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## An Application for Measuring Performance Quality of Schools by Using the PROMETHEE Multi-Criteria Decision Making Method

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### Abstract

Multi-criteria decision making techniques are extensively used in selecting the best one among alternatives. Sorting schools by measuring their quality of performance is also supposed as a decision-making problem. In this study, it is aimed to measure the performance of five secondary schools and two high schools with respect to achievement, non-attendance, social activities and projects criteria by using PROMETHEE outranking method in the scope of a local project. Study has been executed at the end of the 1<sup>st</sup> term of academic year 2014-2015. In consequence of the study, it is seen that secondary schools have better performance than high schools and town schools have better performance than village schools. Furthermore, it has been found out that there is a strong relationship between achievement and non-attendance criteria.

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### 1. Introduction

Education is a process which leaves some remarkable signs on individuals. Those signs are sort of tools making people enable to struggle against difficulties during their life. Schools are as effective as what extent they can contribute students' abilities. Although, it is impossible to measure directly the consequences of those effects, they show up itself as the quality of life. Particularly in rural areas where poor people live, schools play more crucial role

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in society (Sisiman, 2002). That is the reason why as if the quality of education in such schools is a mile stone on providing social justice (Cubukcu and Pinar, 2006). Effective school can be defined as a place in which a convenient environment supporting all kinds of development for children is designed (Balci, 1993). Such development opportunities must be created for not only skillful pupils, but also everybody in the school. In effective schools, pupils display better performance than what was expected to be fulfilled (Mortimore, 1995). A school is an organization that products a number of services for society. However, the most important duty of schools is teaching and learning. Therefore, what makes a school effective is the achievement level of its students.

In order to boosting the performance of achievement, schools must be improved. Before take some steps through the betterment process, existing situations in a school are clarified by which performance level is accurately measured with respect to certain criteria. Hence, all strengths as well as weaknesses can be determined within corresponding schools in order that they benchmark know-hows among each other (Schildkamp, Visscher & Luyten, 2009).

Recently, it is clearly understood that classical school inspecting concept contributes almost nothing on school performance (Gaertner, Wurst & Pant, 2013). On account of changing paradigms, there is a strong tendency towards new performance appraisal systems depending on quality improvement manner in accordance with both qualitative and quantitative data-base all over the world (Grek, Lawn, Lingard, & Varjo, 2009).

This study has been executed in the scope of a local project that was supported by the municipality of Keles/Bursa during the 2014/2015 academic year. Purpose of the study is to analyze seven of schools according to school type, location and region on the performance of achievement, nonattendance, social activities and project criteria. PROMETHEE multi-criteria decision making technique is applied for analyzing by visual Promethee software (Promethee, 2012). Outputs are used for preparing the activity plans for improving presence schools. Project will have been completed at the end of the 2015 June.

## **2. Literature Review And Hypotheses**

Although, there are not so much studies purely carried out by PROMETHEE application, it is easy to come across many of those which are conducted via several multi-criteria decision making techniques for performance measurement. Kazan, Çiftçi and Coşkun (2014), aimed to measure the relationship between financial performance and corporate governance outcomes that belongs to seven of large companies trading in IMKB, by using PROMETHEE method. Yurdakul and İç (2003) measured the intuitional performance of five of big scaled automotive companies whose stocks are traded in IMKB, by using their financial ratios via TOPSIS method. Albayrak and Erkut (2005) proposed models taking both financial and non-financial diminutions into account for measuring general corporation performance by using AHP method. Soba, Akcanlı and Erem (2012) measured the efficiency of 28 of firms which are from machine and metal equipment producing sector between 2008-2010 by applying DEA and TOPSIS. Kazan and Pekkanlı and Çatal (2012), Eleren and Karagül, (2008) accounted the performance score for the economy of Turkey according to economical outcomes between 1986 and 2006 with respect to seven of basic economical parameters by using TOPSIS method. In results, it was seen that 1986 was the best year for the Turkish economy. Özden, (2009) examined how the financial performance of deposit banks covering 2002-2007 were effected in Turkey via MCDM methods, after implementing a set of legal regularities due to 2001 economic crisis.

There are also some studies dedicated for measuring the performance of schools from educational effectiveness field. Here, we see a few examples of them.

