying financial support, which will be return of working in all subjects such as						
4	wage of overtime, for staff						
	To provide social and monetary possibilities enhancing the institutional belonging of employees						
5	To provide social and monomy possibilities emininents the institutional beforging of emptoyees						
	To provide uninterrupted extra financial support and financial discipline						
6							
	With moving from the importance of using the latest health technologies, to increase the						
7	financial resources, allocated for technological investment						
	To plan the resource distribution in the scope of the responsibility of unites for baing able to						
8	account and institutional management principles.						

According to the results in Table 3, in the direction of content analyses carried out and the views of specialists, 8 main strategies toward financial issues of hospital were set. In these strategies, generally the subjects such as taking actions increasing the income of hospital; providing the satisfaction of staff on the financial issues; and planning the resource allocation and budgetary fairly and according to aims and etc. stand out.

### **Table 4:** Stategies on the dimension learning development

	LEARNING DEVELOPMENT DIMENSION						
	To develop the educational and research possibilities that are suitable for the quality and needs						
1	of staff from every stage						
2	To provide continuity in education of staff and increase in-service education applications						
	Following the developments and innovations in the science and technology, to implement at the						
3	top level in all processes in hospital						
	For a high quality and good-humored service, to train the health providers and form the employee						
4	<b>4</b> awareness and institutional culture related to the way they do work						
To use a technological infrastructure in presenting health services, which is new and in compatil							
5	5 with the technical sufficiency of the hospital						
6	To shape the presentation of health services in consciousness of learning organization						
	To support their employees for them to follow the national and international developments and						
7	innovations occurring in their areas and to become pioneer						
	Especially providing coordination with the other famous hospitals presenting service in the close						
G	geographical region and/or having a certain specialty area, to arrange training and cooperation						
C	programs for administrative and academic staff						
	Considering the needs for patient, patient relative, and staff, to design and strengthen the technical						
9	and physical infrastructure of hospital,						

According to the results in Table 4, in the direction of content analyses carried out and the views of specialists, 9 main strategies toward learning and development of hospital were set. In these strategies, generally the subjects such as giving importance to in-service education; subjecting the staff to the continuous education; following the technological innovations in the presentation of health services, applying them to the services; according to the need of hospital shareholders, forming the technical, and physical infrastructure, and etc. stand out.



# Table 5 Strstegies of the dimension internal processes

	INTERNAL PROCESSES DIMENSION					
1	To establish units, regarding the missing sub-branches that will provide differentiation from the					
_	other health providers in the areas such as trauma, transplantation, and ambition units					
2	Determining quality standards, in accordance with the legislation of Health Ministry and the					
	requirements, to enable an units to work in uns unecuoin					
3	To develop the infrastructure that will present the equipped health services, which are high quality and modern, which have ethical values, and equipped					
	To become an institutionalized health agency realizing coordination between units and main					
4	scientific branches and teamwork with high cooperation					
_	To take actions to improve the operational indicators such as occupancy rate of hospital, hospitalization					
Э	duration, and occupancy rate of bed					
	Following the leading health institutes of the world, which are specialist in their areas in the					
6	national and international scale whose reliability and familiarity are high to make administrative					
o national and international scale, whose renability and raining the high, to make admini						
-	and academic cooperation with these institutes					
1	To take actions to shorten the times of examination, results, and appointment					
8	To give service in international standards on the services of diagnosis and treatment.					
0	To form a renewable organization scheme that is in compatible with the managerial requirement					
,	of age					
10	To make the resource allocation to the ordering of priority					
10						
	To continuously renew the medical device park according to the need and global technological					
11	developments					
	In the strategical processes such as management, promotion, and performance, to receive support					
12	from the professional people and institutes					
10	to complete the deficiencies of physical infrastructure in the short time					
13						
	To develop hotel management service, indispensable part of presenting the heslth service,					
14	according to the needs of patients and patient relatives					

According to the results in Table 5, in the direction of content analyses carried out and the views of specialists, 14 main strategies toward internal processes of hospital were set. In these strategies, generally the subjects such as strengthening the infrastructure of hospital according to actual developments and increasing the equipment; eliminating the deficiencies toward the areas, where the hospital is weak; taking actions increasing performance, improving the operational indicators, and providing the satisfactioin and quality, and etc. stand out.

### **Conclusion and Discussion**

Strategic management applications in health institutes is one of important issues of the last 20 years. Health institutes, with the effect of both financial and legal institutes and the changing needs, should realize the applications of strategic management.

Strategic management is a managerial techniques, used in making decisions toward future. In a business, the aim of top management is to increase the performance of organization in the future and raise the profitability and effectiveness. When regarded from this viewpoint, strategic management is an issue concerning the top management.

In their studies and decisions of strategic management, businesses are obliged ro evaluate both their internal environments and external environments. In the stage of applying the managerial technique, which enables to plan, organize, coordinate, apply, and control the activities related to the future, there are different alternatives in front of businesses.

In this study, as a result of content analyses of data obtained at the end of focus group interview, one of these alternatives, and of evaluation of them according to the views of specialists, the issues forming the vision and mission of S.U. Medical Faculty Hospital and strategies for hospital from 4 different aspects, as financial, learning, development, and internal process, were determined. According to this, there are 15 subjects, considered to be included in the mission declaration of hospital. Among these subjects, presenting service and employing qualified staff stand out as the subject given importance the most stands out. On the other hand, there are 12 subjects considered to take place in the mission declaration of hospital. Among these subjects, becoming an sample and pioneer hospital in the region, and presenting high quality service as the subject given importance the most stands out. After determining



the general roof of vision and mission declarations of hospital, the strategies that will serve this aim were attempted to be identified. The views of managers were grouped according to their contents were collected under the four main headings as the issues regarding the patient and staff, financial issues, issues toward learning and development, and issues related to the internal processes. The managers set 7 main strategies toward the issues that will serve the future of hospital; 7, toward staff; 8, toward financial issues; 9, learning and development; and 14, toward internal processes. Considering the general features and future, of health sector, the strategies that are human oriented, increase the satisfaction and quality, and are based on the change and effectiveness were set.

At the end of this study, hospital managers found the possibility to achieve the information to support the process of making decision in the managerial decisions; and to be able to give direction to the future of hospital. For the next studies, carrying out the studies complementing the strategic management process such as making SWOT analysis of hospital in detail, measuring the service quality, and forming the balanced scorecard are suggested.

### References

- Buzlu Volkan (2014), "Stratejik Yönetim, Planlama Ve Sağlık Sektörü", Beykent Üniversitesi Yüksek Lisans Tezi.
- Daşhan Canan (2012), "Sağlık Kurumlarında Strateji Haritalarının Oluşturulması Ve Yönetsel Kararlarda Kullanılması Üzerine Bir Araştırma", Dokuz Eylül Üniversitesi Yüksek Lisans Tezi.
- Gökbel Hakkı (2014), "Sağlık Kurumlarında hizmet Kalitesi Analizi", Medimagazin, Mart 2014. (http://www.medimagazin.com.tr/authors/hakki-gokbel/tr-saglik-kurumlarinda-hizmet-kalitesi-analizi-72-103-3589.html; E.T.:13.08.2015)
- Marr, B., Schiuma, G. ve Neely, A. (2004), "The Dynamics of Value Creation: Mapping Your Intellectual Performance Drivers", Journal of Intellectual Capital, 5(2): 312-325.
- Özer M. Akif (2009), "Vizyondan Misyona Örgütsel Gelecek Tasarımı", Dosya Çerçeve Dergisi, s.70-84
- Pearce, J. A. ve Robinson R. B. (1991), "Strategic Management Formulation, Implemantation And Control", Usa: Richard D. Irwin Inc.
- Şeremet Meryem (2013), "Sağlık Sektörü Yöneticilerinin Stratejik Liderlik Özelliklerinin Değerlendirilmesi: Balıkesir İli Kamu Hastanelerine Yönelik Bir Uygulama", Beykent Üniversitesi Yüksek Lisans Tezi.
- Ujunwa, A. ve Modebe, N.J. (2012), "Adopting Strategic Management Approach in the Capital Market Development: The Nigerian Case", International Journal of Economics and Finance. Vol. 4, No. 1; p.5
- Zuckerman M.Alan (2000), "Leveraging Strategic Planning for Improved Financial Performance", Healthcare Financial Management, Aralık, p.54-57.



# THE INVESTIGATION OF THE RELATION BETWEEN NDVI IMAGE AND FOREST MANAGEMENT-SITE INDEX DATA, THE CASE OF BARTIN REGION OF FORESTRY, TURKEY

Ayhan Atesoglu<sup>1</sup>, Metin Tunay<sup>1</sup>, Hüseyin Simsek<sup>2</sup>

<sup>1</sup> Bartin University, Faculty of Forestry, 74100 Bartin <sup>2</sup> Bartin Forest District, 74100 Bartin

aatesoglu@yahoo.com

**Abstract:** Site index is defined as the power of product and service production of somewhere. However, a forested land has actual and potential efficiency power. In the application, it is the actual site index we have determined according to several criteria. Actual situation is far from reflecting the real efficiency. The stand could have been affected negatively from various factors. The common structure seen in Turkey forests is like that. When the real situation is demanded, it is necessary to identify the potential productivity. Within the scope of site index term, site indicators and indexes for productive stands have been determined and accepted. We have sufficient information about these. However, the subject of making disordered stands and clearings is site index hasn't been clarified. The site index of the areas in inventory studies increasing the cost are assigned using age-length data of the trees. However, this method does not provide sufficient accuracy for someone examining the area in separation of the site classes. Inferences have been made related to actual and potential site index by comparing NDVI images through satellite image data for the study area of which site index maps have been decided in the study and the relations have been searched. Actual and potential site index thematic maps have been formed for the sample study area through NDVI image data as the final outcome.

Keywords: Forestry, NDVI, Remote sensing data, Site index

### Introduction

Bonitet is defined as the products and service production power of a place. The field has actual and potential efficiency power. In practice, it is the actual bonitet we determine according to various criteria. Actual case may be far from reflecting the true yield potential. Existing stand might be affected by several factors negatively. Actual and potential efficiency can differently emerge very dramatically. Potential efficiency is the efficiency that will be obtained if a stand is found in the normal setup that the field can exploit the real efficiency power and collect on it. The difference between the actual and potential efficiency increases with the rate of the existing stand gets away from the normal setup. Bonitet concept, bonitet indicators and indices are determined for efficient stands and have been accepted. However, in the boniteting the disordered stands and opening areas, the subject has not been clarified. In some places, the cases that is conflicting to the knowns may be found structurally. There may be situations that this contradiction cannot be even explained by the soil structure or the plants nutrients inside the soil (Eler, 2002; URL 1).

Site index is based on the quite different projections of the site in near infrared and visible red bands. A healthy site absorbs the visible light reflects most of the near infrared light, on the other hand, a sick/unhealthy site reflects the visible light more and the near infrared less. Reflection in the visible bands depends on the pigments in plant leaves, while it depends on the plant cell structure in near infrared region (Baker, 1987). The most widely used index in the Normalized Difference Vegetation Index. The algorithm of the Normalized Difference Vegetation Index is given as;

Normalized Difference Vegetation Index =  $\frac{\text{Near Infrared} - \text{Red}}{\text{Near Infrared} + \text{Red}}$ 

The results vary between -1 to +1 depending on the situation of the area where the site is located. For example, if the obtained value if 0,1 or lower, it corresponds to rocky areas, between 0,2 to 0,3 it will be meadow or grass; for 0,6 to 0,8 it corresponds to a healthy site (Akkartal et al., 2005).

