A MODEL FOR IMPROVING ENTERPRISE'S PERFORMANCE BASED ON COLLABORATIVE E-LEARNING

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Abstract: Collaborative learning and e-learning are believed to be very important to the success of enterprises. Some qualitative and quantitative variables that characterises collaborative learning through e-learning are depicted. The incidence degree between them and enterprise's performance was determined through a model. Also, the difference between enterprise's financial and non-financial performance was underlined. The proposed model is constructed using the facilities offered by grey systems and ϕ-fuzzy sub-set theory. For better understand the model, we used it on two branches of the same bank. We conclude our paper by presenting and comparing the obtained results and by giving some future work guidelines.

1 INTRODUCTION

The economic context in which firms carry out their activities is dynamic and constantly changing. (Delcea & Scarlat, 2009)

By identifying changes and anticipating them, firms can take decisions to compensate or eliminate any negative effects and leverage the positive effects, thus facilitating the achievement of the firm's goals.

Also, as Nonaka pointed out, in an economy where the only certainty is uncertainty, the one source of lasting competitive advantage is knowledge (Nonaka, 1991).

From this point of view, an organization that fails to learn may be sub-optimal or even dysfunctional (Law & Ngai, 2008).

As Slater and Narver (1995) argue, an enterprise with a continuous tendency of learning has a better chance to respond to customer needs, to sense the market opportunities and to offer more appropriate and more finely targeted products, all these leading the enterprise to superior levels of profitability, sales growth and customer retention.

Over the years, all the traditional learning techniques were revised and new ones were introduced. Internet-oriented applications and e-learning were the revolutionary new ways through which the workforce got the necessary needed skills and knowledge (Tzouveli, Mylonas, & Kollias, 2008).

In an enterprise, partners may accumulate substantial experience and lessons through learning from each other. Some theoretical and practical learning related to how to avoid repetitious mistakes, how to reduce production and transaction costs, and how to enhance the capacity of mutual understanding, coordination, and problem solving can be acquired by partners' interaction (Jiang & Li, 2008) . Sometimes, when partners are faced with a physical distance, this collaborative interaction can be done only through computer, mainly by discussion forums and teleconference.

Depending on enterprise's strategy, some components of collaborative learning through e-learning can be identified.

Our purpose is to identify the qualitative variables that characterise best the collaborative learning from the point of view of e-learning and how these components are influencing enterprise's performance.

We will also analyse the enterprise performance from two directions. The first one is given by the

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accountants' point of view, related to the financial perspective, while the second one is coming from the managerial point of view.

Based on the idea that each firm is different from another, we proposed a single firm model that will help the managers to decide which component of collaborative learning they should improve on their enterprises based on their purpose. For this reason the qualitative variables taken into account will be ordered using grey systems theory and ϕ-fuzzy sub-set theory as we shall see in the following.

2 COLLABORATIVE LEARNING THROUGH E-LEARNING IN ENTERPRISES

Over the past years, work becomes more interdisciplinary, complicated and nevertheless knowledge-based. In this sophisticated environment, in which enterprises carry out their activity, e-learning succeeded through the different interaction tools to offer ample opportunities for learners to collaborate with peers, experts, professionals or with other learners.

The evolution of knowledge-based society involves the development of enterprises through a collaborative learning environment. Collaboration is an important dimension when it comes to sharing and integrating the experiences and training courses of different groups of learners. Supervisors, instructors, and learners from enterprises play different roles in the learning process. They need to work in the same environment, collaboratively instead of individually, to perform an adaptive learning strategy. (Yi, Schwaninger, & Gall, 2008)

In an enterprise, the use of collaborative learning can develop higher level thinking skills, social interaction skills, responsibility for each other and even promote higher achievement. (Chang & Lee, 2009)

Interaction between learners is indispensable to collaborative learning, and learners need to do real work together in which they promote each other's success by sharing resources, discussing, helping, and congratulating each other's efforts to achieve. (Wu, Zhengbing, Yang, & Liu, 2009)

The collaborative learning process from an enterprise may be achieved through a virtual campus or an intranet e-learning platform. The intranet collaborative learning system should focus on how to instruct and stimulate learners to achieve knowledge, and the system is to visualize traditional classroom education and learning environment in web. (Xiuhua & Wenfa, 2008)