Balcı (1993) developed a scale for investigating what extent primary schools have attributes of effective schools on administrator, teacher, student and school atmosphere and parental factors in the study of evaluating primary schools in accordance with effective schools attributes. Şişman (2002) conducted a survey covering 14 schools and 224 teachers in Eskişehir. In consequence, he found that there is statistically meaningful difference in school culture and atmosphere, teacher, student, school environment and parent factors between village and town schools. Scheerens & Bosker (1997) created a model in order to compare developed countries with developing countries in educational effectiveness on behalf of World Bank and UNESCO IIEP. According to results, inequality ratio may rise approximately until 40% among schools in developing countries while it is restricted roughly 5% in developed countries. Besides, there is a positively strong relationship between human and material inputs and achievement output in developing countries.

### 3. Methodology and Method

#### 3.1. PROMETHEE

PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluation) is a kind of MCDM method developed by J.P. Brans. It is quite easy in both understanding and applying in comparison to other methods. The gist of method based on pairwise comparison. However, the main difference from other methods is that PROMETHEE takes inner relationships of each evaluation facts into account while the decision making process (Brans & Mareschal, 2005). Initially, an evaluation table where several alternatives are evaluated according to each criteria is established. After this point, there are some more calculation stages while the procedure.

First of all, a particular preference function need to be determined ( $P_j(a,b)$ ) in order to translates deviation between the evaluations of two alternatives (a and b) on a specific criterion ( $g_j$ ) into a preference degree ranging from 0 to 1. Preference scores of alternatives on a certain criteria are derived from ( $f_j(a)-f_j(b)$ ), as shown in Formula 1. Selection method is enriched by six possible shapes of preference function which are usual shape, U-shape function, V-shape function, level function, linear function and Gaussian function.

$$P_j(a,b) = G_j\{f_j(a) - f_j(b)\} \quad (1)$$

Second, relative importance (weights) of each criteria need to be assigned. It is required especially when the number of criteria is too large. Thanks to the fact that PROMETHEE does not facilitate how appropriate weights can be elicited, it is very common to integrate PRMETHEE with several methods for this purpose. Macharis et al. (2004) advise to determine weights according to several methods: AHP, direct rating, point allocation, trade-off, pairwise comparisons, and so on.

Within this content, an overall preference index (a,b) can be computed via taking all the criteria into account (see Formula 2). This preference index is based on the positive  $\phi^+(a)$  and negative  $\phi^-(a)$  preference flows for each alternative, which measures how an alternative (a) is outranking (see Formula 3) or outranked (see Formula 4) by the other alternatives. The difference between these preference flows is represented as the net preference flow  $\phi(a)$  (see Formula 5), which is a value function whereby a higher value reflects a higher attractiveness of alternative a.

$$\left\{ \begin{array}{l} \pi(a,b) = \sum_{j=1}^k w_j P_j(a,b) \\ \varphi^+(a) = \frac{1}{n-1} \sum_b \pi(a,b) \\ \varphi^-(a) = \frac{1}{n-1} \sum_b \pi(b,a) \\ \varphi(a) = \varphi^+(a) - \varphi^-(a) \end{array} \right. \quad \begin{array}{l} (2) \\ (3) \\ (4) \\ (5) \end{array}$$

Three main PROMETHEE tools can be used to analyze the evaluation problem: (1) PROMETHEE I partial ranking, (2) PROMETHEE II complete ranking and (3) the GAIA plane. In PROMETHEE I, the partial ranking is obtained from the positive and negative outranking flows (see Formulas 3 and 4). In this respect, alternative (a) is preferred to alternative (b) if it has a high positive flow and a low negative flow. In some cases, the ranking of alternatives may be incomplete as PROMETHEE I allows indifference (both positive and negative flows are equal) and incomparability (alternative (a) scores high on a set of criteria on which (b) is weak and vice versa) situations. PROMETHEE II provides a complete ranking of the alternatives from the best to the worst one, which is based on the net preference flow (see Formula 5). The Geometrical Analysis for Interactive Aid (GAIA) plane provides a graphical representation in which the alternatives and their contributions to the criteria are displayed. Additionally, a decision stick can be used to further investigate the sensitivity of the results in function of weight changes (Brans and Mareschal, 1994).

### 3.2. Sample and Data Collection

Here, we see some information about Keles town and schools which are evaluated within the project. Besides, four of evaluation criteria are introduced below.