In this study, for the study area whose bonitet maps are determined, the findings and the realtionships related to the actual and potential Bonite are investigated by comparing NDVI images over the satellite images. As a resulting product, actual and potential bonitet thematic maps are formed for the sample area over NDVI image data.



### **Materials and Methods**

The field of study is located between 32° 06' 43" and 32° 45' 39" East longitude and 41° 34'33" and 41° 50' 31" North latitude in the Western Black Sea Region in Turkey. The total area is covered by forest community (*Quercus sp., Carpinus betulus, Castenae sativa, Fagus orientalis, Pinus sylvestris, Pinus nigra, Abies bornmülleriana* are formed mixed forest) with the rest being pseudo-maquis land (Atesoglu and Tunay, 2010) (Figure 1). The land, deeply fragmented by the River of Bartin, and its branches has a rough appearance. There are narrow and deep valleys in the lands where the river gets wider and in between the quite steep slopes of the mountains.



Figure 1. The field of study

Landsat TM satellite image data with different dates and whose geographical definition and geometric adjustment were made based on WGS 84 UTM 36N coordinate system were used in the study. Detailed information about Landsat satellite images can be obtained from Lillesand *et al.*, (2004).

The vegetation index image of satellite image data were formed in order to identify the land use according to the purpose of the study. Vegetation index is based on a quite different reflection of vegetation on near infrared and visible red bands. The vegetation index mostly used in practice is the Normalized Difference Vegetation Index (NDVI). The algorithm of NDVI is the ratio of the sum of the difference between near infrared band and red band. Classified result image data were formed from vegetation image data generated. In assessing RS data, the related modules of PCI EASI/PACE image processing software were used. Arc View 9.1 program, an ESRI software, was used for GIS practices.

As the method, a vegetation map created with the satellite images and a map made by using the management plan data of Bartin Forest Management Directorate are compared. Taking 0. Bonitet and 5. Bonitet in the management plan data as the basis, bonitet map is produced. With the help of NDVI from the satellite images, vegetation map is formed. In NDVI values, 0% areas are the areas without vegetation, areas having 0%-15% values are the areas having less dense vegetation, areas having 15%-65% values are the areas with high density vegetation.

### Results

With the help of the management plans, classification in which no vegetation is found within the border of the study area (Site indeks\_0) is composed of 6 site index classes (Figure 2). Due to the lack of the areas with 1. And 2. Bonitets, these areas are combined. Actual case was determined in 2009 and the management plan is prepared in 2010.





For the vegetation map obtained with the help of the satellite images; 0% NDVI corresponds to "no vegetation" areas, areas up to 15% are "low vegetation" ones, up to 65% are the "moderate vegetation" areas and the areas more than 65% are determined to be "high vegetation" areas (Figure 3).





Figure 3. Vegetation Map

When two bonitet maps formed by using both satellite images and the management plan are investigated, the areas with "2" and "3" bonitets in the map made with the management plan are observed to overlap largely with the "high vegetation" areas formed with the help of satellite images (Figure 4).



**Figure 4.** Areas with "2", "3" bonitet values according to the management plan (A); areas with "high vegetation" bonitet value according to the satellite images (B)

The map showing "0" bonitet areas made by taking the management plan as basis and the maps showing "no\_vegetation" and "low\_vegetation" areas with the help of the satellite images agree well in general. In addition, "medium-vegetation" areas are also observed partially to be coincide with the areas with "0" bonitet (Figure 5).

Furthermore, the areas "4" and "5" from the map made with the management plan are observed to be included in the "medium\_vegetation" areas. When both maps are examined, differences are observed (Figure 6). The reason can be said to be that the management plan is constructed in 2010.





**Figure 5.** Areas having "0" boninet value according to the management plan (A); the areas with "no" (B), "low" (C) vegetation boninet values according to the satellite image



**Figure 6.** Areas having "4" and "5" boninet value according to the management plan (A); the areas with "medium" vegetation boninet values according to the satellite image (B)



### Results

In NDVI maps, areas having 0% represent no vegetation, the ones with 15% represents to the areas with low vegetation, areas with 65% correspond to the moderate amount and the areas having 85% value represent the areas with dense vegetations.

Maps formed based on NDVI and Bonitet show conformity within the border of Bartin Forest Management Directorate, but there are differences when they are examined in detail. For example; the areas with no vegetation in the maps produced by NDVI are the areas with 0% value and no vegetation is found. On the other hand, the areas shown with "0" bonitet in Bonitet maps are thought to be inefficient areas and they might be thought as the areas without vegetation but in these areas, some degraded forest areas, agricultural areas can be seen. This means the vegetation existence in those areas even though it is individual.

As a result, it is shown that healthier bonitet classification can be made about the area by using satellite images instead of the management plan. It also helps to form the maps closer to the actual situation.

## References

Eler, Ü. 2002. Bonitetin Önemi. Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi Seri: A, Sayı: 2, Yıl: 2002, ISSN: 1302-7085, Syf:1-10

UIRL 1. http://www.resmigazete.gov.tr/eskiler/2008/02/20080205-15.htm

Akkartal A., Türüdü O. ve Erbek S. F. 2005. Çok Zamanlı Uydu Görüntüleri ile Bitki Örtüsü Değişim Analizi, TMMOB Harita ve Kadastro Mühendisleri Odası, 10. Türkiye Harita Bilimsel ve Teknik Kurultayı Bildiriler Kitabı, Ankara.

Baker, C. B 1987. Changes in Financial Markets and Their Effects on Agriculture, Federal Reserve Bank of St. Louis.

http//research.stlouisfed.org/publications/review/87/10/Financial\_oct1987.pdf

A. ATESOGLU, M. TUNAY : Spatial and Temporal Analysis of Forest Cover Changes in The Bartin Region of Northwestern Turkey, African Journal of Biotechnology. **9**(35), 5676 (2010).

Lillesand, T.M., R.W. Kiefer, J.W Chipman: Remote Sensing and Image Interpretation. John Wiley & Sons Inc., New York, p. 427-524 (2004).



# THE ISSUE OF COSTS IN TEACHING ECONOMIC COURSES IN INFORMATICS

Mária Ďurišová, Alžbeta Kucharčíková

Department of Macro and Microeconomics Faculty of Management Science and Informatics, University of Žilina, Slovak Republic

Maria.Durisova@fri.uniza.sk, Alzbeta.Kucharcikova@fri.uniza.sk

**Abstract:** The teaching process involves a content and procedural aspect at every level of education. The content of higher education in study programme of Informatics should reflect practical requirements. The graduate will be applied to the labour market, if s/he has knowledge of several disciplines and the ability to view the solution to the problems in the enterprise in terms of technology and economy as well. The costs are the basic economic category, along with revenues and economic result. The article gives reasons for the justification of the incorporation of the costs to the content of education within economic courses in Informatics. The article also points to the need to maintain dynamics in teaching, even though the prevailing form of teaching in higher education – lecture – is based on the description and explanation. The dynamics can be achieved using a combination of changing work methods, namely lectures, scenarios, discussion, question brainstorming, activating exercises, etc. applied to the issue of costs.

Keywords: Teaching process, teaching methods, costs, lecture, scenarios, discussion

## Introduction

The graduates of the study programme of Informatics will be applied in practical professional life on the positions of analysts, designers, constructors, programmer, system designers and specialists. They will find the application in various areas of informatics itself, but also in all areas of information systems and information technology applications. The knowledge acquired will allow them to operate at different stages in the management in software companies, industrial enterprises, education system, both in the public and private sector, banking, transport, healthcare, ecology etc. They will be able to design, develop, implement, expand, adapt and locate extensive information systems. Considering each working positions, in addition to the programmer, they have to evaluate their activities economically, that is, to compare the costs and benefits. The result of the comparison is to assess whether the implementation of activities will bring a profit or a loss.

When teaching students in Informatics, it is possible to come across a barrier to the reluctance to learn economic information. Many students take the view that they came to study programming. The task of a higher education teacher is the right motivation for the students. A graduate able to solve tasks interdisciplinary has a higher rate of application in the labour market. It is possible to achieve it using the content and teaching methods, attractive to young people.

### **Definition of the Substance of the Cost**

Each enterprise activity is immediately associated with the emergence of costs and revenues. Characteristics of the concept "cost" depends on the definition of the relevant point of view, as shown in Figure 1. The economic sciences define costs and their structure in terms of the subject of their examination. The understanding and therefore their definition vary depending on the purpose it is used for. In general economic theory, costs are defined wider than in the enterprise economy and accounting.





Figure 1: Aspects of the definition of cost

Basic (General) expression is an expression of corporate cash cost of factors of production and other expenses associated with its assigned activity. The essence is made up of various types of costs, for example, material consumption, energy, wage costs, depreciation, services, repair, and interest.

The accounting definition of cost represents a decrease of economic benefits of the accounting entity in the accounting period. It means that if there is a cost in the accounting period, at the same time there is a decrease in an asset or an increase in obligation.

The economic concept of the cost comes from the fact that the costs are not real, but the estimated costs for the individual variants of the solution. They originate from the limitation of the economic resources, which does not allow producing all of the products and services. They are expressed as explicit and implicit costs, relevant and irrelevant costs, and alternative and opportunity costs. Under the explicit costs of the enterprise we understand the costs associated with specific payments of enterprises in the past and the presence of entities that are not owners. Thus, they are actual costs, considered to be objective quantity. Implicit costs can usually be estimated; therefore they are less objective quantity. Economic theory considers implicit costs alternative, which represent the value of an alternative use, thus opportunity sacrificed.



Figure 2: Comparison of the definitions of explicit and implicit costs

The relevant costs are the costs necessary for the implementation of specific activities in the future. Their amount will change when carrying out a variety of options. Irrelevant costs will remain unchanged in different variants of the solution. Alternative costs represent the value of the property, or services we have given up on the basis of the decision (unrealised revenue). Opportunity cost represents the maximum loss of effect as a result of the use of the economic resource to another alternative (maximum revenue was reached among the alternatives of choice of products). They do not represent real economic resources consumed or used, but the measure of efficiency made by choice.

The managerial definition of cost is a value expression of effective investment of economic resources of the enterprise, associated with economic activity. Value expression of the cost means that they are expressed in the parameters that are valid at the moment. They reflect the consumption of economic resources under the conditions that exist at the time of implementation of processes. Financial expression of the cost is their expression in parameters that applied at the time of the acquisition of economic resources. The evaluation is at historical costs, based on the application of money form of property cycle. Efficient use of economic resources is of rational and adequate to the result of the activity. The purpose of the resource lies in the fact that the cost is always associated with a specific performance. The point of the implementation of economic resource (cost) is its evaluation, i.e. there is to create a component of property, which brought greater economic effect as initially consumed component. Considering managerial understanding of costs, there are used marginal and incremental costs. Marginal cost represents the increase in the cost of producing an additional unit of performance. (The part of the cost, which is added with each the following product to the total costs allocated to the previous number of production units). Incremental cost is associated with larger volumes of production growth.



