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MULTI-CRITERIA METHOD AS A TOOL OF A PRODUCTS EVALUATION

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Abstract: The paper inform about the Multi-criteria method of the products evaluation. Evaluation is applied in the educational process. The range of the assessment is dependent on the number of evaluated factors. By the selected products analysis student receives fair values which are necessary for a comprehensive evaluation of environmental standards based on criteria coming out of multi-criteria method algorithm. This article provides guidance for evaluation of environmental levels of selected types of the passenger cars in the educational process.

Keywords: multi-criteria method, passenger cars and environmental factors

1. INTRODUCTION

The car offers a wide range of parameters designed to meet user requirements. These parameters can display information about the technical equipment of the engine, dimensions, weight, and also information about the equipment and comfort of a car. Basic technical data include also parameters that have a direct adverse impact on the environment. Nowadays, when we put high emphasis on the environment, the European Union tries to regulate the automotive industry. The long-term objective of the EU is to reduce those parameters that have a negative impact on the environment [4, 5].

2 MULTI CRITERIA EVALUATION METHOD IN TEACHING

For multi-criteria decision making the student selects 10 kinds of cars. Different types of cars, which will be subject to evaluation in a particular case, are shown in tab. 2. Cars are selected from one category to comply with the terms of comparability. Students choose from a variety of manufacturers operating in the European market. In these cars, the student chooses total of 12 parameters under which the impact on the environment is detected. The specific parameters are given in Table 1 even with the shortened labeling of individual parameters that student needs when entering values into the software. This is a simple program that works in the software environment of Microsoft Excel.

Consequently, student according to the pre-obtained values for selected

parameters fills in the table which is within the multi-criteria method named as the "Matrix of input data" - see Table 2.

Matrix of input data is the main part and a data source for the further calculations. To obtain a correct calculation the student must multiply increasing values of this matrix by the value of (-1). With multi-criteria method it is necessary to select and calculate the computational modules u , a , s .

≡ u_j - represents the value of the j -th component of the artificial vector, which determines the minimum value of the j -th P parameter.

≡ a_j - represents the average value of the set of j -th P parameter.

≡ s_j - represents the standard deviation of the j -th P parameter.

The calculations of these parameters are given in the Table 3, as these values of auxiliary computing modules after careful completing of the input data matrix is generated for the student by the program itself.

In order for the student to obtain a statistical dependence between two numeric variables, he needs to know the correlation coefficients. These coefficients are generated after entering the auxiliary computing modules [1]. Calculated values of correlation coefficients are shown in Table 4. Correlation coefficients take values from the interval $<-1,1>$ [1, 2].

Table 1. Evaluated parameters in cars

Parameter	Short designation
Fuel consumption [l/100km]	P1
Emissions CO ₂ [g/km]	P2
Emissions NO _x [g/km]	P3
Noise [dB]	P4
Price [€]	P5
Acceleration 0 - 100 km/h [s]	P6
Engine power [kw]	P7
Max. speed [km/h]	P8
Weight [kg]	P9
Load volume [l]	P10
Number of airbags	P11
Warranty [year]	P12

Table 2. Matrix of input data according to the software

Matrix of input data												
Parameter / Type	Fuel consumption [l/100km]	Emissions CO ₂ [g/km]	Emissions NO _x [g/km]	Noise [dB]	Price [€]	Acceleration 0-100 km/h [s]	Engine power [kw]	Max. speed [km/h]	Weight [kg]	Load volume [l]	Number of airbags	Warranty [year]
	-	-	-	-	-	-	+	+	-	+	+	+
Opel Corsa	5.3	124	0.0422	62	8290	13.6	63	172	1145	285	2	6
Fiat Punto	5.4	126	0.0403	64	8110	14.4	51	156	1030	275	2	5
Citroën C3	4.3	99	0.429	61	8790	14.3	50	163	1045	300	4	2
Renault Clio	5.5	127	0.022	62	8888	15.4	54	167	1563	300	4	5
Hyundai i20	4.9	114	0.0355	63	8990	12.7	63	168	1515	295	6	5
Škoda Fabia	5.5	128	0.0362	61	8990	14.9	51	163	1095	315	4	2
Seat Ibiza	5.9	139	0.036	62	9250	11.8	63	177	1560	292	6	4
Peugeot 208	4.3	99	0.0186	63	8990	14	50	163	1485	285	6	4
VW Polo	4.7	106	0.034	61	9750	15.5	47	161	1570	280	6	5
Ford Fiesta	4.6	105	0.0405	63	9590	14.9	59	165	1525	276	7	4