The intranet collaborative learning system is a virtual organizational structure of collaborative type in which interact three target groups:

- The target group of learners, composed by participants in tele-activities of training, testing, documentation, participation in online meetings, forums communication;
- The target group of teachers who complete multimedia teaching materials for virtual campus training, evaluates papers submitted online, update databases proper evaluations;
- The target group of people outside the system, which informs about the performance on collaborative learning system and which allows the selection on learners by interact and conveying the information. (Ciurea, 2009)

Related to the idea of collaboration through virtual knowledge spaces some systems have been developed that insure more flexible mechanisms to foster communication and cooperation in learning and work processes. (Eßmann, Gotz, & Hampel, 2006)

Based on recent researches, some quantitative and qualitative characteristics regarding the collaborative learning through e-learning can be identified, with a peculiar impact on enterprise's performance.

Some of qualitative characteristics related to the knowledge acquisition (at individual, group and enterprise level) and learning flow (exploration and exploitation) are listed in the following: (Kreijns, Kirschner, & Jochems, 2003) (Baker & Sinkula, 1999), (Prieto & Revilla, 2006) (Bodea & Dascalu, 2009)

- The degree of group cohesion gained through collaborative learning;
- The development of critical thinking, shared understanding, and long term retention of the learned material;
- The capability of the collaborative learners to resolve effectively the conflicts;
- The capacity of sharing successes and failures within the collaborative group;
- The degree of confidence and responsibility felt by individuals about doing their work;
- The degree to which the quality of the enterprise's market-oriented behaviours are improved by collaborative learning through e-learning;

- The quality of enterprise's learning structure that allows working effectively;
- The quality of internal training and work training through collaborative e-learning provided within the organization;
- The development of social and communicational skills;
- The degree to which the collaborative learning through e-learning enables the development of competencies and skills for working properly.

From the quantitative point of view, we can identify the following variables:

- The number of qualifications that the employees are getting in an year period;
- The number of employees that are using collaborative learning through e-learning in enterprise;
- Collaborative learning group size;
- The number of training sessions that the enterprise is financing in a year period.

All these variables and other more that can be identified at enterprise's level can be analysed and ranked based on their influence on enterprise's financial and non-financial performance, as we shall see in the following sections.

3 FINANCIAL AND NON-FINANCIAL PERFORMANCE MEASURE

The importance and the impact of organizational learning or learning orientation on financial and non-financial performance have been recognized in the research literature related to this field many years ago. (Jiang & Li, 2008)

The financial performance of an enterprise can be measured through several indicators: sales growth, increase in overall profitability, increase in sales resulting from new products, improvement in work productivity, improvement in production cost, enterprise's market share, defect rates, earnings per share (EPS), return on assets (ROA), return on investment (ROI), net income after tax (NIAT) and other more, depending on the enterprise's goals.

As for the non-financial performance, even it has no intrinsic value for companies' directors, it can be used as a leading indicator of financial performance, especially for future financial performance that is not yet contained in the accounting measures. (Prieto & Revilla, 2006)

Through the indicators that are measuring the non-financial performance we can firstly identify the customers' satisfaction, expressed qualitatively by the degree of satisfaction felt by customers or numerically by the average number of satisfied customers or by the number of customers whose level of satisfaction exceeds a certain level. Knowing that satisfied customers are more likely to buy a greater volume of enterprise's products or services, or even to recommend those products/services to other potentially customers, the cost of attracting new customers is lower, the failure costs are reduced and the financial performance is increased.

Another performance indicator, non-financial by its nature, can be enterprise's reputation. Having a high reputation, an enterprise can easily introduce new products and services, by reducing the buyer's risk of trial. (Anderson, Fornell, & Lehman, 1994) Also, a good reputation can lead to a good maintenance of the relationships with key suppliers, distributors and potential allies. (Anderson, Fornell, & Lehman, 1994)

Without expanding, other variables that succeed in measuring non-financial performance can be taken into account: employee satisfaction or morale, employee efficiency, quality of products and services, growth of number of customers, on-time delivery, long term relation with suppliers and customers response time.

Even the enterprise's management is giving a higher importance to the financial performance, the non-financial performance is also extremely important by the fact that it leads to the achievement of a better financial performance, through a higher reduction of production costs, an increasing in productivity, an improving the yield or reducing the material consumption and nevertheless a higher level of sales growth over time.