# Traditional and New Teaching Methods Applied in Teaching the Issue of Costs in Informatics

There are many teaching methods and they are distinguished according to several points of view (according to the source of knowledge, degree of activity of the students, thought operations, etc.). They transform the content of education to a specific teaching process. Higher education in the Slovak Republic has traditionally been interpreted in the professional and lay public, so that teaching methods and forms are combined. Lecture, description and explanation are primary used. The current development trends of building a knowledge-based society and the use of the principles of knowledge management are bringing changes to higher education. There are gradually promoted participatory methods, methods of experiential learning. "The main obstacle to the use of the principles of knowledge and undergo changes in their procedures and methods." (Sujová, 2012, p. 96) Teaching method is primarily characterised as the procedure for achieving the objectives of the teaching. "Teaching method is a coordinated system of teaching activities of students, which is aimed at achieving the objectives for students, set by teachers and accepted by them". (Maňák, 1990, p. 14)

A student can adopt the knowledge on the basis of the active approach. The rate of its active approach is proportional to the chosen teaching methods of the teacher, which fundamentally affects success in achieving its objectives. Teaching method is the way of activity of the teacher affecting the way of the activities of the student in the acquisition of knowledge. "There is no clear instruction for choosing the most appropriate and most effective methods". The appropriate choice will depend on the circumstances. It is advisable to change teaching methods, it can be part of a common cultural change, but there must be considered the impact of teaching methods on the content (Vodák, Kucharčíková, 2011, p. 111).

Considering the study programme of Informatics, students meet with the definition of costs only in terms of economic theory and microeconomics. There is absence in the general definition of the costs, i.e. the definition from the perspective of the corporate economy; therefore we propose to incorporate them in teaching content. In terms of procedural aspect, we propose to combine traditional teaching method of lecture, which is based on the description and explanation and complete it to the teaching methods of questions and answers, discussion, scenarios, brainstorming of questions, activating exercise.

In the lecture, it is necessary, when transferring knowledge, to take advantage of the power of the art of speaking, to avoid monotony and to make efforts to attract the emotions. It is necessary to describe and explain the issue of costs on the basis of examples from practice, based on the costs in household and use the analogy to the enterprise. There is an insignificant role in effective lecture formed by the explanation of the importance of the issue of costs, because there is no business activity without them. Cost assessment has an impact on the resulting effect of the business activity, that is, whether the business will be profitable or loss-making.

The method of questions and answers is based on the effect of questions. "Questions have enormous power. Using them we manage what participants will think of. When placing the question, the focus of our mind is immediately changing." (Miklovič, 2013, p. 64) There are questions asked in the introduction, which will determine the level of knowledge on the issue of costs. Using questions it is possible to examine the understanding of the topic during training. The conclusion of education should include questions that encourage thinking and the other dealing with the topic of costs. Figure 3 contains specific questions.

	Questions in the course of education				
	Introduction	Introduction		Introduction	
•	Have you already met with the concept of cost? If yes, in personal life, in other lessons, in mass media? Do you think that it is necessary to handle the issue of costs in personal life, or are you going to meet up with them in the next job?	•	Have you already met with the concept of cost? If yes, in personal life, in other lessons, in mass media? Do you think that it is necessary to handle the issue of costs in personal life, or are you going to meet up with them in the next job?	•	Have you already met with the concept of cost? If yes, in personal life, in other lessons, in mass media? Do you think that it is necessary to handle the issue of costs in personal life, or are you going to meet up with them in the next job?

Figure 3: Method of questions and answers applied to the issue of costs



Regarding higher education, discussion is used as a supplementary method of lecture during or at the end, to a lesser extent than the main method. The essence of this teaching method is that students ask questions. The precondition for the discussion is that the students have already had a certain degree of knowledge on the issue of costs. Even though there are students who mainly ask questions once a teacher does not miss one. Using questions s/he can open discussion, deepen its contents, encourage the students to the activity of asking questions and keep it in the right direction. The advantage of discussion as a teaching method is that students can change the view on the issue of costs only from dry theory to practical applications, discover new points of view and there is a possibility to get a confirmed their hypothesis and conjectures. Discussion is a valuable source of information for the teacher, because s/he can find the level of perception of the costs on the part of students and may adapt its content during the next lecture or teaching methods.

Scenarios are the simplification of reality through a variety of means of expression. There is a teacher who is active in the introduction of scenario, who explains the assignment, procedure how the entire activity will be in progress and s/he is a key person in determining the roles of the individual students (activists, observers). When implementing, individual students are active and teacher is just an observer and evaluator. The scenario in the area of cost can be represented by decision-making of enterprise management, whether we will continue to carry out internal in the enterprise or the enterprise will purchase transport services. Teacher will divide students the positions of Director, the Head of the Transport, Manager and Economist. The other students are observers. The scenario can run through the relevant costs (fuel consumption, driver wage including insurance, dispatcher wage) and irrelevant costs (depreciation of the garage where the car parked, administrative expenses, cancellation of transport will not be noticeable at the level of the administrative expenses, phone when ordering an external transport, consumption of paper to fill orders, etc.

Question brainstorming is based on the substance of the brainstorming, which is the expression of the greatest number of ideas from students. According to Miklovič, rules that must be respected when brainstorming are as follows: "The rule of banning the evaluation of your ideas or ideas of others. The rule of the greatest number of ideas – its principle is that quantity raises quality – the more ideas, the more likely that there will appear the one we use in real practice. As a rule, the best ideas will appear at the end. The rule of mutual inspiration – if people work together, inspire and help each other, they produce more ideas than when working on an individual basis, and the results of their work are counted together. The rule of full equality of participants lies in the fact that there are no relations of superiority and subordination during brainstorming. All participants are equal, and therefore they should also behave accordingly". (Miklovič, 2013, p. 104) Question brainstorming is mainly based on the formulation of rhetorical questions and their answers. However, questions that suggest a response in the form of a variety of questions are the motivator of answers.

Activating exercises are used for the application of the knowledge acquired on problem tasks, or fixing and review. Classical forms of exercises are the solution of specific tasks, for example; calculate the amount of the costs of the enterprise from the following items.

?		Item	Amount in €
	1 Depreciation of machine		1
	2	Payment of the invoice for the purchase of a commercial vehicle	2
	3	Material consumption	3
	4	Payment of invoice for the material	4
	5	Payment of short-term bank credit	5
	6	Gross wages paid to employees	6
	7	Payment of wages to employees	7
	8	Invoice for products	8
	9	Invoice for the sale of the machine	9
	10	The customer has paid the invoice for the products on a bank account	10
	11	Payment of invoices for mobile phones	11
	12	Invoice received for the consumption of electricity	12
	13	Depreciation of software	13



Activating exercises are close to the game, which to a certain extent unties the student from the reality of the acquisition of knowledge. For example, they include a memory game, pyramid game. Playing a memory game, there are questions on the short cards and answers on the longer. The students, who are divided into groups, assign correct answers to the questions. The student with the greatest number of answers is the winner. Pyramid game is based on the correct answers of students, who are divided into two groups. After each correct answer of the student, his/her group will move to the next step above. Students choose questions according to the number and there is a question following some number without a point, with a negative point and bonus point. The winner is the group that will be on the top. For a teacher, activating exercises are challenging because s/he must prepare thoroughly the entire course of the game and even during the game, s/he is organiser, regulator, motivator and objective evaluator. Questions must be prepared in an intelligible form, and with the possibility of only one unambiguous answer. Teaching the issue of costs in Informatics, there are applied traditional and new teaching methods. The advantage of traditional methods includes a wider range of teaching subject a teacher can convey to students, refer to the mutual connections, and explain the essential parts. The advantage of new teaching methods is the emphasis on the active approach of the student and the acquisition of knowledge in a playful way. For the efficiency of the teaching process, it is recommended to combine traditional and new methods.

# Conclusions

The issue of the cost in teaching economic courses in Informatics constitutes added value for its graduates. The graduate will be able not only to apply the knowledge of Informatics in practice, but also economically evaluates his/her project or its part. In any enterprise, including informatics, achieving profit is one of the objectives. There are compiled cost budgets for the individual projects. The article focuses on the issue of costs through their applications in teaching methods – lecture, questions and answers, scenario, discussions, question brainstorming, activating exercises. The use of several teaching methods affects to maintain the attention of students in the acquisition of knowledge and the process is more efficient.

### Acknowledgements

This article was created as part of application of project: Quality education with the support of innovative forms of quality research and international cooperation - a successful graduate needs to practice: ITMS: 26110230090/Project is funded by EU; Grant (granted by Ministry of Education) VEGA No 1/0421/13 Attribute efficiency and the human capital, VEGA 1/0526/13 Modelling of the multilateral relations of economic entities and improving the quality of their decision-making processes with ICT.

### References

Ďurišová, M. (2013). Modern methodological approach to teaching business economics for IT students In: *Procedia - social and behavioral sciences*. - ISSN 1877-0428. - Vol. 106 (10 December 2013), online, pp. 1850-1856.

European Commission Report to the European Commission on New modes of learning and teaching in higher education October 2014. Luxembourg: Publications Offi ce of the European Union. ISBN 978-92-79-39789-9 Maňák, J. (1990). *Basics of didactics*. PeDF Masarykova Univerzita

Kirkpatrick, D. (2006) *Evaluating Training Programs: The Four Levels* (3 ed). San Francisco: Berrett-Koehler Publishers

Miklovič, I. (2013). Lecturing skills. Bratislava, GtoG, s.r.o.

Salemi, K. M. & Walstad B.W. (2010) *Teaching Innovations in Economics. Strategies and Applications for Interactive Instruction.* Edward Elgar Publishing Limited. Massachusetts, USA.

Sujová, A. (2012). Using principles of knowledge management at management of change in process

performance. In: Theory of Management 6: Proceedings of scientific works: Žilina: Institute of Management, University of Žilina, 2012, s. 93 - 97 (str. 96) ISBN 978-80-554-0591-9

Vodák, J., & Kucharčíková, A. (2011). *Effective training of employee*. Grada Publishing, Prague 2011, (2nd ed.).

Tokarčíková, E. (2014). *Microeconomics*, EDIS – publishing center of University of Žilina, 2014

Wafta, M. K. & Audi, D. M. (2015). New learning methodologies using modern Technologies. *International Journal of Innovation and Learning*, 2015 Vol.17, No.3, (pp.275–297), ISSN 1471-8197, DOI: 10.1504/IJIL.2015.068463



# USE OF PARTICIPATORY METHODS IN TEACHING AT THE UNIVERSITY

Alžbeta Kucharčíková, Emese Tokarčíková

Department of Macro and Microeconomics, Faculty of Management Science and Informatics University of Žilina, Slovak Republic

Alzbeta.Kucharcikova@fri.uniza.sk, Emese.Tokarcikova@fri.uniza.sk

**Abstract:** The methods used represent an important tool for ensuring the educational process. The selection of appropriate methods is determined by the aim of the subject. However, the use of a suitable combination of mutual educational methods should be conditional on the individual needs of students and teachers, social needs and trends. The selection should respond to the current global trends in technical, economic, and educational research and development. The implementation of appropriate methods is determined by various factors. It is, for example, the number of students in one group, their present and desired level of knowledge, skills, motivation to learn, functional position. The level of expertise and experience of teachers and spatial capabilities are also important. The aim of the article is to show how it is possible to increase the efficiency and attractiveness of the subject at university using participatory methods.

Keywords: motivation, teaching methods, participatory methods, role play

### Introduction

The key elements in the implementation of education are the students themselves. Their motivational readiness to learn depends inter alia on the emotional state of mind, cultural and educational backgrounds. Emotional status and disposition also have an effect on what will be their approach to learning. Motive is an internal momentum that causes a change in human's behaviour and to leads to his needs.