Table 3. Auxiliary computing modules according to the software

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
u:	4.3	99	0.0186	61	8110	11.8	-63	-177	1030	-315	-7	-6
a:	5.04	116.7	0.07343	62.2	8963.8	14.15	-55.1	-165.5	1353.3	-290.3	-4.7	-4.2
s:	0.5276	13.2518	0.1188	0.9798	480.9511	1.1200	5.9573	5.5902	227.2246	11.9336	1.6763	1.2490

Table 4. Triangular matrix of indexes of correlation r_{ij} according to the software

Triangular matrix of indexes of correlation r_{ij} according to the software											
r [x,y]	1	2	3	4	5	6	7	8	9	10	11
1											
2	0.99712										
3	-0.45064	-0.42796									
4	0.00387	0.02773	-0.40468								
5	-0.27447	-0.31629	-0.13011	-0.35388							
6	-0.29443	-0.35068	0.03254	-0.23692	0.16197						
7	-0.39640	-0.42852	0.26007	-0.27069	0.08906	0.71712					
8	-0.43396	-0.45694	0.14394	0.18257	-0.12746	0.68756	0.80925				
9	-0.04698	-0.07688	-0.47757	0.07564	0.72475	-0.10324	-0.23889	-0.38100			
10	-0.25855	-0.26742	-0.25606	0.59526	0.02999	0.02581	-0.04965	0.20611	0.20504		
11	0.37084	0.38669	0.15538	0.02435	-0.89100	0.12516	0.09313	0.19742	-0.79074	-0.10048	
12	-0.21547	-0.20300	0.58054	-0.45760	0.19470	0.10722	0.38706	0.18619	-0.34580	-0.60785	-0.16239

Then the student according to the rules of multi-objective evaluation methods adjusts values of descriptors. Instead of laborious counting of the difference between the values a_j and a_{ij} , software automatically generates for the student a matrix of modified descriptors which is displayed in the Table 5.

Table 5. The matrix of the modified descriptors

The matrix of the modified descriptors												
	1	2	3	4	5	6	7	8	9	10	11	12
1	0.26	7.3	-0.03123	-0.2	-673.8	-0.55	-7.9	-6.5	-208.3	5.3	2.7	-1.8
2	0.36	9.3	-0.03313	1.8	-853.8	0.25	4.1	9.5	-323.3	15.3	2.7	-0.8
3	-0.74	-17.7	0.35557	-1.2	-173.8	0.15	5.1	2.5	-308.3	-9.7	0.7	2.2
4	0.46	10.3	-0.05143	-0.2	-75.8	1.25	1.1	-1.5	209.7	-9.7	0.7	-0.8
5	-0.14	-2.7	-0.03793	0.8	26.2	-1.45	-7.9	-2.5	161.7	-4.7	-1.3	-0.8
6	0.46	11.3	-0.03723	-1.2	26.2	0.75	4.1	2.5	-258.3	-24.7	0.7	2.2
7	0.86	22.3	-0.03743	-0.2	286.2	-2.35	-7.9	-11.5	206.7	-1.7	-1.3	0.2
8	-0.74	-17.7	-0.05483	0.8	26.2	-0.15	5.1	2.5	131.7	5.3	-1.3	0.2
9	-0.34	-10.7	-0.03943	-1.2	786.2	1.35	8.1	4.5	216.7	10.3	-1.3	-0.8
10	-0.44	-11.7	-0.03293	0.8	626.2	0.75	-3.9	0.5	171.7	14.3	-2.3	0.2

Consequently, student accesses to the specifying of the car parameters based on the generated table of significance of individual parameters test (Table 6). The table, based on the predefined relationships shows strengths (+) and weaknesses (-) of the rated car. For the coefficients of dependence applies:

- ≡ from +1,0 to +0,7 strong positive dependence (+**)
- ≡ from +0,7 to +0,3 weak positive dependence (+*)
- ≡ from +0,3 to 0 low positive dependence (+)
- ≡ from 0 to -0,3 low negative dependence (-)
- ≡ from -0,3 to -0,7 weak negative dependence (-*)
- ≡ from -0,7 to -1,0 wrong negative dependence (-**)

Table 6. Test of significance

Test of significance												
T [x,y]	1	2	3	4	5	6	7	8	9	10	11	12
1	+	+	-	-	-**	-	-**	-**	-**	+	+**	-**
2	+*	+*	-	+**	-**	+	+*	+**	-**	+**	+**	-*
3	-**	-**	+**	-**	-	+	+**	+	-**	-**	+	+**
4	+**	+**	-	-	-	+**	+	-	+**	-**	+	-*
5	-	-	-	+**	+	-**	-**	-	+	-	-**	-*
6	+**	+**	-	-**	+	+*	+*	+	-**	-**	+	+**
7	+**	+**	-	-	+*	-**	-**	-**	+**	-	-**	+
8	-**	-**	-	+**	+	-	+**	+	+	+	-**	+
9	-*	-**	-	-**	+**	+**	+**	+**	+**	+**	-**	-*
10	-**	-**	-	+**	+**	+*	-*	+	+**	+**	-**	+