#### Demographic Data

Keles is a small town where is located on the sought side of Uludağ mountain. Economy mostly depends on agriculture and forestry. It has 35 villages and 7 neighborhoods. Total population is 14,327. According to a survey that indicates the socio-economic development level within whole country, Keles takes the 607<sup>th</sup> place among 872 towns (DPT, 2004). Towns are classified for workers from one to six service region related to socio-economic development level by Education Ministry. Teachers work compulsory for a particular time in somewhere located between four and six region during their career (Mevzuat, Meb. 2006).

Table 1 Conditional school data

	Pupil/School	Pupil/Classroom	Pupil/Teacher	Classroom/School	Teacher/School	School Type	Location	Region
DO	334	20	14	17	24	Secondary	Town	4
İO	119	20	12	6	10	Secondary	Town	4
BO	128	13	9	10	15	Secondary	Village	5
KO	109	9	10	12	11	Secondary	Village	6
AO	120	13	10	9	12	Secondary	Village	6

CPAL	269	17	10	16	26	Highschool	Town	4
AIHL	239	18	10	13	25	Highschool	Town	4
KELES	188	16	11	12	18			
BURSA	304-375*	25-23*	18-15*					
TR	315-369*	27-23*	18-15*					
EU	?-?	21-?*	12-?*					
OECD	?-?	24-?*	13-?*					

Notes: DO = Davut Zeki Akpınar Yatılı İlköğretim Bölge Okulu; IO = Imam Hatip Ortaokulu; BO = Baraklı Ortaokulu; KO = Kiranısıkla Ortaokulu; AO = Abdullah Akca Ortaokulu; CPAL = Çok Programlı Anadolu Lisesi; AIHL = Anadolu Imam Hatip Lisesi; TR = Turkish Republic, EU = European Union; OECD = Organization of Economic Cooperation and Development.

#### \*Secondary school – High school

As it is shown in Table 1, all of schools evaluating within the research belong to compulsory service region. Mean of student number per school is 188, which is far below from Bursa and Turkey average. Besides, mean of student number per classroom, 16, is better than not only Bursa and Turkey, but also EU and OECD averages. When we look at the mean of student number per teacher, it is seen that village schools has slightly better conditions than EU average.

### 3.3. Evaluation Criteria

*Achievement:* This is the mean of weighted average school report of each student in a certain school. Data has been collected just after 1<sup>st</sup> term ends up. This criterion represents for achievement level of a school.

*Nonattendance:* This criterion represents for how steadily students continue courses in a school. Related to school reports, average missing days per student has been calculated as the nonattendance score for each school. Here, we appreciate that nonattendance criterion differs from others because of it works invers (see Table 2). It means that the less average of nonattendance a school has, the higher impact shows up itself on the whole performance.

*Social Activities:* This criterion stands for what extent social and cultural activities spread over the school residents. In order to determine a social activity score, sum of attendance ratios of students, teachers and parents is calculated for each activity. Each score has been derived from a simple index.

*Projects:* This is how many projects have been carried out during the semester. Both international and local projects are accepted.

### 3.4. Applying Promethee

Firstly, according to what performance scores each of school possess, evaluation matrix is formed. In this case, each criterion has equal weight, so that it doesn't need to be shown in Table 2. Besides, due to characteristics of evaluation structure, all of threshold types are selected as absolute, but not percentage. They are all same of each other, thus they are not placed in Table 2, as well.

Table 2 Evaluation matrix					
SCHOOLS	CRITERIA				
		Achievement	Nonattendance	Social Act.	Projects
	max/min	max	min	max	max
DO		76,69	2,16	5,77	4

IO	75,55	3,42	15,36	2
BO	72,46	1,14	7,75	0
KO	73,35	2,16	1,64	3
AO	79,29	0,85	1,78	0
CPAL	64,37	11,4	4,31	4
AIHL	68,65	6,44	4,87	1

Before acquiring the ranking order of schools according to their performance on each criterion, a specific preference function and thresholds are defined. While setting the preference function, criteria and data structure have been considered regarding their special features. Preference functions and thresholds are provided in Table 3.

Table 3 Preference Functions

Criteria	PF	Thresholds		
		q	p	s
Achievement	Linear	3,75	9,84	-
Nonattendance	Linear	3,38	7,52	-
Social Activities	Linear	4,11	9,311	-
Projects	V-shape	-	3	-

Evaluation matrix that shows up performance scores of schools and appropriate preference functions with thresholds have been entered Visual Promethee software simultaneously. Hence, positive flow ( $\Phi^+$ ), negative flow ( $\Phi^-$ ) and net flow ( $\Phi$ ) values are obtained, as it is seen in Table 4.

