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EVOLUTIONARY BASED SYSTEM FOR QUALIFICATION AND EVALUATION – A CASE STUDY

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Abstract: In a previous paper the new EBSYQ (**E**volutionary **B**ased **SY**stem for **Q**ualification and Evaluation of Group Achievements) system has been proposed for teachers and juries, helping them in making accurate and objective ranking. The analysis of the behaviour of the special characteristic sigmoid functions of the groups gives the possibility to discover some interesting points of view for qualifying the achievement and the standard of the groups (subgroups of talented and under- motivated students, spectrum of the group, eigenvalues, Lorentz function). This paper shows a case study of an international project of student groups competition in the field of product design, with Finnish and Hungarian students. Comparison of the decision process of the jury without using the EBSYQ system and with the application of the system shows the efficiency of the qualification system in realizing a well-founded and careful ranking of the groups, even in case of very close competition. Each point of view of the decision-making system is evaluated by numbers, which can increase the objectivity and accuracy of the decision.

Keywords: *Sigmoid functions; evolutionary based system; evaluation, qualification and comparison of group achievements; EBSYQ methodology of qualification and evaluation.*

1. INTRODUCTION

In this paper a system is shown and applied for evaluation, ranking and comparison of results and achievements of groups or teams. The proposed system for comparison and evaluation (EBSYQ) [1] can provide advantages to each participant in engineering education, testing or competitions: Teachers could more easily find the target groups for special attention (close- up consultations, coaching, special instructions, talent treatment etc.), the jury or decision makers could make decisions or selections more quickly and objectively, eminent students could receive prizes or appropriate ranking based on objective and accurate decisions, failing student could receive more appropriate and targeted special consultations.

The efficiency of the proposed system is demonstrated through a case study of an international project competition (RePCI, **Re**shaped **P**artnerships for **C**ompetitiveness and **I**nnovation Potentials in Mechanical Engineering) of students. The decision-making process of the jury deciding the winning team of the competition is

compared when they make the decision without using the EBSYQ system and we can see the advantages when the system is used.

The case study shows that without the proposed system the results of the groups are extremely close, if in one criterion one group was better, the other group was better from an other point of view, so the final decision would normally contain a high percentage of subjectivity. Since the new system is able to detect and compare numerically every small differences, this subjectivity can be eliminated and the decisions will be more objective, more precise and based on accurate numerical justification.

2. CASE STUDY: INTERNATIONAL STUDENT PROJECT ON PRODUCT DEVELOPMENT

Between September 2014 and January 2015, within the framework of the EU-financed RePCI [2] (**Re**shaped **P**artnerships for **C**ompetitiveness and **I**nnovation Potentials in Mechanical Engineering) international project [3], JAMK (Jyväskylä University of Applied Sciences, Finland) and UM (Institute of Machine and Product Design, University of Miskolc, Hungary) [4] carried out an international student project in product development, titled "Design of a multifunctional garden tool" with the helps and suggestions of the experts of Robert Bosch Power Tool Company, Miskolc, Hungary.

Each partner university participated with an 8-member team, two teams were formed, each with 3 Finnish and 5 Hungarian students. The two groups received the same instructions and the same objective, but after this the groups worked separately, within competition-like circumstances, without communication between the two groups, even keeping their results secret from each other.

The objectives of the project were to:

- Increase intercultural competence
- Solve real-life problems
- Make contacts with international companies
- Gain interdisciplinary project skills
- Obtain deeper knowledge in project management
- Communication between group members during project realisation
- Increase social competence and communication skills
- Improve the ability to work in teams.

The total time of the project was one complete semester and the students worked in the project as if completing a course, receiving 5 credits at the end. Two intensive weeks were organised: the first intensive week was at the very beginning of the project, in September 2014, in Miskolc, Hungary, with an introduction section, and a chance for the Finnish and Hungarian students to get acquainted. During a visit to the Bosch factory, the students received the description of the task, requirements of the product to be designed and all the necessary instructions to start the project. They selected their own team leader from the members of the team, and

they made every decision concerning the necessary steps of the solution, time scheduling, task distribution amongst the team members, etc. Two supervisors (teachers of mechanical engineering, with project realisation experience) visited both teams regularly to answer questions and give useful instructions during the solution of the problems.