Much of the criticism has been directed to higher education in Slovakia over the decades. It is argued that the current education focuses more on acquiring encyclopaedic knowledge rather than promoting the creativity to develop ability to identify problems. As a result, students are less able to analyse specific situation, to present and evaluate alternative solutions, stand up for their own opinions and use their knowledge in practical applications. These applied tools will help us enhance the quality of education and attract the attention to more effective learning at the universities as the imperative of successful preparation of students for both their professional and personal life.

### Motivation

At universities, unfortunately, studying also those students who do not wish to periodically prepare and they decided to study only because this wished their parents or because of their field of study is the low interest from other students. The idea of obtaining a university degree is great, but interest in the study and willingness to make an effort - it is negligible for some of students. What to do in such cases? Is it possible to motivate some young people with no interest in anything?

There are a lot of motivational factors, of course. Interest in the subject depends on the content and form of teaching, nature of teachers and students and of other factors. Everything is determined by the time possibilities arising from the timetable, the number of students in a class, surround possibilities, teacher's readiness and alike. For students is motivating when the teacher at the beginning of the semester informs about content and goals of the course, and also gives them space to comment about what they interested in, respectively what another topic related to the content of the course would be welcomed and what are their expectations. This is useful information for teachers about what could be added to the content part to meet the requirements and the interest of teachers and students, too.

Motivation increases the amount of effort and energy that learners expend in activities directly related to their needs and goals (Csikszentmihalyi & Nakamura, 1989). It determines whether they pursue a task enthusiastically and wholeheartedly or apathetically and lackadaisically.

Motivation increases initiation of and persistence in activities. Students are more likely to begin a task they actually want to do. They are also more likely to continue working at it until they've completed it, even if they are occasionally interrupted or frustrated in the process Motivation increases students' time on task and it is an important factor affecting their learning (Larson, 2000).

We can say that motivation is the force that drives us to carry out activities. We are motivated when we feel like doing something and we are able to sustain the effort required during the time required to achieve the objective we set ourselves. Motivation should be considered carefully by teachers, trying to mobilize the capabilities and potential of each student for academic success. (Ferreira, Cardosob & Abrantesc, 2011)

Educational science defined two basic types of motivation: intrinsic and extrinsic, that have a potentially different consequences on learning (Standage, Duda&Ntoumanis, 2005). These are based on self-determination theory that considers humans to actively seek optimal challenges and new experiences to master and integrate. The most self-determined type of motivation is intrinsic motivation. Intrinsic motivation refers to engagement in activities for their own sake, namely for the feelings of pleasure, interest, and satisfaction that derive directly from participation. When intrinsically motivated, individuals are fully self-regulated, engage in activities out of interest, experience a sense of volition, and function without the aid of external rewards and constraints (Deci & Ryan, 1985).

Teachers should also create an active learning environment that enhances students' perceived autonomy and competence, providing students with choices and opportunities for self-directed learning, and planning learning activities that might increase their feeling of mastery. In fact, intrinsic motivation was shown to be a factor of great importance that can lead to higher perceived learning in the course (Ferreira, Cardosob&Abrantesc, 2011).

Motivation affects cognitive processes. Motivation affects what learners pay attention to and how effectively they process it. For instance, motivated learners often make a concerted effort to truly understand classroom material—to learn it meaningfully—and consider how they might use it in their own lives (Ormrod, 2006). One of the most important motivational factors in the learning is the use of suitable, modern and interesting teaching methods.

# **Teaching Methods**

The term teaching method refers to the general principles, pedagogy and management strategies used for classroom instruction. The choice of teaching method depends on what fits the teacher - educational philosophy, classroom demographic, subject area(s) and school mission statement. Teaching theories primarily fall into two categories or "approaches" — teacher-centered and student-centered.



Figure 1: Teaching methods

Teacher-Centered Approach to Learning - teachers are the main authority figure in this model. Students are viewed as "empty vessels" whose primary role is to passively receive information (via lectures and direct instruction) with an end goal of testing and assessment. It is the primary role of teachers to pass knowledge and information onto their students. In this model, teaching and assessment are viewed as two separate entities. Student learning is measured through objectively scored tests and assessments.



Student-Centered Approach to Learning - while teachers are an authority figure in this model, teachers and students play an equally active role in the learning process. The teacher's primary role is to coach and facilitate student learning and overall comprehension of material. Student learning is measured through both formal and informal forms of assessment, including group projects, student portfolios, and class participation. Teaching and assessment are connected; student learning is continuously measured during teacher instruction.

Teaching methods are an important tool for the implementation of the educational process. Selection and use appropriate methods should reflect the needs of students and respond to current global trends in technological and economic development. Choosing appropriate methods course is determined by various factors such as the number of students in the study group, spatial and technical capabilities, motivating students to learn, professional level and experience of teachers, as well as the quality and availability of teaching resources and supporting textbooks (http://teach.com).

The most frequently used methods of teaching at universities are lectures and seminars. Lectures are suitable for the transmission of large quantities of information to large numbers of students, but this is missing the opportunity of interaction. **Lectures** are verbal presentations of a particular topic. They are suitable for the presentation of a large amount of information to large groups, but there is missing the opportunity to mutual interaction of a lecturer with participants. They are focused primarily on improving knowledge. They can be very impressive and imaginative using modern multimedia tools; however, in terms of preserving the information, they are not very effective.

**Seminars** realised as seminary works or discussions allow the exchange of information and views on certain issues, but the quality of learning depends on the knowledge level and responsible preparing of students. The advantage is the support and development of ideas, immediate feedback. However, the quality of learning depends on the knowledge level of the participants.

Currently, there has been dynamically expanding **E-learning** (electronic education), which is faster and cheaper than other conventional forms of education, but its use is limited to the theme of education and technological equipment of companies. The advantages of using modern ICT in education is also the fact that: the student can use his own pace, updated material is available immediately and it can be provided for a large number of students at the same time, opinions and thoughts on the topic being acquired can be easily exchanged among the participants. Some disadvantages can include the following factors: lack of visual contact with the teacher in each group, therefore, non-verbal reactions cannot be easily captured and processed; difficult to set down rules of cooperation, high demands are placed on teacher in the coordination and involvement of all participants. Because students are very happy to work with ICT, e-learning is very useful as a complementary tool to the above methods (Vodák&Kucharčíková, 2011). The e-learning concept had professionally been applied on some majors offered at The Hashemite University in Jordan and gained a great impact on the learning process, students and staff. The Hashemite University has made an excellent progress toward practicing e-learning environment through sequence of actions in real life scenario that overcome the limitations related to the traditional learning system (Fayyoumi, Idwan, AL-Sarayreh & Obeidallah, 2015).

Technology becomes a more integral part of education more teachers want to use different forms of modern tools to help teach students. There are innovative and new teaching methodologies which incorporate the use of modern technology to encourage students to participate and take an active role in learning. Wafta &Audi (2015) presented for the first time three teaching methodologies: 1) dynamic lecture notes using live student feedback; 2) an extension to the dynamic lecture notes that incorporates an online video repository to substitute some lecture presentations both during and after class; 3) 24/7 teacher-student portal using mobile social networking.

To achieve higher efficiency of education is necessary to use a combination of several methods. They should also include participative methods. Participative methods assume a high degree of student activities. Their advantage is that they support better remember learned. They represent the current modern methods, which is typical for active practice, experience and direction to the learning of "learning by doing". They are thus based on the fact that people will learn more if you try to do something, than if they just read or listen to the new information, such as a lecture. Lecture prefer the content of learning, participative methods prefer the procedural aspect. Students can be activated using a combination of various participative methods such as group work, brainstorming, case studies, role playing, management games, and so on. An important part of this method of teaching is to provide feedback and evaluation of activities.

Successful managers understand that a reasonably activity in processing information not only accelerate their use, but primarily improves the quality of decision-making. And it is this activity which students should be prepared using participative methods. In the context of teaching are often created problems with space, time, time-tables



and the like. Many students take more than the studies focus on "chasing credits" and often they are not interested about course itself. However, for all those who are interested in learning, it is important that teachers do experiments and use the innovative, non-traditional teaching methods and practices. In order to achieve a higher efficiency of education it is appropriate to use a combination of several methods. The most frequently used includes lectures, seminars, but more modern and more efficient are so-called participatory methods. Because participative methods are used for education (training) small groups, universities can be applied mainly in seminars or tutorials. In this way there is a better choice than strengthen knowledge accumulated in lectures and linking them to practical model situations (Kucharčíková, 2013).

# **Participatory Methods**

Participatory teaching approach is a form of a reflective teaching approach which is sometimes termed as interactive teaching method or learner centered teaching method. This method stresses the subjectivity of learners and the self construction of knowledge. It is a shift from a belief that learners are empty plate who are supposed to be imparted with knowledge (teach concept) to a belief that learners can construct knowledge and learn on their own if properly guided (learn concept) (Kafyulilo).

Participatory methods expect a high degree of activity and personal involvement of participants in the learning process. They are designed only for smaller groups of participants, but their advantage is that they encourage better retention of learned. They are contemporary modern methods of education (Table 1).

METHOD DESCRIPTION		ADVANTAGES	DISADVANTEGES
BRAINSTORMING	Frequently used method to solve problems. It is necessary to respect the principle of non-criticism, fantasy release, mutual inspiration and equality of participants	<ul> <li>speed</li> <li>the involvement of a large number of students</li> </ul>	<ul> <li>necessity of clearly explain the method before using</li> <li>the need for compliance with the rules of the method</li> </ul>
WORKSHOP	Popular method addressed to discuss specific situations and find possible approaches to their positive management.	<ul> <li>informality</li> <li>use in the more numerous group</li> </ul>	<ul> <li>requirements for teacher facilitation skills</li> </ul>
AQUARIUM One group of students solves the problem the second group observes and then provides the feedback.		<ul> <li>practicing of giving feedback</li> <li>solid training of the learned skills</li> </ul>	<ul> <li>stage fright and nervousness participants who solves the role and who are observed</li> <li>demanding facilitation by the teacher</li> </ul>
ROLE PLAYSThe group gets the script with roles. Students play a selected situation and examine the various possible approaches to solving problems or unforeseen events.		<ul> <li>fun</li> <li>practicing well as unpleasant situations</li> </ul>	<ul> <li>games can be considered unrealistic</li> <li>stage-fright and fear of missed "actor's" performance</li> </ul>
SOLUTION TO THE INCIDENTThe method is similar to the case study. Enter the basic facts of the incident and the group decides what further information needs and what needs to answer questions.		<ul> <li>exploration real problems without the risk</li> <li>good simulation of reality</li> </ul>	<ul> <li>possible sense the artificial situation by the participants</li> </ul>
LABYRINTH	Used induced situation. At some point, students have to solve several tasks simultaneously and options identified consequences of one of the selected options. Proceed in this way until the successful solved task.	<ul> <li>it can keep its own pace of work</li> <li>a high degree of student participation</li> </ul>	<ul> <li>time-consuming</li> <li>difficulty preparation for teachers</li> </ul>

### Table 1: Same of the participative methods



The more efficient application of any method is supported by audio-visual device, such as flipchart, projector, overhead projector, whiteboard, various educational or amusing films, models or support materials. Fashion hit is the use of computers and presentation of educated themes in PowerPoint programme. The risk is that the interactivity is disappearing and teachers and students often focus more on the visual aspect of the presentation when creating presentation, the content is underestimated. We should not forget the appropriate arrangement of the room where the educational activities are practiced. The arrangement is necessary to adapt to the main theme of activity, methods used, group size, room size, timing etc. Also, new technologies open new possibilities and opportunities in education. When using them, it is necessary to pay attention to that they can meet the expectations of students and make learning efficient enough. The conditions and approaches to learning, as well as specific conditions for learning support, are generally applicable and it is necessary to pay attention to them, even using the most modern technologies. The creation of more effective combinations of these methods and the ability to design new innovative methods of education will be important for the future.