Because all the two components of enterprise's performance are important, in the proposed model we will analyse the impact that collaborative learning through e-learning has on both financial and non-financial performance.

4 THE RESEARCH MODEL

The model proposed in this paper is a hybrid one, obtained by fusion between grey systems theory and fuzzy theory. While fuzzy theory has the methods

and techniques for treating the quantitative variables, but especially the qualitative ones, grey systems theory manages to achieve good performance in analysis conducted on a small range of data and on a large number of variables.

4.1 Preparation

In this section we will present some definitions and formula related to grey arithmetic and grey incidence which we will use in the proposed model.

4.1.1 Grey Systems Theory Arithmetic

Definition: A grey number is a number whose exact value is unknown but a range within the value lies is known. (Liu & Lin, 2005)

In applications, a grey number in general is an interval or a general set of numbers.

Assume that $\otimes_1$ and $\otimes_2$ are two grey numbers, defined as follows:

$$\otimes_1 \in [a,b], a < b \text{ and } \otimes_2 \in [c,d], c < d$$

The following operations between them can be done (Liu & Lin, 2005):

- Sum:

$$\otimes_1 + \otimes_2 \in [a+c, b+d] \quad (1)$$

- Difference:

$$\otimes_1 - \otimes_2 = \otimes_1 + (-\otimes_2) \in [a-d, b-c] \quad (2)$$

- Reciprocal: The reciprocal of $\otimes_1 \in [a,b]$ with $a < b$ and $ab > 0$, noted $\otimes_1^{-1}$ is defined as:

$$\otimes_1^{-1} \in [\frac{1}{b}, \frac{1}{a}] \quad (3)$$

- Product:

$$\otimes_1 \bullet \otimes_2 \in [\min\{ac, ad, bc, bd\}, \max\{ac, ad, bc, bd\}] \quad (4)$$

- Quotient:

$$\otimes_1 / \otimes_2 = \otimes_1 \bullet \otimes_2^{-1} \quad (5)$$

- Scalar multiplication: Assume that k is a positive real number, the scalar multiplication of k and $\otimes_1$ is defined as follows:

$$k \bullet \otimes_1 \in [ka, kb] \quad (6)$$

Theorem: Interval grey numbers cannot in general be cancelled additively or multiplicatively. More specifically, the difference of any two grey numbers is generally not zero, except in the case that they are identical. And the division of any two grey numbers is generally not 1 except in the case when they are identical. (Liu & Lin, 2005)

4.1.2 Relative Degree of Grey Incidence

From the grey systems theory (Liu & Lin, 2005) we will use in this paper only de items related to the construction of the relative degree of grey incidence and its calculation.

Assume that X_0 and X_j, j=1...n, are two sequences of data with non-zero initial values and with the same length, with t = time period and n = variables:

$$X_0 = (x_{1,0}, x_{2,0}, x_{3,0}, x_{4,0}, \ldots, x_{t,0}), \quad (7)$$

$$X_j = (x_{1,j}, x_{2,j}, x_{3,j}, x_{4,j}, \ldots, x_{t,j}), \quad (8)$$

The initial values images of X_0 and X_j are:

$$X_0' = (x_{1,0}', x_{2,0}', \ldots, x_{t,0}') = (\frac{x_{1,0}}{x_{1,0}}, \frac{x_{2,0}}{x_{1,0}}, \ldots, \frac{x_{t,0}}{x_{1,0}}) \quad (9)$$

$$X_j' = (x_{1,j}', x_{2,j}', \ldots, x_{t,j}') = (\frac{x_{1,j}}{x_{1,j}}, \frac{x_{2,j}}{x_{1,j}}, \ldots, \frac{x_{t,j}}{x_{1,j}}) \quad (10)$$

The images of zero-start points calculated based on (3) and (4) for X_0 and X_j are:

$$X_0^{0'} = (x_{1,0}' - x_{1,0}', x_{2,0}' - x_{1,0}', \ldots, x_{t,0}' - x_{1,0}') = (x_{1,0}^{'0}, x_{2,0}^{'0}, \ldots, x_{t,0}^{'0}) \quad (11)$$

$$X_j^{0'} = (x_{1,j}' - x_{1,j}', x_{2,j}' - x_{1,j}', \ldots, x_{t,j}' - x_{1,j}') = (x_{1,j}^{'0}, x_{2,j}^{'0}, \ldots, x_{t,j}^{'0}) \quad (12)$$