After the first intensive week the group members continued their work using communication possibilities offered by the Internet (Google, Skype, e-mail, chat, Facebook etc.). They solved the questions and sub-problems decided and distributed during the first intensive week and they exchanged their results. This system was a great challenge for the team leaders as well, working with groups with members in different countries.

The second intensive week was in Jyväskylä, Finland, at the end of October 2014. After one month of working, during this intensive week they put together their task results, started to form the main concept of the designed product, and determined the further steps necessary to solve the task completely. After the intensive week everyone continued the work, similarly to after the first intensive week.

The project ended with a video-conference day in January 2015, where both groups presented their results, each student having the chance to present his/her own results, ideas and solutions in 5–10 minutes. After the presentations they responded to the questions and comments of supervisors, project manager, or others in the audience. The work of the students was evaluated by the expert of the Bosch factory and by the supervisors. Representatives of the local press (TV, radio, newspapers) reported this event in the news, showing the pictures of the resulting products of the teams, giving a wider platform and reputation to the work and results of the students.

2.1. Comparison of the groups without the EBSYQ system

At the end of the semester, the project reaching the stage of evaluating, comparing and ranking the teams and the students participating in the project. Supervisors and managers of the project and institutions together had to give detailed opinions and evaluations on the work and results of the groups. Since both of the teams worked excellently and each had a new and fully elaborated concept of a garden tool as their result, the jury was really in a difficult position in making the decision of which group could be the winner. As shown in *Table 1*, the two groups were very good and their results were equivalent – if one group was better in one point of view, other group was better in a different aspect. At that time the system proposed in this paper was not yet available, therefore the decision at the end was very subjective: Group A was chosen as the winning team, but the close result and outstanding work of both groups were emphasised. *Table 1* shows the points of view used for the comparison of the groups and the points given (average points given by the members of the jury).

Table 1
Comparison of groups without EBSYQ system
(out of five points per item)

Points of view	Group A	Group B
Communication, interaction, attention to each other	4	5
Distribution of tasks, organisation of the work	3	4
Time scheduling, creating and meeting deadlines	5	3
Partitioning the tasks and assigning them to members	4	4
Forming the main conception of the product	5	4
Price-analysis, material and technology costs	5	4
Taking into account the opinion of the customers	4	5
Marketing, advertising and communicating results	5	4
Presentation :		
Timing, rhythm, fluency	5	4
Content, quality	4	4
Figures, pictures, colors	4	5
Each member presents his/her results	4	5
Communication with supervisors, questions	4	5
Sum of the points	56	56

2.2. Comparison using the EBSYQ system

For comparison, the usage of the evaluation and comparison system EBSYQ is demonstrated, following the method of the system, analysing the curves and characteristics of the groups. Since this system needs the point results of the group members, it is necessary to create points for the individual comparison of the students and it is necessary to give the points. This step is the only subjective one in this system. A short description of the group members, without giving the names or without identifying the individuals:

Group A [5]
A1: boy, Hungarian A2: girl, Hungarian A3: girl, Finnish A4: boy, Hungarian
A5: girl, Finnish A6: boy, Hungarian A7: boy, Hungarian A8: boy, Finnish

Group B [6]
B1: boy, Hungarian B2: girl, Finnish B3: girl, Hungarian B4: boy, Hungarian
B5: boy, Hungarian B6: boy, Hungarian B7: boy, Finnish B8: boy, Finnish

Table 2 gives all the results of the comparison points of view, taking into account separately each group members, possible points are 1 to 5. On the basis of the data given in *Table 2*, it is possible to create the logistic function, the growth function and the first derivative of the logistic function. In order to create the life-curve, it is necessary to „translate" these points into grades (1–5): for this reason, the following limits were created: until 40 points, the mark is 1. From 41 to 45 the mark is 2. From 46 to 50 the mark is 3. From 51 until 55 the mark is 4, and 56 or above is 5. Using these limits, *Table 3* shows how many students obtained a given mark in the groups. (The close competition can be seen here too, because the average of the marks in both groups is the same, 3.62).