Table 4 PROMETHEE flows

Alternatives	$\Phi^+$	$\Phi^-$	$\Phi$
DO	0,2827	0,0417	0,241
IO	0,4033	0,0619	0,3413
BO	0,122	0,2101	-0,0882
KO	0,2045	0,094	0,107
AO	0,1833	0,2142	-0,0309
CPAL	0,1576	0,4599	-0,3022
AIHL	0,0442	0,3123	-0,2681

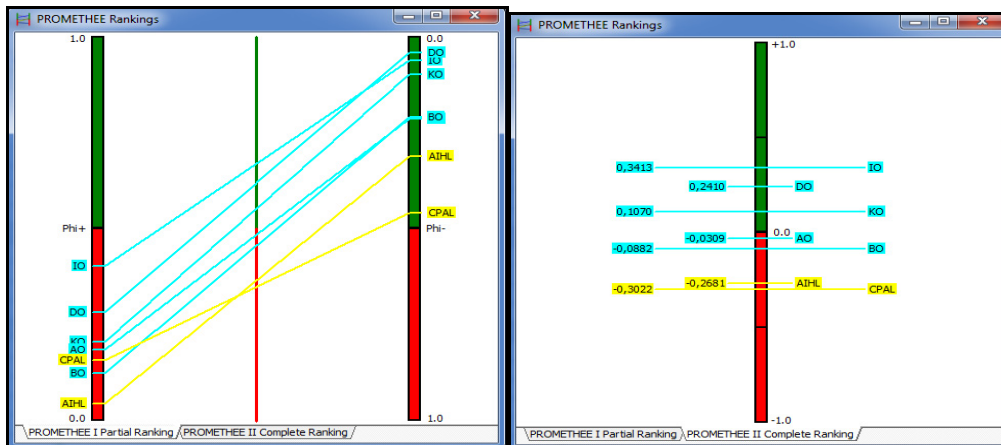


Figure 1 PROMETHEE I partial ranking

Figure 2 PROMETHEE II complete ranking

Figure 1 illustrates the Promethee 1 partial ranking that is calculated by using positive and negative flow values. In positive flow, schools are ranked in the order of IO-DO-KO-AO-CPAL-BO-AIHL. When we look at the negative flow, there is a little bit difference on the order of schools, which is like DO-IO-KO-BO-AO-AIHL-CPAL. Let us have a look if this difference comes up complete ranking.

PROMETHEE I is not able to provide sufficient information about the best alternative, so we need PROMETHEE II complete ranking as it is shown in Figure 2. In order to determine the best performance, net flow is taken into consideration. According to this, schools are ultimately ranked in the order of IO-DO-KO-AO-BO-AIHL-CPAL. Here, we see IO comes first at complete ranking as opposed to negative flow. It means that even if IO is worse than how much DO is on a certain criteria, it does not influence the complete ranking.

Performance evaluation can also be analyzed in GAIA plane (see Fig.3) where schools are represented by points and criteria by vectors. In this plane, conflicting criteria can be observed clearly. In case criteria vectors are oriented in the same direction, it is understood that they are expressing similar performances. The length of each vector responses to its power on alternative schools (Dağdeviren, 2008).

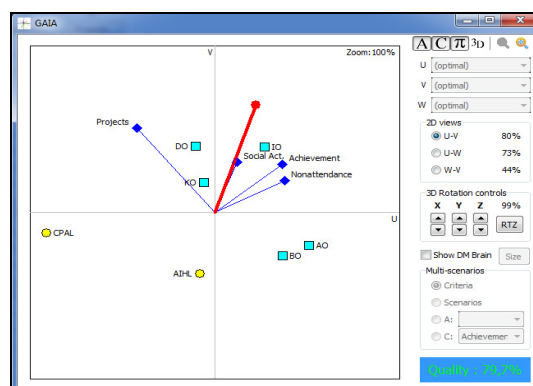


Figure 3 GAIA plane

As it is shown in Figure 3, quality of measurement is approximately 80%. It means, 20% of total information gets lost by the projection, nevertheless analysis can be assumed reliable enough as long as quality remains above 75% (Brans and Mareschal, 1998).

GAIA plane illustrates that Project criteria has a highly differentiation power and express independent structure, different from those expressed by most of all other criteria. It is understood that school performance on projects is more likely related to individual or small groups endeavor.