The relative degree of grey incidence is given by:

$$r_{0j} = \frac{1 + |s_0'| + |s_j'|}{1 + |s_0'| + |s_j'| + |s_0' - s_j'|} \quad (13)$$

where $|s_0'|$ and $|s_j'|$ are computed as follows:

$$|s_0'| = \left| \sum_{k=2}^{t-1} x_{k,0}^{'0} + \frac{1}{2} x_{t,0}^{'0} \right| \quad (14)$$

$$|s_j'| = \left| \sum_{k=2}^{t-1} x_{k,j}^{'0} + \frac{1}{2} x_{t,j}^{'0} \right| \quad (15)$$

The relative degree of grey incidence represents a numeric characteristic for the relationship of closeness between the two sequences.

In practical numerical examples, the numerous degree of grey incidence developed in the literature

were used to measure the incidence between two quantitative variables. In our paper, we include some qualitative variables related to collaborative learning and we try to determine their influence on enterprise performance. For a better work with qualitative variables we will use some "expertons" built as it can be seen from the following section.

4.1.3 Expertons

Fuzzy logic offers the suitable tools for the treatment of uncertainty and subjectivity. Because in our model, we will work with qualitative variables, we will use the ϕ-fuzzy sub-set theory and some exertons.

The main characteristic of fuzzy sub-sets is that the function characteristic of membership is taking its values from [0; 1] instead of {0; 1}. For a better representation of reality, we will consider that those values are intervals and not numbers, situated in [0; 1]. (Gil-Lafuente, 2005)

Once with the idea of ϕ-fuzzy sub-set comes even the idea that the opinion of a single expert is being insufficient. That is the reason why it is preferred to gather several experts' opinion and even to construct an experton.

Expertons are in fact intervals built using the ϕ-fuzzy sub-set and the opinion of several experts over a certain problem. For a complete reading on how these expertons are built, see (Gil-Lafuente, 2005).

4.2 The Research Model

The proposed model combines the advantages offered by grey systems theory and ϕ-fuzzy sub-set. Figure 1 summarises the steps involved.

We shall mention that in first stage of the model construction we will use some experts for the selection of the collaborative e-learning variables that are the most important at enterprise's level. Also, the team of experts will establish the performance indicators that will be measured and used, one for the financial performance and another one for the non-financial performance. Depending on the manager's will, it can be taken into account only the performance or only the non-performance indicator.

In the next step, the quantitative variables, including the quantitative performance indicators are measured. In some cases, enterprise's financial statement or other enterprise's documents can be used.

The qualitative variables are also measured. For this, each expert from the team will give his opinion

Figure 1: The proposed model.

on the values of qualitative variables through a number or an interval between 0 and 1 in the following manner: if an expert is absolutely sure about the level of the considered variable, he will note that value through a number; otherwise, he will record an interval. Also, if the expert has no clue about the values among which the variable can be found, he will simply record the whole [0; 1] interval.

After gathering all experts' opinions, an experton will be build for each variable.

Having all the variables measured, we will apply the grey arithmetic on intervals presented at 4.1.1 to the relative degree of grey incidence.

By computing, the collaborative e-learning variables taken into account are ordered based on the value of the relative degree of grey incidence. Acting on them, the financial and the non-financial situation of a company can be improved.

5 REAL NUMERICAL APPLICATION

In period July 2008 – October 2009 we conducted a study on two branches of Raiffeisen bank. Our

purpose was to detect which of the qualitative or quantitative characteristics of collaborative e-learning through learning identified in the two branches are influencing the performance of each of them. By comparing the findings we can establish some similarities and some differences as we will see further.

For this purpose, a number of four specialists in the field helped us. Based on the interviews with the managers of the two branches we established the performance indicators. For the financial performance we measured the sales growth (noted X_0^P), while for the non-financial performance: the average number of satisfied customers (X_0^{NP}). The period of time of almost 15 month was divided into five equal periods, each of them having three months.

The qualitative and quantitative characteristics identified related to the knowledge acquisition and learning flow that are gained through the collaborative learning held in the branches' that are more appropriate to influence their performance are listed below: the development of social and communicational skills (X_1), the increase of competences as a result of the collaborative learning process made through e-learning (X_2), the development of critical thinking, shared understanding and long term retention of the learned material (X_3), the average size of collaborative learning group (X_4) and the number of employees that are using collaborative learning through e-learning (X_5).