Figure 1 shows the resulting curves based on the data of the *Table 2*. The parameters of the approximating logistic curve and growth curve are given in *Table 4*. The approximation curves can be seen in *Figure 2*. It can be observed that the growth curve is very close to the logistic curve, so both can give a good approximation. All the characteristics used for the comparison are collected in *Table 6*. It can be seen in the figures and tables that in the case of Group B, the effect of a possibly under-motivated (low performing) subgroup is weaker than in case of Group A, because the regression coefficient of the logistic function is smaller for Group B. The shape of the result curves, approximation curves and the derivative of the logistic function is very similar for the two groups, also showing the close competition. Minimal slow tendency can be seen in the curves shown by a horizontal part of the curves, but these sections are short, which means that only a few students are included. The value (point result) of the under-motivation zone in Group A is 45, while in of Group B it is 50. The number of students involved: in Group A: 2, in Group B: 4. Note that a second horizontal part with 2 students can be found in Group A around 50 points.

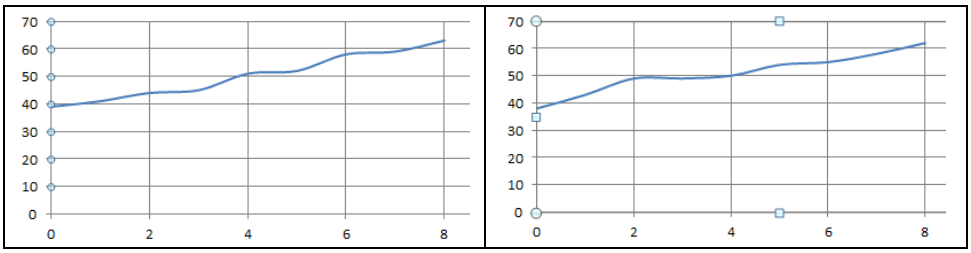
Table 2
Individual points of group member students

Point of view	**A 1**	**A 2**	**A 3**	**A 4**	**A 5**	**A 6**	**A 7**	**A 8**	**B 1**	**B 2**	**B 3**	**B 4**	**B 5**	**B 6**	**B 7**	**B 8**
English language	4	3	3	4	5	4	4	3	4	3	3	4	4	4	3	5
Com-puter skills	4	3	3	5	4	4	5	3	5	4	4	4	5	4	3	5
Engng skills	4	4	4	5	4	5	5	4	5	4	4	5	4	5	4	5

Point of view	A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	B 1	B 2	B 3	B 4	B 5	B 6	B 7	B 8
Economy skills	3	4	4	3	5	4	4	3	4	4	3	4	4	3	3	4
Manager skills	3	4	3	4	5	3	4	3	4	3	4	4	5	4	4	5
Communication	4	4	3	4	5	4	5	3	4	4	4	4	5	4	4	5
Intercultural skills	3	3	3	5	5	4	4	3	4	3	4	5	5	4	4	5
Tolerance	4	4	4	5	5	4	4	3	4	3	4	4	5	4	4	4
Integration	5	4	3	5	5	4	5	3	5	3	4	4	5	4	4	5
Commun. with superv	4	4	3	5	5	4	4	3	5	3	4	4	4	5	4	5
Presentation	5	5	4	5	5	4	5	4	5	3	4	4	5	5	4	5
Quality of results	4	4	4	5	5	4	5	3	5	3	4	4	5	4	4	5
Teammember skills	4	4	3	4	5	4	4	3	4	3	4	4	5	5	4	4
Sum of points	51	45	44	59	63	52	58	41	58	43	50	54	49	55	49	62

Table 3
Data for the life curves of the groups

Group	points	41–45	46–50	51–55	56–65
A	Grade	2	3	4	5
	No. of students	3	0	2	3
B	Grade	2	3	4	5
	No. of students	1	3	2	2