Table 7. The values of reduction constants

The values of reduction constants	
k1	1
k2	0.00288
k3	0.31425
k4	0.57657
k5	0.27881
k6	0.28344
k7	0.04797
k8	0.01119
k9	0.04940
k10	0.09270
k11	0.00415
k12	0.01096

Correlation matrix represents further indication that helps the student by means of software to evaluate the relationships between descriptors and forms the basis for calculating the reduction constants k_n listed in Table 7.

Calculations based on predefined parameters are set the way that the smallest value of quantifier Q_i marked the object with the best features and minimal negative impact on the environment and vice versa, the biggest value of Q_i marked the object with the worst properties and therefore with the greatest negative impact on the environment [1, 2]. After this categorization the program generates obtained values of quantifier for the student (Table 8), which represent the fair impact values of compared cars on the environment, based on pre-selected parameters listed in tab 1.

Based on the obtained values student finally verbally evaluates the result of the analysis and defines the input parameters that were decisive for the result obtained.

In the case of our example student stated that the car with the lowest impact on the environment is Citroen C3, due to its low fuel consumption in the combined cycle, low levels of CO₂ and NO_x emissions and low noise. The least satisfactory passenger vehicle student named Fiat Punto, because of its fuel economy, high levels of CO₂ and high noise levels.

Table 8. The values of quantifier Q_i

Final value of the quantifier									
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Opel Corsa	Fiat Punto	Citroën C3	Renault Clio	Hyundai i20	Škoda Fabia	Seat Ibiza	Peugeot 208	VW Polo	Ford Fiesta
3.3919	5.0419	2.4079	4.5810	3.3900	3.8031	4.6504	2.7285	3.2488	3.9315

3. CONCLUSIONS

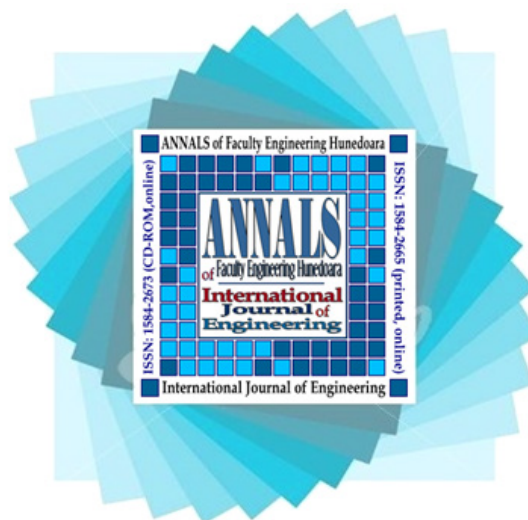
By the example above we were able to prove the justness of using information-communicative technologies in the educational process, as manual calculation of the example would take the student took at least 4 lessons. In terms of applicability of the applied method, the most important is not the calculation and its individual steps, but the result itself. Nowadays, when we put high emphasis on the environment, it is important to give students a realistic example (method) of using a variety of methods available for evaluating the impact of products on the environment. Generally, designed software product is not only applicable to specific products, but more importantly, even in assessing the impact of various activities on the environment and on humans [3].

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REFERENCES

- [1] Ocelíková, E.: Multikriteriálne rozhodovanie. Košice: FEI TU, 2004. 87 s. ISBN 80-89066-28-3
- [2] Multikriteriálne metódy. [online]. [cit 2014-4-20]. Available at: <<http://prezi.com/d6i0-xux1zsm/multikriteriálne-metódy/>>.
- [3] Hricová, B., Nakatová, H., Badida, M., Lumnitzer, E.: Utilisation of tools of environmental management in evaluation of environmental profile of products. In: MTeM 2009: 9. Medzinárodná konferencia: 8.-10.10.2009, Cluj-Napoca. - Cluj-Napoca: MTeM, 2009 P. 317-320. - ISBN 97379370704
- [4] Pacana, A., Bednárová, L., Liberko, I.: Wožny: Effect of selected production factors of the stretch film on its extensibility, Przemysl chemiczny 93/7 2014 lipiec, pp. 1139-1140, ISSN 0033-2496
- [5] BEDNÁROVÁ, L., LIBERKO, I., WEISS, R.: Benchmarking v riadení podnikov, In: Acta Montanistica Slovaca. - ISSN 1335-1788. - Roč. 14, č. 1 (2009), s. 86-91



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