For the qualitative variables (X_1, X_2 and X_3), whose values were expressed by each one of the four experts through intervals or numbers between 0 and 1, we have built three expertons for each branch.

The values of all the variables, including the expertons, were gathered in two tables as they can be seen in Figure 2 and Figure 3.

Next, we apply the relative degree of grey incidence. In the qualitative variables case, expressed through expertons, we will use some grey arithmetic on intervals presented at 4.1.1.

Branch 1	X_0^P	X_0^{NP}	X_1	X_2	X_3	X_4	X_5
T_1	0.11	821	[0.45; 0.75]	[0.35; 0.7]	[0.7; 0.8]	5.5	11
T_2	0.27	753	[0.425; 0.65]	[0.4; 0.775]	[0.675; 0.8]	3.6	11
T_3	0.31	912	[0.575; 0.725]	[0.55; 0.65]	[0.725; 0.925]	3.6	11
T_4	0.33	866	[0.675; 0.8]	[0.6; 0.85]	[0.7; 0.825]	3.3	23
T_5	0.26	972	[0.75; 0.825]	[0.725; 0.925]	[0.6; 0.825]	3	24

Figure 2: The values of performance indicators and qualitative and quantitative variables collected at Branch 1.

Branch 2	X_0^P	X_0^{NP}	X_1	X_2	X_3	X_4	X_5
T_1	0.13	514	[0.675; 0.825]	[0.425; 0.6]	[0.375; 0.75]	7	7
T_2	0.09	526	[0.75; 0.8]	[0.4; 0.725]	[0.5; 0.625]	4	8
T_3	0.24	634	[0.725; 0.75]	[0.4; 0.8]	[0.55; 0.725]	4.2	21
T_4	0.28	877	[0.55; 0.8]	[0.625; 0.65]	[0.475; 0.825]	3.5	21
T_5	0.27	1004	[0.725; 0.825]	[0.575; 0.85]	[0.725; 0.85]	3.5	21

Figure 3: The values of performance indicators and qualitative and quantitative variables collected at Branch 2.

After computing, the following results were found. Figure 4 summarizes the values of the relative degree of grey incidence for the case when we are interested on financial performance, while Figure 7 summarizes the values of the relative degree of grey incidence for the case of non-financial performance.

Branch 1	r_{01}^P	r_{02}^P	r_{03}^P	r_{04}^P	r_{05}^P
	0.5336	0.5534	0.5374	0.5321	0.6691
Branch 2	r_{01}^P	r_{02}^P	r_{03}^P	r_{04}^P	r_{05}^P
	0.5947	0.5879	0.5592	0.5581	0.7419

Figure 4: The values of the relative degree of grey incidence on financial performance obtained in the two branches.

For the first branch, from $r_{05}^P > r_{02}^P > r_{03}^P > r_{01}^P > r_{04}^P$ it can be seen that $X_5 \succ X_2 \succ X_3 \succ X_1 \succ X_4$. This is equivalent to say that the most influencing factor in this case is the number of employees that are using collaborative e-learning, while the factor with the less influence is the average size of the collaborative learning group. As for the second branch, it can easily be seen that the factor with the most and the less influence remains the same, with the only difference that the order of the qualitative factors is $X_1 \succ X_2 \succ X_3$.

Graphically the values obtained in the two branches cases are represented in Figure 5 and Figure 6 below:

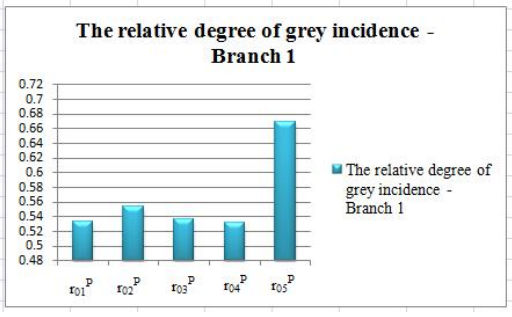

Figure 5: The values of the relative degree of grey incidence for each variable on financial performance indicator - Branch 1.