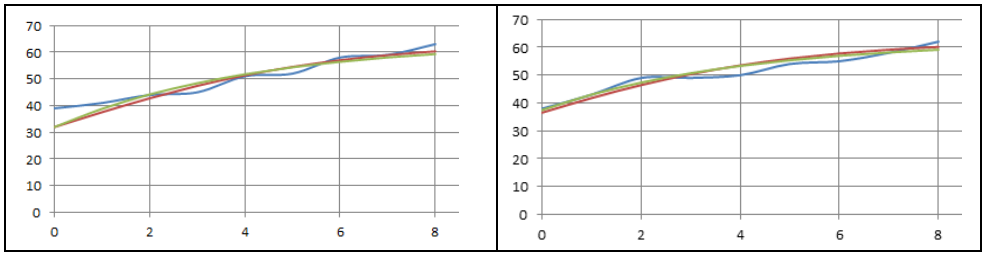


Group A Group B

Figure 1. Result curves of the groups, on the basis of individual points

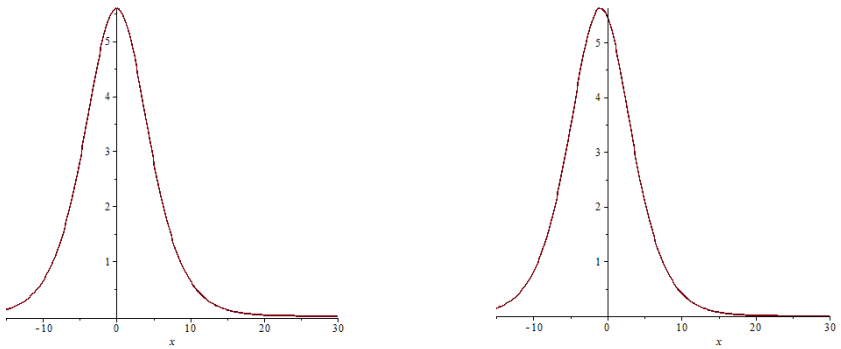
Table 4
Parameters of the approximation curves

curve type	**Group A**				**Group B**			
	K	*r*	*c*	Regr. coef.	*K*	*r*	*c*	Regr. coef.
logistic	64	0.35	1	–0.922	62.5	0.36	0.71	–0.878
growth	64	0.24	0.5	–0.896	62.5	0.25	0.4	–0.848



Group A Group B

Figure 2. Approximation curves of the groups. The growth curve is very close to the logistic curve.



Group A Group B

Figure 3. First derivative of the logistic curves of the groups

A part of the curve showing better than average motivation can be seen in the curve of Group B from 40 to 50 points, and for Group A this is from 35 to 45, so a slightly smaller. Another good motivation section can be found for Group A at 58 points (2 students) and for Group B around 50 points, with 3 students. Table 6 shows several points of view which gives equal points for the groups. This phenomenon decreases the number of the available points, so instead of a maximum of 32 points in this case there will be only 26.

The maximum of the growth velocity is somewhat higher for Group B (5.7) than for Group A (5.5), but the place of the maximum is around 0 or in the negative zone, therefore, this maximum is only theoretical, it does not show the effect of a subgroup. The best point result in Group A is 63 and in Group B it is 62.

Table 5
Data necessary for Lorentzian curves of the eigenvalues

		Eigenvalue 1	**Eigenvalue 2**
Group A	*K*	3	3.2
	r	2	5.1
	c	3.02	0.67
Group B	*K*	3	2
	r	3.1	5
	c	0.9	4.9

Analysis of the life-curves and eigenvalues *(Figure 4)* also shows the similarity of the groups and the close competition: each group has two eigenvalues. The data necessary to write the equations of the Lorentzian curves of the groups for all the eigenvalues are collected in *Table 5*. Some differences can be found only in the significance of the eigenvalues and in the half-maximum – width. The smaller dispersion height or smaller dispersion width of a group *(Figure 6)* can be explained by the better "cohesion" or by the closer cooperation of the group members. *Figure 5* shows the error functions for the first eigenvalue of the groups.