We also observe that achievement and nonattendance criteria have very close relationship with each other, so it is possible to infer that the more students continue courses regularly, the higher achievement they can get at the end of semester.

At first glance, no matter how short the vector social activity is seen, it is quite remarkable in terms of which vector social activity and vector pi (decision axis) are both oriented same direction. Thus, if an alternative school is good enough on social activities, then it can also be assumed as a well-performed school without considering other aspects of performance.

When we examine how schools spread out on the plane, we can estimate performance of schools on each criterion according to their location. For example, we can say IO has the best performance on social activities and whole concept because of that it is located the most closest place to vector pi as well as vector social activities. On the other hand, CPAL and AIHL stay far away from decision axis and cluster of well-performed schools, so it is concluded that high schools have relatively have worse performance than secondary schools. Additionally, DO and KO are particularly good at projects. BO and AO moderately good at attendance, as well.

Visual PROMETHEE facilitates sensitivity analysis for checking out how sensitively the complete ranking order reacts when we manipulate individual criterion weights. So-called “stability intervals” values gives the limits for each criterion in which a single weight can be varied without causing changes in the PROMETHEE II complete ranking order. How much narrow a respective interval on a certain criterion indicates what extent it effects the complete ranking (Schwartz and Göthner, 2009).

Table 5 Sensitivity analysis

Criterion	Stability interval	Change in PROMETHEE II ranking order when exceeding	
		lower bound	upper bound
Achievement	[0.1787; 0.4543]	IO-DO-KO-BO-CPAL-AO-AIHL	AO-DO-IO-KO-BO-AIHL-CPAL
Nonattendance	[0.2127; 0.7921]	IO-DO-KO-CPAL-AO-BO-AIHL	AO-BO-KO-DO-IO-AIHL-CPAL
Social Activities	[0.1757; 0.3959]	DO-KO-IO-AO-BO-AIHL-CPAL	IO-BO-DO-CPAL-AIHL-AO-KO
Projects	[0.1268; 0.2753]	IO-AO-DO-BO-KO-AIHL-CPAL	DO-CPAL-KO-IO-AIHL-BO-AO
Stability Level	7		

From the result of sensitivity analysis, it is clear that project criterion has the greatest impact on complete ranking. When we exceed the limits for each of criteria, we observe some considerable modifications. For example, we see that high schools have the worst performance on achievement and nonattendance. Village schools have better performance than town schools on nonattendance. Furthermore, village schools look rather weak on social activities and projects.



It is not easy to say that complete ranking order seems robust with respect to variations of weights allocated to the criteria. However, this situation is not surprising, because even if investigated schools were selected from a constricted environment, they have very different conditions i.e. school type, location, service region and so on.

#### 4. Conclusion

In this paper we shed some light on the question of how to identify the most effective school with respect to achievements, attendance, social activities and projects criteria in the scope of a local education project. For this purpose, PROMETHEE multi criteria decision making method was applied. On the basis of a restricted dataset gathered from five of secondary school and two of high school, the comparison employing PROMETHEE yields evaluation results that are considerably inconsistent in case assumptions are modified.

If only schools were evaluated according to weighted criteria, we might possess more accurate results, so the shortcoming of the study is that equal weights were allocated to criteria thanks to lack of sufficient knowledge about appropriate weightings. PROMETHEE does not assist decision-maker for assigning proper weights. For this reason, AHP features can combine with PROMETHEE. The weights obtained from AHP can be included in performance evaluation process by using them in PROMETHEE computations and the alternative schools can be prioritized based on these weights. This may improve the proposed method and is one of the directions in our future research. Another point is that schools were evaluated with respect to only four criteria related to school results at the end of semester. In fact, there are many of other performance indicators in school effectiveness literature. In case different criteria are taken into account, performance ranking of schools may diversify.

Apart from some weaknesses regarding the method as well as the criteria employed in this analysis, this paper shows the potential of PROMETHEE not only for evaluation of schools as a controlling mechanism in general, but also for a self-assessment tool in particular. Our results might be useful as the starting point of a more effective allocation of resources and subsidies. Additionally, conducting such a performance comparison on a periodic basis (eg annual or biannual) would create a time series of evaluation results to provide detailed information for policy makers and school administrators regarding the dynamics of school effectiveness that is, how the ranking order has changed over time.

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