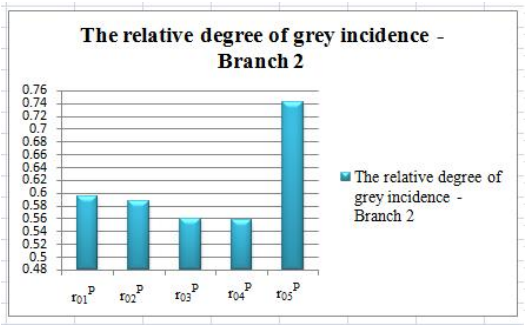

Figure 6: The values of the relative degree of grey incidence for each variable on financial performance indicator - Branch 2.

For the non-financial performance case, the values of the relative degree of grey incidence are presented in the following figure:

Branch 1	r_{01}^{NP}	r_{02}^{NP}	r_{03}^{NP}	r_{04}^{NP}	r_{05}^{NP}
	0.6647	0.5418	0.6442	0.6254	0.6546
Branch 2	r_{01}^{NP}	r_{02}^{NP}	r_{03}^{NP}	r_{04}^{NP}	r_{05}^{NP}
	0.5711	0.6719	0.5671	0.6159	0.5514

Figure 7: The values of the relative degree of grey incidence on non-financial performance obtained in the two branches.

In the case of non-financial performance, the order of the variables identified at first branch's level according to their relative degree of grey incidence is: $X_1 \succ X_5 \succ X_3 \succ X_4 \succ X_2$. That is equivalent to say that the average number of satisfied customers depends most on the development of social and communicational skills of the employees. For the second branch, the increase of competences as a result of collaborative learning process is the most influencing variable on non-financial performance, followed by X_4, X_1, X_3 and X_5. This can also be seen from Figure 8 and 9.

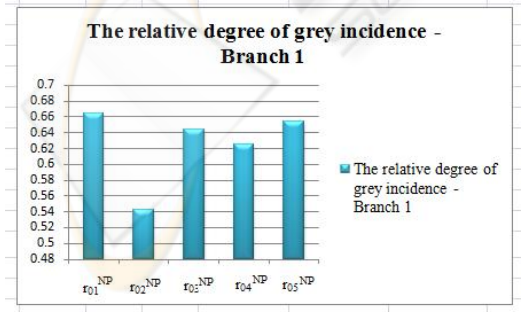

Figure 8: The values of the relative degree of grey incidence for each variable on non-financial performance indicator - Branch 1.

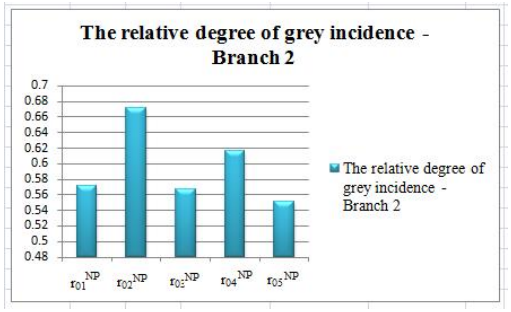

Figure 9: The values of the relative degree of grey incidence for each variable on non-financial performance indicator - Branch 2.

6 CONCLUSIONS

In the analize of enterprise's performance a peculiar attention should be given to the variables that are influencing it. From this cathegory, the variables that undeline the level of collaborative e-learning represent an important cathegory.

Starting from idea that each enterpise is unique, we propose a single-enterprise model, built using grey systems theory and ϕ-fuzzy sub-set theory.

By simulating the model on the data collected in the two branches, it was easy to see that the results obtained in the two cases were different. From this point, based on each manager's purpose, the manager can decide whether to act on the variables that are influencing financial or to the ones that are influencing the non-financial performance. For our numerical example, in the first branch case, if the manager wants to improve the financial performance, he/she should try to increase primary the number of the employees which are using the collaborative e-learning by offering the possibility of studying through intra/internet and through collaboration to a large number of employees. Or, contrary, if the non-financial performance is aimed, the manager should concentrate on the communicational skills, which can be acquired through some training sessions.

The research can be extended to include facilities offered by other theories, such as case based reasoning, which is similar to the human way of thinking. Also, a soft procedure can be created in order to aggregate easier the identified variables and the experts' opinions. In order to bring future improvement to the proposed model, the number of variables can be extended by taking into account other variables unrelated to the collaborative e-learning.

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