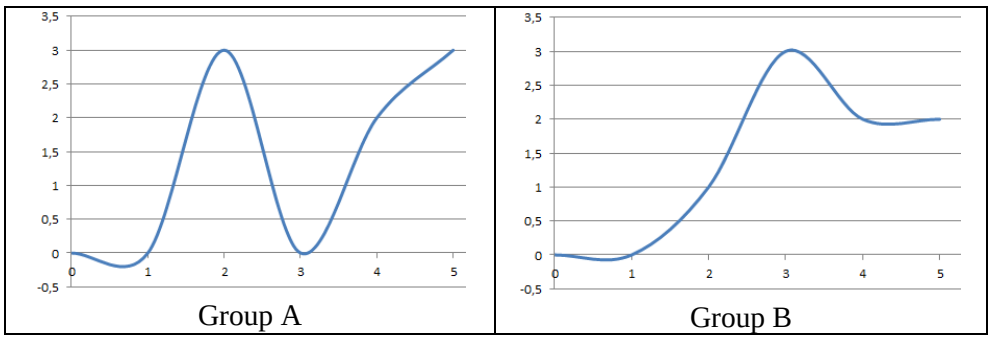


Figure 4. Life curve of the groups

Finally, from the possible 26 points of *Table 6*, Group A wins 14 and Group B wins 12, so the decision is that Group A will be the winner, with 53.85% of the points while Group B has 46.15% of the points. (soccer-like result: 7 to 6 for Group A, it was really a very close fight!).

Table 6
Summarizing table of the characteristics

Type of curve	**Parameter name**	**Notation**	**Group A**	**Group B**	**Comment**	**Wins**
Real curve of results	Slow growth (horizontal)	L/H	0.04	0.076	Length/value	A
	No. of students involved	n	3	4	More motivation needed	A
	Average of point results	P_{av}	3.62	3.62	Easily comparable	–
Growth function	Regression coefficient	R_{kg}	–0.896	–0.848	Strength of correlation	A
	K	*K*	64	62.5	Capacity of the group	A
	r	*r*	0.24	0.25	Evolution (growth) velocity	B
	c	*c*	0.5	0.4	Parameter with mixed effect	–
Logistic function	Regression coefficient	R_{kl}	–0.922	–0.877	Strength of conclusions	B
	No. of failed students	A_m	2	0	Undermotivation	B
	K	*K*	64	62.5	Capacity of the group	A
	r	*r*	0.35	0.36	Growth speed	B
	c	*c*	1	0.71	Parameter with mixed effect	–
	Place of under-motivation	M_h	45	50	Point result	B
	No. low motiv. students	M_{sz}	2	4	Sub-group	A
	Excellent value	U	63	62	Record, best result	A
	No. of excellent students	U_{sz}	1	1	Better in the group	–
	Place of higher motivation	E_m	58	50	For which result	A
	No. high motiv. students	E_{sz}	2	3	How many students	B

Type of curve	**Parameter name**	**Notation**	**Group A**	**Group B**	**Comment**	**Wins**
1st deriv. of logist. f.	Maximum growth speed	v_{fmax}	5.5	5.7	High motivation	B
	Place of maximum	v_m	0	–2	For which result	A
Life curve (Lorentz function)	*K*	*K*	3.2	3	At most signif. eigenv.	A
	r	*r*	5.1	3.1	Place and spreading	–
	c	*c*	0.67	0.9	Param. with mixed effect	–
	How many eigenvalues	S	2	2	How many sub-groups	–
	Eigenvalue 1	s_1	2	3	Eigenresult of subgroup 1	B
	Eigenvalue 2	s_2	5	5	Eigenresult of subgroup 2	–
	Eigenvalue 3	s_3	–	–	Eigenresult of subgroup 3	–
	Significance of s_1	Sz_1	3.6	18	Signif. of the expectable result	B
	Signif. of eigenvalue s_2	Sz_2	40.8	10	Signif. of eigenresult	A
	Signif. of eigenvalue s_3	Sz_3	–	–	Signif. of the result	–
	Width at half max. s_1	η_1	0.6	2	Spreading around the result	B
	Width at half max. s_2	η_2	2.5	1	Spreading around the result	A
	Width at half max. s_3	η_3	–	–	Spreading around the result	–
1st deriv. of Lorentz f.	Width of Lorentz profile	b_d	2	5	Dispersion width	A
	Height of Lorentz profile	h_d	16	5	Dispersion height	B
Integral of Lorentz-function	*K*	K_1	0.8803	0.858	No. of students for a result	B
	$r = r_1 / c$	r_1	6.04	3.1	Mixed effect	A
	c	*c*	3.02	0.9	Parameter with mixed effect	–