The current labour market effects the university education to a large extent requiring a graduate of interdisciplinary knowledge and with the skills to find the solutions to both technological and economic issues (Ďurišová, 2013). But many contemporary students study subjects that are not profiled for their chosen field of study with displeasure and unwillingness. The most common argument used therein, is "what I do in life will be?" It depends on the teacher that he himself explain the practical application of the "unpopular" subject or to ask the students themselves to seek and identify possibilities for practical application. This also applies to students of Informatics who are prejudiced to study the subjects of economic character for students of study programme Informatics, we have innovated teaching Macroeconomics at the Faculty of Management Science and Informatics using participatory methods of education. In the context of the previous text, we apply a combination of lectures, discussions, brainstorming, group work, buzzing groups within teaching. At the end of the semester, when students have plenty of expertise knowledge, obtained presentation skills and have enough experience of teaching using participatory methods, we use role plays "Negotiation."

### **Role Play**

It is an active method, which is based on the simulation of real situations and practice different work tasks (Průcha&Veteška, 2012). Role-play is useful where learners share a somewhat similar experience, which is difficult to recall because of its emotional nature. Here learning takes place from re-enactment of past experiences. It is a powerful training method if the focus of learning is to generate awareness. The method of role-play is useful as it helps learners utilize their experiences of real life situations. The enactment is helpful in developing awareness at individual and group levels. Through role play it becomes easier to discuss complex social issues in a non threatening environment. In order to use role-play effectively, you need to select a suitable role play depending on the purpose of learning and identify role enactors/performers. Next, you need to prepare briefs and explain the situation to the learners and tell the audience all the points to be noted. Now is the time to set the stage and start role-play. After the play you can consolidate and debrief. In certain situations, a role-play is also used to practice skills. For example, you can practice how to motivate adult learners by enacting different roles. The prime method of learning here is practicing and receiving feedback from learners and adult educators after that practice. As a re-enactment of past experiences. Learners may enact a past situation with which they are familiar (Subin).

In role plays, participants use their own experiences to play a real life situation. When done well, role plays increase the participants' self-confidence, give them the opportunity to understand or even feel empathy for other people's viewpoints or roles, and usually end with practical answers, solutions or guidelines. However, role plays can be time-consuming and their success depends on the willingness of participants to take active part. Some trainees may feel a role play is too exposing, threatening or embarrassing. This reluctance may be overcome at the outset by careful explanation of the objectives and the outcome. Some role plays can generate strong emotions amongst the participants. It is therefore essential that a role play is followed by a thorough debriefing. This provides the opportunity for the trainer and the participants to raise and assess new issues. (Makokha&Ongwae). Role plays are useful for exploring and improving interviewing techniques and examining the complexities and potential conflicts of group meetings. They help participants to consolidate different lessons in one setting and are good energisers.

The rapid and steady changes in a field of information and communication technologies have increased demand for high qualified specialists not only in a field of cybernetics and applied informatics, but also in related fields such as economy and management (Tokarčíková, 2013). This role play is designed for students of Macroeconomics to practice and repeat topics related to models of macroeconomics equilibrium (Keynes's model of equilibrium output determination, IS-LM Model, IS-LM-BP Model, AD-AS Model), topics related to macroeconomic problems (unemployment, inflation, deflation, business cycles) and the application of knowledge in the field of



economic policy, particularly fiscal, monetary and foreign trade policy. In addition to repeating knowledge of entire semester study of Macroeconomics, the aim of the game is that students examine communication skills, professional reasoning, presentation and teamwork.

The game, however, can be determined as well as for other economic subjects such as Microeconomics, Business Economics, and the like. The game can be adjusted to conditions for any economic subject to a demonstration of what is deciding demanding solutions to a problem, and it is necessary to have mastered the theoretical knowledge. All students are always involved in a game within a particular study group. Based on our experience, it is more preferable when under observation of character properties and communication skills of the students during the semester, the teacher determines the **key players** of game which are three members of the government (left-wing, right-wing and independent expert). Each member of the government has at his disposal policy **advisers** and **experts** from the field (there may be three experts depending on the number of students present in the group). Journalists observe the behaviour of the actors, the search for solutions and progress throughout the game. Number of students role for advisors, and journalists will determine the teacher, depending on the total number of students in the study group.

**Time subsidy** for the game is 100 min. At the beginning of the teaching, all players / students receive short game instruction input from the teacher (10 min.). Subsequently, there are distributed information sheets with the necessary instructions to all players. It is basically a scenario according to which the players will play their roles. The examples of information sheets for the players are shown in Figure 2-4. Then, the teacher defines physical space for three teams (it is important that the various work teams do not disturb and influence each other), assigns the necessary tools and specifies the beginning of game. He does not provide players with further instructions, all the necessary information is in information sheets. In order to better understand the instructions, they depend only on mutual communication for explanation of uncertainties. Teacher supervises the smooth course, points out time limits, takes notes from observation of students/players throughout the game. He monitors whether and how correctly they solve tasks using the theoretical basis, what extent they are identified with their task, what is the level of activity and participation of individual members, what is the level of mutual communication, cooperation, teamwork, what other skills students apply and he facilitates feedback at the end (Kucharčíková, Ďurišová&Tokarčíková, 2015).

Information sheet
Member of the government - representative of <u>right-wing party/ left-wing party/ independent expert</u>
Slovakia is the country of EU with a high degree of unemployment. Although governments have taken various measures to address this problem in different years, we still have not won over the high unemployment. You are a member of the present government to which you are nominated by a political party oriented to <b>left-wing (social)</b> . Your <b>task</b> will be to read and think about this instruction during 5 minutes. Then, prepare together with your advisory team (which consists, first, of either your political contemporaries and experts from the economic and social fields) material for government meeting in the course of 25 minutes, where you design various options for addressing high unemployment in the Slovak Republic referring to any difficulties, or advantages and disadvantages of each solution. When preparing, use the knowledge you obtained from the existing study of Macroeconomics - models of macroeconomic equilibrium, economic policies (fiscal, monetary, foreign trade). Proposals must correspond with your political orientation. It is necessary to prepare these proposals for the government in writing (on A4 paper, flipchart or whiteboard) so that they are clear, understandable and illustrative for all involved. At the same time prepare for difficult negotiations in the government, which except you, attend even a member of the
government for the right-wing party and independent and that will take 30 minutes.
1. to present proposals of Yours and Your advisory team: 7 min.,
2. to respond to the objections of other members of the government,
3. to factually discuss the other two proposals,
4 to decide to adopt one proposal

Figure 2: Information sheet for member of the government



#### Information sheet

#### Advisors of right-wing / left-wing politics/expert advisors

Slovakia is the country of EU with a high degree of unemployment. Although governments have taken various measures to address this problem in different years, we still have not won over the high unemployment.

You are the members of **the political advisory team/expert advisory team** of one of the members of the present government. Your **task** will be to read and think about this instruction during 5 minutes. Then, help to prepare material for government session for the member of government of your political group together with his expert advisory team, where you propose various possibilities for addressing high unemployment in the Slovak Republic referring to any difficulties, or advantages and disadvantages of each solution. When preparing, use the knowledge you obtained from the existing study of Macroeconomics - models of macroeconomic equilibrium, economic policies (fiscal, monetary, foreign trade). Proposals must correspond with your political orientation.

For the government negotiations, it is necessary to:

- 1. prepare proposals in writing (on A4 paper, flipchart or whiteboard) so that they are clear, understandable and illustrative for all involved,
- 2. prepare for negotiations (prepare your arguments and counter-arguments) to the government for approval of proposals you submitted.

#### Figure 3: Information sheet for advisors



inform the public objectively about the course of negotiations after the government session,

write a short and interesting article in tomorrow's newspaper about what you have observed.

Figure 4: Information sheet for journalists

Evaluation is a final, but very important phase of educational process. Evaluating allows looking back on educational activities, successfulness and interest of students and provides information about what to do in other way in future activities, what improve, what topics omit, what complete etc. For this reason, it is also important to implement evaluation of the game after realization of role plays. Students will get a little feedback about how they worked in content and procedural aspects during the game from journalists/observers. It is a view of the students. However, it is necessary that the players themselves express their initial impressions of the game and subsequently analyse both sides of the problem-solving process (content and process) and identify their contribution to the game and their failures. Finally, teacher provides feedback to the whole game. It depends only on his facilitation skills, to what depth in the feedback he will go and what lessons he "pulls out" of the students. There is one interesting finding arising from our experience. The game of learning "weaker and lazier" students has the greatest positive impact. They understand the reasons just using this form, why they study the subject, they realize their imperfections in the study and final achieve excellent results in the examination. This is precisely the objective. To make subject more attractive for those who do not take interest at the beginning of the semester. These students make the greatest promotion and marketing of the subject among the student public. Of course, it is expected that smart students who deal with their obligations responsibly throughout the semester provide the appropriate background and expertise for the game. These are the students who create the necessary support for the teacher. Therefore, teacher must appreciate the work and contribution of all involved at the end of the game. The game



does not succeed if students bring "great solutions", but when they realize the importance of knowledge obtained during their studies at the university and later in the practical and personal life. Evaluation has a higher positive effect, if it is done using a camera and playing key situations that arose in the game by using a projector. However, the use of cameras and data projector is significantly limited by time demands of this approach and timetable at university.

Evaluation creates preconditions to improve the quality of teaching and increase student interest in the future. Short evaluation can be done after each seminar or lecture and exercise, after a check exam, at the end of the semester, after the examination period, but also at the beginning of the next semester, when we find the reasons why the students enrolled on the subject. It is implemented using several methods, such as interviews, questionnaire feedbacks, and self-reflection.

## Conclusion

We have introduced an example of how is it possible to innovate and make more attractive Macroeconomics for students of Informatics using participatory methods, namely the role plays. It depends only on the teacher, his professional and pedagogical knowledge, skills, experience and creativity to find space for the implementation of participatory methods in the context of teaching his subjects. The reward for efforts will be very satisfied teacher and students, resulting in higher interest in the subject, higher education efficiency and better results. Knowledge, skills and experience that students thus obtain, are a more memorable and easier to apply in the future of their profession even personal life. When are properly used different modern methods of education and when learning styles of students are correct linked to teachers' educational styles, it is possible to improve the quality and attractiveness of higher education and student preparedness for successful completion of the examination, thesis defense, state exams, but also to deal with everyday and work situations. This is in a presumption for successful application of students in business practice.

### Acknowledgements

This article was created as part of application of project: Quality education with the support of innovative forms of quality research and international cooperation - a successful graduate needs to practice: ITMS: 26110230090/Project is funded by EU; Grant (granted by Ministry of Education) VEGA No 1/0421/13 Attribute efficiency and the human capital, VEGA 1/0526/13 Modelling of the multilateral relations of economic entities and improving the quality of their decision-making processes with ICT.