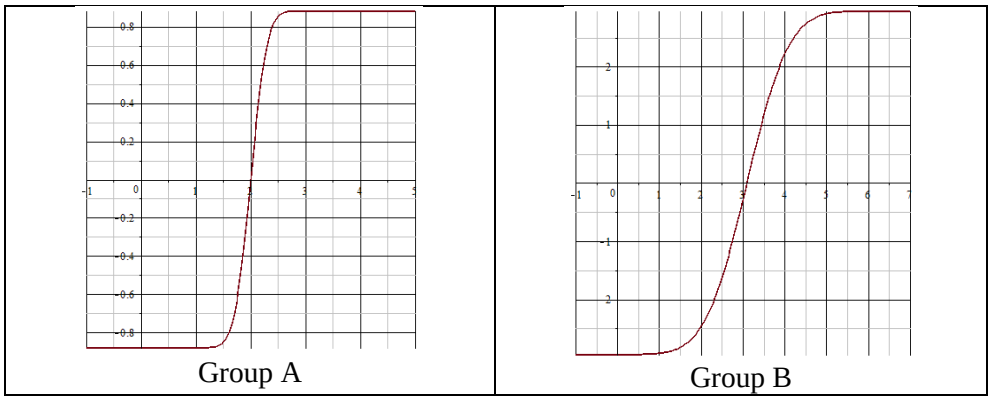


Figure 5. Error functions of the groups
(since K is smaller, Group B wins this point)

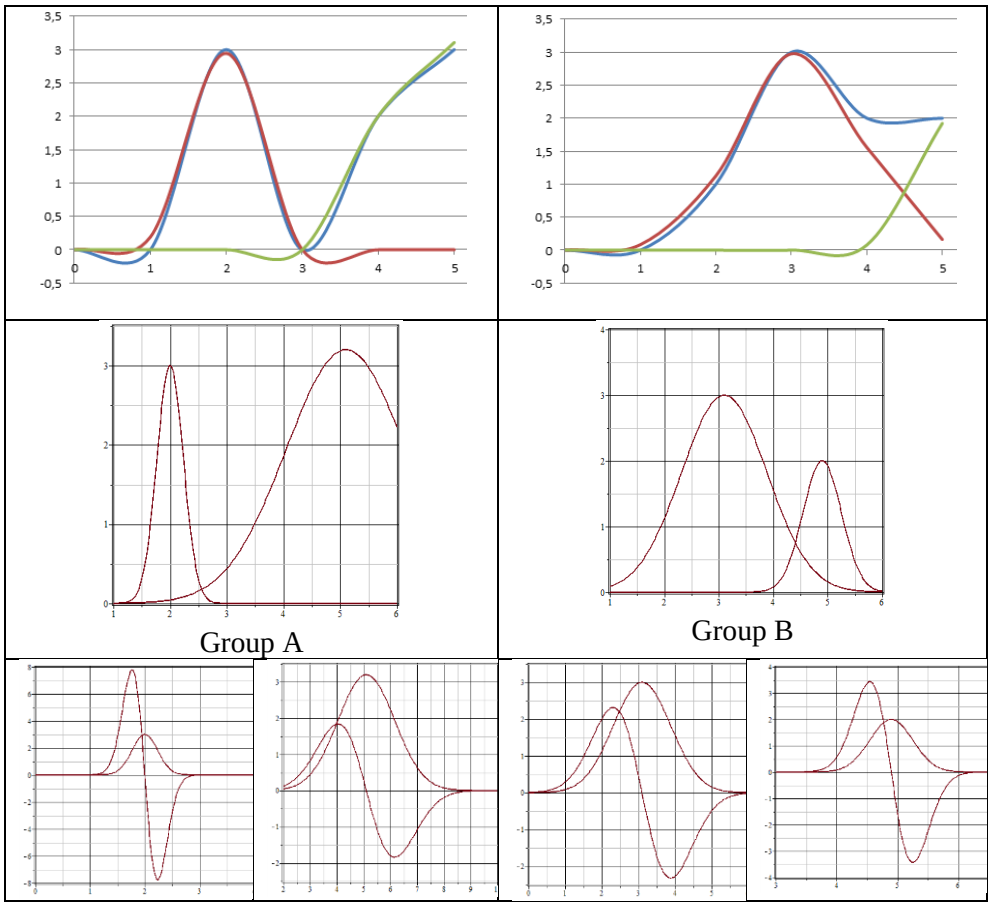


Figure 6. Life curve, eigenvalues and Lorentz profiles of the groups

Equations of the characteristic curves:

Logistic function:	Growth function:	Lorentz function:
$y(x) = \frac{K}{1+ce^{-rx}}$	$y(x) = K(1 - ce^{-rx})$	$y(x) = \frac{K}{e^{c^2(x-r)^2}}$

The Lorentz profile is the first derivative of the Lorentz function.

3. SUMMARY

In this paper an evolutionary based evaluation and qualification system (EBSYQ) is proposed and applied for the comparison of group or team results or achievements. The evolutionary basis of the system comes from the application of sigmoid curves (growth curve, logistic curve), since these curves can be used also for the description of the iteration history of evolutionary type optimisation algorithms. Thirty-eight different points of view are collected for the comparison of the group results, (twelve of these points of view were equal or impossible to decide the winner of it). On the basis of these comparison criteria it will be very easy for a teacher to find the appropriate target–sub-group for a given type of special work or consultation activity (for talented students, competitions for outstanding students, increasing the interest and attendance of average students, or special consultations or remedial work for undermotivated or failed students). The application of this system during a competition among groups (or selection of possible applicants for a job, etc.) makes possible to the decision makers to see the existing differences more clearly, even if they are small, and hard to detect or notice in other ways. This could help a jury or decision makers to make decisions in more objective and accurate manner, numerically evaluating and comparing each point of view during the comparison process. The working and efficiency of the proposed system is shown by the comparison of the decision making process during an international product design cooperation project with the participation of Finnish and Hungarian student groups as a case study, with and without the proposed system. The case study shows that without the proposed system the results of the groups are extremely close, if in one criterion one group was better, the other group was better from an other point of view, so the final decision would normally contain a high percentage of subjectivity. Analysis of the case study by the EBSYQ system proves that the proposed method can detect and separate even very small differences clearly and characterise them numerically, which can be useful help even in case of very close competitions.

Application of the EBSYQ evaluation system of group achievements can be an efficient tool in several decision-making situations in scientific and education fields, resulting more accurate and more objective decisions, which can give advantages to teachers in finding more precisely the target groups for special treatments and consultations, or to decision makers in making better decisions more easily and quickly, to the students or to the members of evaluated groups to win and obtain with higher probability and on more objective basis the prize they are compete for and to arrive more surely in a position where they can enjoy the results of their long, hard and

diligent work. These results can be also useful during increasing the development and methodology skills [7] of students and designers, as well as during the design of talent- treatment, talent- nurturing programmes [8].

Further research in this theme could be to extend this system to other fields of life: analysis and comparison of sports results (groups, individuals) or analysis of evolutionary type optimisation algorithms.

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HEIBus 575660-EPP-1-2016-1-FI-EPPKA2-KA (Smart HEI- Business Collaboration for Skills and Competitiveness) ERASMUS+ International Project
(HEI = Higher Education Institutes).
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