### References

Buckle Y, R., & Caple, J. (2004). Training. Computer Press, Brno 2004.

Csikszentmihalyi, M., & Nakamura, J. (1989). The dynamics of intrinsic motivation: A study of adolescents. *In R. Ames & C. Ames (Eds.), Research on Motivation in Education (Vol. 3). San Diego, CA: Academic Press.* 

Deci, E. L., & Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behaviour. New York: Plenum.

Ďurišová, M. (2013). Modern methodological approach to teaching business economics for IT students. In: *Procedia - social and behavioral sciences*. Vol. 106 (2013), (pp. 1850-1856). ISSN 1877-0428.

Fayyoumi, E., Idwan, S., AL-Sarayreh, K. & Obeidallah, R. (2015). E-learning: challenges and ambitions at Hashemite University. *International Journal of Innovation and Learning*, 2015, Vol.17, No.4, (pp.470 – 485), ISSN 1471-8197, DOI: 10.1504/IJIL.2015.069632

Ferreira, M., Cardosob, A. P., & Abrantesc, J. L. (2011). Motivation and Relationship of the Student with the School as Factors Involved in the Perceived Learning. *International Conference on Education and Educational Psychology (ICEEPSY 2011), Procedia - Social and Behavioral Sciences 29 (2011)* (pp. 1707 – 1714).

Kafyulilo, A.C: *Training workshop for teachers on participatory teaching methods*. http://www.slideshare.net/Vangidunda/training-workshop-for-teachers-on-participatory-teaching-methods?related=3

Kucharčíková, A., Ďurišová, M. & Tokarčíková, E. (2015). The role plays implementation in teaching macroeconomics. *Procedia – Social and Behavioral Sciences*, Vol. 174 (2015), (pp. 2489-2496), ISSN 1877-0428 Kucharčíková, A. (2013). The quality improvement of the university education. In: *Procedia - social and behavioral sciences*. ISSN 1877-0428. - Vol. 106 (2013), (pp. 2993-3001).

Kucharčíková, A. (2014). The importance of identification and analysis of educational needs for investment in human capital. *Communications*, Vol. 16, No.3/2014, (pp. 86-92), ISSN 1335-4205

Larson, R. (2000). Toward a psychology of positive youth development. *American Psychologist*, Vol. 55, No.1, (pp. 170-183).

Makokha A., & Ongwae, M. A 14 days Teaching Methodology Course-trainers handbook. German development service. Kenya, 190 p.



Ormrod, J. E. (2006). *How Motivation Affects Learning and Behavior*, Pearson Allyn Bacon Prentice Hall, 2006, http://www.education.com/reference/article/motivation-affects-learning-behavior/

Průcha, J. & Veteška, J. (2012). Andragogical dictionary, Grada Publishing, Prague, 2012

Standage, M., Duda, J. L., & Ntoumanis, N. (2005). A test of self-determination theory in school physical education. *British Journal of Educational Psychology*, 75, (pp. 411-433).

Subin, K. M.: *Participatory training methods*. http://www.slideshare.net/Vangidunda/training-workshop-for-teachers-on-participatory-teaching-methods?related=1

Teaching. Methods. http://teach.com/what/teachers-teach/teaching-methods.

Tokarčíková, E. & Kucharčíková, A. (2015). Diffusion of innovation: the case of the Slovak mobile communication market In: *International journal of innovation and learning*. Vol. 17, no. 3 (2015), (pp. 359-370), ISSN 1471-8197, DOI: 10,1504 / IJIL.2015.068467

Tokarčíková, E. (2013). Aspects of teaching economics for students of informatics. In: *Procedia - social and behavioral sciences*. Vol. 106 (10 December 2013), (pp. 495-502). ISSN 1877-0428.

Vodák, J., & Kucharčíková, A. (2011). *Effective training of employee*. Grada Publishing, Prague 2011, (2nd ed.). Wafta, M. K. & Audi, D. M. (2015). New learning methodologies using modern Technologies. *International Journal of Innovation and Learning*, 2015 Vol.17, No.3, (pp.275–297), ISSN 1471-8197, DOI: 10.1504/IJIL.2015.068463



# WASTEWATER TREATMENT BY ELECTRODIALYSIS SYSTEM AND FOULING PROBLEMS

### Elif OZTEKIN, Sureyya ALTIN

Bulent Ecevit University, Department of Environmental Engineering, Zonguldak-Turkey

elif.alaydin@gmail.com, saltın@karaelmas.edu.tr

**Abstract:** Electrodialysis ED is a separation process commercially used on a large scale for production of drinking water from water bodies and treatment of industrial effluents (Ruiz and et al., 2007). ED system contains ion exchange membranes and ions are transported through ion selective membranes from one solution to another under the influence of electrical potential difference used as a driving force. ED has been widely used in the desalination process and recovery of useful matters from effluents. The performance of ED, depends on the operating conditions and device structures such as ion content of raw water, current density, flow rate, membrane properties, feed concentration, geometry of cell compartments (Chang and et al., 2009, Mohammadi and et al., 2004).

The efficiency of ED systems consist in a large part on the properties of the ion exchange membranes. Fouling of ion exchange membranes is one of the common problems in ED processes (Lee and et al., 2009, Ruiz and et al., 2007). Fouling is basically caused by the precipitation of foulants such as organics, colloids and biomass on the membrane surface or inside the membrane and fouling problem reduces the transport of ions. The fouling problems are occasion to increase membrane resistance, loss in selectivity of the membranes and affect negatively to membrane performance (Lee and et al., 2002, Lindstrand and et al., 2000a, Lindstrand and et al., 2000b).

Membrane fouling leads to high energy consumption and poor separation efficiency. Therefore some methods such as pretreatment of the feed solution, turbulence in the compartments, zeta potential control, pH and flow rate optimization, modification of the membrane properties and pulsed voltage have been studied to reduce fouling in ED systems. Also some reducing methods such as chemical methods require additional chemicals, more energy or instruments and those requirements increase the operation and investment cost (Chang and et al., 2009, Lee and et al., 2002, Park and et al., 2003). The fouling problem has been disqualified also by electrodialysis reversal systems EDR. EDR is similar to ED but the direction of ion flow is reversed periodically to break fouling progress by reversing the polarity of the applied electric current. This process is not use only for the removal of fouling but also for removing salts in desalination systems. EDR does not require additional chemicals and it increases membrane life (Bouhidel and Rumeau, 2004, Strathmann, 2010).

Fouling of membranes is one of the major problems in ED systems. For this reason there is a need to understand the fouling factors and fouling formation. This study includes brief introduction about ED systems, a literature review of the different kinds of fouling mechanisms, fouling mitigation techniques, cleaning methods to enhance the ED efficiency and advantages /disadvantages of those cleaning methods. This paper concludes with an outlook to future ED system studies.

Key Words: Electrodialysis, Electrodialysis Reversal, Fouling, Fouling Mitigation, Wastewater.

### Introduction

Recycling and reuse of wastewater after the convenient treatment will reduce the use of natural water sources. Also this method provide to waste reduction. Thus a variety of treatment methods have been investigated, such as adsorption, flotation, chemical coagulation, biological degradation, electrochemical methods, and membrane filtration (Ashrafi and et al., 2015). The membrane is an interface that has selectively between in two phases. Membranes can be made from inorganic, organic and metal polymer and they are used for gas separation solid - liquid and liquid- liquid separation. Separation is depending on the membrane pore size [Figure 1].





Figure 1. Membrane Processes (AWWA, 1995).

Electrodialysis (ED) is an alternative membran separation process that used in wastewater treatment. The ion exchange membranes are arranged between the anode and cathode in ED system. Ionic compounds that in the feed water, starts to move across ion exchange membranes using an electrical driving force. The cations in the solution migrate toward to the cathode and the anions migrate toward to the anode by applying electrical current between the anode and cathode. Cations pass through the cation exchange membrane but they are retained by the anion exchange membrane. Similarly, anions pass through the anion exchange membrane but they are retained by the cation exchange membrane [Figure 2]. The overall result of the process, concentrated and diluted compartments occurs in the system. The electrolyte solution used to ensure the conductivity and remove gases produced by electrode reactions in the system. The degree of electrodialysis depends on (Caprarescu and et al., 2012, Mohammadi and et al., 2004);

- Ion exchange membrane structure,
- Feed water ion concentration,
- Current density
- pH
- Flow rate
- ED cell structure



Figure 2. Schematic diagram of ED system (AEM: Anion exchange membrane, CEM: Cation exchange membrane)



The most important limiting factor in electrodialysis system is fouling such as other membrane systems. Particles that larger than the membrane pore size cannot pass through the membrane in solution and causing deposition on the membrane surface. Accumulation of insoluble biomass, colloid and organic substances inside membrane or on the membrane surface is called as fouling. Fouling affects to membrane performance adversely by flux drop or increase in the electric resistance. Most of works on membrane fouling have focused on anion exchange membranes (Ruiz and et al.). Because of studies carried out that anionic membranes were more affected than cationic membranes, since most colloids present in natural water are negatively charged (Araya-Farias and Bazinet, 2006a, Ayala-Bribiesca and et al., 2006, Lee and et al., 2002).

In this research working principle of the electrodialysis system is explained. Also fouling mechanism of ED ion exchange membranes and its control methods investigated and provided information on the fouling problems. In this context this study includes a literature about fouling mechanisms, causes and removal methods.

# **Operating Principles of ED System**

Electrodialysis consists of the combination of electrolysis and dialysis methods. This method was used by Maigrot and Sabates in 1890 for the first time. The aim of their study was demineralize of sugar syrup. The first ED system is illustrated in figure 3. The frames of ED system were made of wood, electrodes were made of carbon and membranes were made of permanganate paper. Electrical current is provided from the dynamo. The middle electrode is used as anode. The syrup was poured through the anodic compartment. Potassium, sodium, magnesium and calcium cations were migrate from the anodic compartment to the cathodic compartment by electrical current. At the end of the process the syrup has been demineralized in the anodic compartment (Shaposhnik and Kesore, 1997).



Figure 3. Scheme of the first electrodialysis system (Shaposhnik and Kesore, 1997).

ED is an electromembrane separation process that ions are transferred through ion exchange membranes under electrical current (DC voltage). When electrical current is applied (Murray and et al., 1995);

- Cations migrate to the cathode, or negative electrode.
- Anions migrate to the anode, or positive electrode.
- Water molecules break down and produce two hydroxyl ions and hydrogen gas at the cathode.
- Water molecules dissociate to four hydrogen ions, one molecule of oxygen, and four electrons at the anode
- Chlorine gas may be formed at the anode.

Electrodialysis (ED) processes are used on a large scale in commercially. ED systems, corresponding processes and their applications are summarized in table 1. ED has been widely used to demineralize, concentrate and/or convert salt-containing solutions. ED contains ion exchange membranes that ions are transported from one solution through ion selective membranes to another solution under influence of an applied electric potential difference. Performance of the system depends on operating conditions and ED cell structure (Chang and et al., 2009, Ruiz and et al., 2007).



Table 1. ED syster	n, related process	es and application	ns (Strathmann, 2010).
--------------------	--------------------	--------------------	------------------------

PROCESSES	APPLICATIONS
Electrodialysis	Water desalination, salt pre-concentration
Diffusion dialysis	Acid and base recovery
Donnan dialysis	Water softening, ion exchange
Bipolar membrane ED	Production of acid and base from corresponding salts
Continuous electrodeionization	Ultra-pure water production
Capacitive deionization	Water desalination, water softening
Reverse ED	Electrodialytic energy generation

Caprarescu and et al. (2012) were study, the removal of copper ions by ED system. They used two different ion exchange membranes and determined initial copper ions concentration, solutions conductivity, pH, flow rate. When applied voltage that during the ED was 7.5 V and initial copper concentration was 4 g/L, the extraction percentage of copper ions increased >85% (Caprarescu and et al., 2012).

Mohammadi and et al. (2004) studied about effects of flow rate, temperature and voltage on lead removal by ED. Their results showed that increasing voltage and temperature improved cell performance; however, the separation percentage decreased with an increasing flow rate.

Dissolved solids are selectively removed by semipermeable ion exchange membranes with their electrical charge in ED systems. The ion exchange membranes used as either anion transfer or cation transfer membranes in ED systems. Each membrane is 0.1 to 0.6 mm thick and it can be homogeneous or heterogeneous. Membranes are produced by blending an ion-exchanging resin with a polymer. The ion exchanger must involve at least half the polymer mixture (AWWA, 1995). Anion exchange membranes used in ED processes and allow only negatively charged ions to pass through. Cation exchange membranes are also used in ED processes and allow only positively charged ions to pass through. This membrane allows the transition of cations while blocking the passage of anions. Both anion and cation exchange membranes have the following qualification (Murray and et al., 1995);

- Semi-rigidity for ease of handling
- Low electrical resistance
- Insolubility in aqueous solutions
- Availability to use above 46°C
- Availability in different sizes and configurations
- Long life expectancy
- Resistance to change in pH from 2 to 9

ED plants can be planned to remove from 50% to 99% of source water pollutants or dissolved solids. When source water salinity content is less than 100 mg/L up to 12,000 mg/L, TDS can be successfully treated by ED to produce finished water of less than 10 mg/L TDS (AWWA, 1995). The system is commonly used by applications of waste treatment such as; removal of hazardous chemical, desalination of salt water, recycling and reuse of valuable compounds, whey demineralization, developing new production methods that require lower energy consumption, pharmaceutical application, recovery of pickling acid, recycling of rinsing solution (Koter and Warszawski, 2000). The main advantages of the ED system are; separation without phase changes, not additional chemicals, high permeability selectivity, low electrical resistance, good mechanical stability, high chemical stability (Nagarale and et al., 2006). One of the most important substances that affect negatively the performance of ED system is fouling of ion-exchange membranes. Industrial applications of ED and key problems are listed in table 2.

Table 2. Industrial applications and key problems of ED (Strathmann, 2010).

APPLICATIONS	STATUS of APPLICATION	KEY PROBLEMS
Desalination	Commercial	Costs
Process water	Commercial	Costs
treatment		
Waste treatment	Commercial	Membrane Fouling
Demineralization of	Commercial and	Membrane Fouling
food products	pilot plants	-
Table salt	Commercial	Membrane Fouling
production		<u> </u>



## **Membrane Fouling of ED Systems**

The membrane recovery rate can be limited by the presence of certain salts that can form a foulant on the membrane surface. High concentrations of salts increase fouling potential in ED systems. The transport of ions increases through ion exchange membranes by applying electric current, and precipitation occurrence on the selective membrane surface in time. Accumulation increase on the membrane surface with time and it becomes gel layer. The precipitation on the membrane surface increases with the increase of accumulated charge and the gel layer becomes thinner and denser. The formation of a gel layer, ion movement is restricted. Consequently gel layer will have an additional electrical resistance. The concentration and the electrical resistance of the gel layer depends on the foulant and membrane structure (AWWA, 1995, Lee and et al., 2002). With increasing current density, current efficiency increases in ED system. However, polarization phenomena impede the achievement to the upper current density value. The higher current value than the limiting current is caused to fouling and reduction of the process efficiency (Koter and Warszawski, 2000). There are three types of blockages;

- The formation of divalent or trivalent ions hydroxides
- The accumulation of proteins or colloidal substances on surface
- Membrane disruption (Bazinet and Araya-Farias, 2005).

Organic substances such as humates, natural organic substances, and dedoksil sodium benzenesulfonate are fouling on anionic membranes. Colloidal materials, proteins, 2 and 3 valent hydroxyl ions do accumulate blockage of the membrane surface and inside on Cationic membranes. The chain length of the fouling molecule is a physical feature that affects the degree of the fouling. Long chain molecules cause a harder fouling. Larger molecules have lower solubility, so the rate of being adsorbed on the membrane is higher. Current density also affects the fouling among other parameters. Fouling is faster at higher current densities (Lindstrand and et al., 2000a). Suspended solids, silicates and low solubility substances such as iron hydroxide or calcium carbonate are causes of high hydrodynamic pressure loss and flow deterioration. Precipitation on the membrane surface increases the electrical resistance as well as lead to physically damage of membrane structure (Bernardes and et al., 2013).

If internal membrane fouiling have control over the membrane fouling is increase with increasing of concentration. Also surface fouling is more dominate at high concentrations. Protein foulant leads to the formation of the gel layer on the membrane surface and additional hydraulic resistance. Some studies have also been reported that the occurrence of calcium and magnesium hydroxide as well as calcium carbonate at the surface and inside the membranes in the chloralkali industry (Mondor and et al., 2009). Precipitation of inorganic salts leads to crystallization on the membrane surface and it is a reversible situation (Guo and et al., 2014). Some compounds which cause different precipitation effect during electrodialysis are listed below (Bernardes and

Some compounds which cause different precipitation effect during electrodialysis are listed below (Bernardes and et al., 2013);

- Heavy Metals
- Organic and inorganic colloids
- Dissolved organic matter
- Biomass
- Dissolved gases
- Alkaline metals

Lindstrand and et al. (2000b) studied about influence of various kinds of organic solutes on the fouling in ED processes. They noticed that a remarkable difference was observed between the anion selective and the cation selective membrane. The resistance of the cation selective membrane was slightly increased whereas the anion selective membrane was fouled by all solutes. They reported that it was definitely due to the electrostatic interactive relation between the negative charges of the membrane and the negatively charged organic molecules. Also they indicated that the molecular size and the pH of the solution affect the solubility of organic acids. Fouling of larger acid molecules can be awaited to cause of their lower mobility, lower solubility, and greater adsorption affinity to the membrane (Lindstrand and et al., 2000b).

# **Damages of Membrane Fouling**

Fouling problems in the ED system is one of the most important parameters that limit its use. Fouling, negatively affects the selectivity of membrane and will result in poor selectivity also increase energy requirements (Chang and et al., 2009). Most especially, organic anions can precipitate on the anion-exchange membranes and increase the electric resistance. Generally, anion-exchange membranes are more critical to organic compounds fouling.



Colloidal particles are a significant pollutant type for all membrane processes. Colloidal matter that in the feed water comes together with growing of concentration, salinity, flocculation, surface interactions and other physical and chemical factors and hold on the membrane surface. There are examples in about decreasing of membrane performance with colloidal foulant in the literature (Bukhovets and et al., 2010).

Araya-Farias and Bazinet (2006b) showed that in the presence of sodium carbonate fouling has not occurred in anion exchange membrane in their study. The fouling was observed when the salt concentration increases in the feed water. Recently, calcium hydroxide precipitated on the cation exchange membrane which is in contact with sodium chloride (Bazinet and Araya-Farias, 2005).

Mechanical failure, leads to increase chemical deterioration and fouling of membrane. In Ghalloussi and et al. (2011) study, they disclosed that fouled membranes lost 93% of their toughness after 2 years of operation and fracture point decreased of 87%. They reported that even today, there is not wide range of information about decomposition occurring as a result of fouling in the ED system used in the food industry (Garcia-Vasquez and et al., 2013).

Korngold and et al. (1970) specified that the fouling is originated from  $H^+$  ions which produced by polarization at the membrane surface and it increases with decreasing salt concentration and decreasing flow velocity also with increasing current density and colloid concentration. Foulant can be regenerated with alkali solutions or under reversed electric current (Korngold and et al., 1970).

### **Prevention or Removal of Membrane Fouling**

Many studies have focused on the need to reduce of ED membrane fouling. Some methods have been proposed in these studies such as turbulence in the cell compartments, pretreatment of the feed solution, optimization of process conditions and the membrane properties. There are several cleaning procedures, including physical and chemical methods. The selection of the chemical to be applied for membrane cleaning depends on the membrane type, intensity of the pollution and pollutants type. Chemicals that usually recommended by membrane manufacturer are; weak and strong acids, alkali (NaOH), detergents, complex agents (EDTA), disinfectants (H<sub>2</sub> O<sub>2</sub>, NaCl) and enzymes. Also operation conditions can be considered to reduce fouling. However, these approaches may require an additional chemicals or equipment and as a result, they increase the operating cost (Lee and et al., 2002). Forward flushing, backwashing, vibrations, air sparge and  $CO_2$  back permeating are used for pressure-driven membrane as physical cleaning methods. But these methods are not suitable for ion-exchange membranes. Alternatively, ultrasound is an effective technique for cleaning foulants (Wang and et al., 2011).

Colloids that commonly found in natural water are clay, silica, iron, and aluminum hydroxide, organic deposits, and carbon dust. Pre-filtration, membrane cleaning with chemicals, cross- flow velocity should be provided for control of colloidal pollution. Many foulants move to ion exchange membranes under an electric field by their surface charge and electrical conductivity. After that the foulants accumulate on membranes and the electrical resistance increases. These deposits can be removed with an alternating electrical current. It was reported the pulsed electric fields can cause irregularity of the gel layer on the surface of ion exchange membrane in ED system (Lee and et al., 2002).

Humic matters have an important role in the organic fouling of ED membranes. Organic anions such as humate can be collapsed as humic acid on anion exchange membranes. Membrane fouling with organic anions small enough to penetrate into the membrane, causing these substances remain within the membrane. It causes to increase of electrical resistance vigorously. The use of certain detergents also causes the same effect which is requires to the proper pretreatment of the feed solution. There have been various studies to reduce it, for instance zeta potential control and pulsed voltage. Mechanical cleaning or acids -bases cleaning methods can disrupt the structure of the membrane (Bernardes and et al., 2013, Chang and et al., 2009). Lee and et al. (2002) worked on negatively charged humate with high molecular weight fouled anion exchange membrane by sedimentation on the surface during an ED. They used ED of NaCl solution containing 100 mg/l humate. They found that the pulsed electric fields enhanced the mobility of the charged particles in the fouling layer and decreased the electric resistance of the electrodialysis cell (Lee and et al., 2002).

Membrane fouling depends on the characteristics of membranes, specifications of feed water and the physical and chemical properties of the foulants. Foulant categories, causes of formation and cleaning methods shows in table 3 (Lee and et al., 2002).



FOULANT	DEFINITION	FOULANTS	CHARGE	CLEANING	REFERENCE
TYPE		FORMULA	PROPERTIES	METHODS	
Scale	Precipitates of less soluble salts in the solution	CaCO <sub>3</sub> , CaSO <sub>4</sub> , 2H <sub>2</sub> O, BaSO <sub>4</sub> , SrSO <sub>4</sub> , SiO <sub>2</sub>	Non	-pH adjustment, - Use of citric acid or EDTA	(Korngold and et al., 1970), (Lonergan and et al., 1982, Wilson, 1959)
Colloids	Stack of suspended material on membrane surfaces	SiO <sub>2</sub> , Fe(OH) <sub>3</sub> , Al(OH) <sub>3</sub> , Cr(OH) <sub>3</sub>	Negative	-Pretreatment with MF, UF, higher flow rate, -pH adjustment	(Grossman and Sonin, 1972), (Schippers and Verdouw, 1980), (Rao and et al., 1989)
Organics	Adsorption of organic species to membrane surfaces	Macromolecules, proteins, whey, polyelectrolytes, humate	Negative	-Pretreatment with MF, UF, activeted carbon, -Clean with NaOH	(Korngold and et al., 1970), (Mallevialle and et al., 1996), (Kressman and Tye, 1969), (Kobus and Heertjes, 1972),

**Table 3.** Foulants and cleaning methods in ED system (Lee and et al., 2002)

In Bazinet and Araya-Farias (2005) study, they investigated that the effect of fouling on cation exchange membranes with composition in calcium and carbonate of a model solution to be treated by ED. They reported that there was no fouling at 400 and 800 mg/L of CaCl<sub>2</sub> in the absence of carbonate but a deposit was observed at only 400 mg/L CaCl<sub>2</sub> with carbonate. They explained that this difference could be by the buffering capacity of the carbonate that affects the system with and without sodium carbonate. They also reported that this fouling formed during ED was easily cleaned by an acid procedure (Bazinet and Araya-Farias, 2005). In a subsequent study Araya-Farias and Bazinet (2006a) indicated that the presence of fouling was only observed on the membranes treated with a solution containing 400, 800, and 1600 mg/L of CaCl2 in presence of sodium carbonate. They saw that fouling on the anionic membranes was typical of a cubic and crystalline material. The crystals would be identified as calcium hydroxide. They reported that this fouling was not found to affect significantly the conductivity and the thickness of the membranes and it was easily dissolved after the soaking with HCl (Araya-Farias and Bazinet, 2006a). According to the Bernardes and et al. (2013) study, biomass is the another important problem for membrane fouling. Biomass fouling is the type of contamination in the feed water caused by microorganisms. Microorganisms such as bacteria, fungi, algae, viruses cause fouling by forming a thin layer on the membrane surface. They can damage the membrane but they can be extinguished by sterilization. Biological fouling not only increases the membrane resistance also it causes biological degradation by hydrolysis of the membrane polymer

Natural organic matter (NOM) is a well investigated another problem in the ED system especially for the brackish water desalination industry. According to some research the current and flow direction are periodically inversed to break fouling originating from NOM. This methods call as "Electrodialysis reversal" (EDR) system. EDR provides a continuous self-cleaning electrodialysis process that uses periodic reversal of direct current polarity. When polarity is reversed in ED system, chemical reactions at the electrodes are reversed. However, EDR can make fouling easily reversible. Some pretreatment is always necessary to complete EDR (Bouhidel and Rumeau, 2004).

# Conclusions

ED system is well constituted in water treatment as a confidential process since more than half a century. Generally, ion exchange membranes are in competition with other separation techniques such as reverse osmosis, ultrafiltration, nanofiltration or conventional ion-exchange. According to some study ED processes have more advantages than the other separation techniques. The main advantages of ED are; there is no osmotic pressure, higher quality product, environmentally friendly, no additional chemicals and ion exchange membranes have long useful life. But ED has various limitations. A major disadvantage of ED system is membrane fouling because it reduces the limiting current, reduces the flux, increases the membrane resistance, decreases the ions migration



yield and lead to serious polarization problems. Fouling increases with decreasing flow velocity, with increasing current density and colloid concentration.

Electrodialysis processes are promising separation technologies for clean production. While decreasing of raw materials in the world, ED system can provide to recycling and reuse some valuable substances. For sustainable development, clean technologies are become more and more important. Electrodialysis can removes ions by electrical potential difference. Thus biomass, colloidal material or organic materials in the feed water will survive in the product stream. To prevent fouling, need for the addition of chemical products, mechanical methods or the system polarity can be reversed periodically with electrodialysis reversal (EDR).

ED based processes are preferable in some applications because of providing products of higher quality or being environmentally friendly. Development of electromembrane system is very important for multidisciplinary science and technology. Thus the researchers focused on the electrodialysis system thoroughly and obviate to current design and operating problems.

# REFERENCES

Araya-Farias, M. and Bazinet, L. (2006a) Effect of calcium and carbonate concentrations on anionic membrane fouling during electrodialysis. Journal of Colloid and Interface Science 296(1), 242-247

Araya-Farias, M. and Bazinet, L. (2006b) Electrodialysis of calcium and carbonate high-concentration solutions and impact on membrane fouling. Desalination 200(1–3), 624.

Ashrafi, O., Yerushalmi, L. and Haghighat, F. (2015) Wastewater treatment in the pulp-and-paper industry: A review of treatment processes and the associated greenhouse gas emission. Journal of Environmental Management 158(0), 146-157.

AWWA (1995) Electrodialysis and Electrodialysis Reversal: M38, American Water Works Association.

Ayala-Bribiesca, E., Pourcelly, G. and Bazinet, L. (2006) Nature identification and morphology characterization of cation-exchange membrane fouling during conventional electrodialysis. Journal of Colloid and Interface Science 300(2), 663-672.

Bazinet, L. and Araya-Farias, M. (2005) Effect of calcium and carbonate concentrations on cationic membrane fouling during electrodialysis. Journal of Colloid and Interface Science 281(1), 188-196.

Bernardes, A.M., Rodrigues, M.A.S. and Ferreira, J.Z. (2013) Electrodialysis and Water Reuse. Novel Approaches, Springer.

Bouhidel, K.-E. and Rumeau, M. (2004) Ion-exchange membrane fouling by boric acid in the electrodialysis of nickel electroplating rinsing waters: generalization of our results. Desalination 167(0), 301-310.

Bukhovets, A., Eliseeva, T. and Oren, Y. (2010) Fouling of anion-exchange membranes in electrodialysis of aromatic amino acid solution. Journal of Membrane Science 364(1–2), 339-343.

Caprarescu, S., Purcar, V. and Vaireanu, D.I. (2012) Separation of Copper Ions from Synthetically Prepared Electroplating Wastewater at Different Operating Conditions using Electrodialysis. Separation Science and Technology (Philadelphia) 47(16), 2273-2280.

Chang, D.I., Choo, K.H., Jung, J.H., Jiang, L., Ahn, J.H., Nam, M.Y., Kim, E.S. and Jeong, S.H. (2009) Foulant identification and fouling control with iron oxide adsorption in electrodialysis for the desalination of secondary effluent. Desalination 236(1–3), 152-159.

Garcia-Vasquez, W., Dammak, L., Larchet, C., Nikonenko, V., Pismenskaya, N. and Grande, D. (2013) Evolution of anion-exchange membrane properties in a full scale electrodialysis stack. Journal of Membrane Science 446(0), 255-265.

Ghalloussi, R., Garcia-Vasquez, W., Bellakhal, N., Larchet, C., Dammak, L., Huguet, P. and Grande, D. (2011) Ageing of ion-exchange membranes used in electrodialysis: Investigation of static parameters, electrolyte permeability and tensile strength. Separation and Purification Technology 80(2), 270-275.

Grossman, G. and Sonin, A.A. (1972) Desalination. (10), 157

Guo, H., Xiao, L., Yu, S., Yang, H., Hu, J., Liu, G. and Tang, Y. (2014) Analysis of anion exchange membrane fouling mechanism caused by anion polyacrylamide in electrodialysis. Desalination 346(0), 46-53.

Kobus, E.J. and Heertjes, P.M. (1972) Desalination. (10), 283.

Korngold, E., de Körösy, F., Rahav, R. and Taboch, M.F. (1970) Fouling of anionselective membranes in electrodialysis. Desalination 8(2), 195-220.

Koter, S. and Warszawski, A. (2000) Electromembrane processes in environment protection. Polish Journal of Environmental Studies 9(1), 45-56.

Kressman, T.R.E. and Tye, P.M. (1969) J. Electrochem. Soc. Electrochem. Sci. (116), 25-31.

Lee, H.-J., Hong, M.-K., Han, S.-D., Cho, S.-H. and Moon, S.-H. (2009) Fouling of an anion exchange membrane in the electrodialysis desalination process in the presence of organic foulants. Desalination 238(1–3), 60-69.



Lee, H.-J., Moon, S.-H. and Tsai, S.-P. (2002) Effects of pulsed electric fields on membrane fouling in electrodialysis of NaCl solution containing humate. Separation and Purification Technology 27(2), 89-95.

Lindstrand, V., Jönsson, A.-S. and Sundström, G. (2000a) Organic fouling of electrodialysis membranes with and without applied voltage. Desalination 130(1), 73-84.

Lindstrand, V., Sundström, G. and Jönsson, A.-S. (2000b) Fouling of electrodialysis membranes by organic substances. Desalination 128(1), 91-102.

Lonergan, D.A., Fennema, O. and Amundson, C.H. (1982) Use of Electrodialysis to Improve the Protein Stability of Frozen Skim Milks and Milk Concentrates. Journal of Food Science 47(5), 1429-1434.

Mallevialle, J., Odendaal, P. and Wiesner, M.R. (1996) Water Treatment Membrane Processes, New York.

Mohammadi, T., Razmi, A. and Sadrzadeh, M. (2004) Effect of operating parameters on Pb2+ separation from wastewater using electrodialysis. Desalination 167(0), 379-385.

Mondor, M., Ippersiel, D., Lamarche, F. and Masse, L. (2009) Fouling characterization of electrodialysis membranes used for the recovery and concentration of ammonia from swine manure. Bioresource Technology 100(2), 566-571.

Murray, P., Cobban, B. and Faller, K. (1995) Electrodialysis and electrodialysis reversal. American water works association. AWWA Manual M 38.

Nagarale, R., Gohil, G. and Shahi, V.K. (2006) Recent developments on ion-exchange membranes and electromembrane processes. Advances in Colloid and Interface Science 119(2), 97-130.

Park, J.-S., Lee, H.-J. and Moon, S.-H. (2003) Determination of an optimum frequency of square wave power for fouling mitigation in desalting electrodialysis in the presence of humate. Separation and Purification Technology 30(2), 101-112.

Rao, J.R., Prasad, B.G.S., Narasimhan, V., Ramasami, T., Shah, P.R. and Khan, A.A. (1989) J. Membr. Sci (46), 215.

Ruiz, B., Sistat, P., Huguet, P., Pourcelly, G., Araya-Farias, M. and Bazinet, L. (2007) Application of relaxation periods during electrodialysis of a casein solution: Impact on anion-exchange membrane fouling. Journal of Membrane Science 287(1), 41-50.

Schippers, J.C. and Verdouw, J. (1980) Desalination. (32), 137.

Shaposhnik, V.A. and Kesore, K. (1997) An early history of electrodialysis with permselective membranes. Journal of Membrane Science 136(1–2), 35-39.

Strathmann, H. (2010) Electrodialysis, a mature technology with a multitude of new applications. Desalination 264(3), 268-288.

Wang, Q., Yang, P. and Cong, W. (2011) Cation-exchange membrane fouling and cleaning in bipolar membrane electrodialysis of industrial glutamate production wastewater. Separation and Purification Technology 79(1), 103-113.

Wilson, J.W. (1959) Trans. Inst. Chem. Eng. (37), 198.