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Methodology for Evaluating the Quality of Distance Learning Courses in Consecutive Stages

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Abstract

The paper presents a new methodology for evaluating the quality of distance learning courses. Evaluation takes place in three stages: content subject experts in the field inspect the material; IT specialists inspect the effectiveness of the tools used for planning training; and students' rating is provided. In order to recalculate the final distance course quality assessment of each expert group stages of evaluation of significance, the Bayes' formula is used. The publication presents the system of criteria for course quality evaluation. The authors use Multiple Criteria Decision Making (MCDM) methods to determine the best course. To estimate the importance weights of the criteria, the Analytical Hierarchy Process Fuzzy (AHPF) method is used.

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Keywords: Distance learning courses; quality evaluation methodology; weights; Analytic Hierarchy Process, MCDM, method stability, Bayes' formula

1. Introduction

This article assesses distance learning courses taught at higher education institutions according to the planned program of the institution. A distance-learning course is defined as a subject taught in a remote mode using information technologies. The quality assessment question of distance learning courses is relevant to any teaching institution. In order to attract more students, the teaching process must be of a high quality. Thus the quality of a distance learning course taught depends on many factors, which have to be evaluated by the connoisseurs of the field – the experts. The experts of different groups take part in the assessment of distance learning courses, and their

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opinions are independent. The expert of each area assesses the part, in which he/she is competent. It is difficult for the experts of different areas, who assess distance learning courses, to evaluate a large number of courses by the light of nature. Therefore in order to make the work of experts easier, it is suggested to apply the prepared methodology to determine the quality of courses. The evaluation of distance learning courses takes place in 3 stages: content subject experts in the field inspect the material; IT specialists inspect the effectiveness of the tools used for planning training; and the students' rating is provided. The learning management authority determines the relevance of each stage of evaluation. In order to recalculate the final distance course quality assessment of each expert group stages of evaluation of significance, the Bayes' formula is used (10). As the methodology suggests, the most stable Multiple Criteria Decision Making (MCDM) method techniques are used for course quality evaluation that increases the objectivity of the results. After selection and comparison using the stable results of the method the Pareto solution is set (9). Such an approach has not been previously applied in distance studies. The methodology is applied both, in a broad context (as it is the best and most appropriate course selection method for the studying audience) and for course quality determination. After considering the importance of each stage mentioned, the best distance course is set.

The development process of studying by distance starts with preparation of the course material content and selection of information technologies to be used in developing it for further teaching. At these stages the inspection of the course is performed by appropriate experts of certain subjects (the teachers) and IT specialists. When verified, the course is admitted for teaching. The students express their opinions of the teacher's regularity and the clearness of the presented material and its explanation. The methodology suggests techniques to estimate the quality of the course material for studying by distance in three consecutive stages: by the teachers; by IT specialists; and by the students. The author has offered a set of criteria for distance learning courses evaluation for each expert group at each evaluation stage. The methodology determines the significance of the criteria, using the AHPF method in each expert group. MCDM methods are used to determine the best course. The methodology suggests using the most stable MCDM methods. The weight of each evaluation stage is determined by using the AHPF method of institution administration since the evaluation stages of the course can also have different significance. The Bayes' formula allows to re-estimate the weight established by administration and consider another group of experts. Due to this it is possible to find a course for each group of experts.

2.1. Structure The AHPF Method for Determining Criteria Significances

The AHP method was developed by Saaty (Saaty, 1980). The analytical hierarchy process method is a closed logical construction that is realized by applying simple rules for organizing and analyzing complex decisions, in order to find the best possible solution. A hierarchy is a multi-level system, which is an arrangement of items and factors. The AHP method is aimed at determining the significances (weights ω_i) of the evaluation criteria and assessing the consistency of questionnaires elicited from experts. The ponderosity of criteria reflects the opinion of the expert assessors on the importance of criteria in comparison with other criteria. The analytic hierarchy approach is applied to every single one of experts (Zadeh, 1965). The foundation of the method is based on the pairwise comparison matrix. The pairwise comparison scale developed by Saaty is a spot valuation method. A theory of uncertainty was born when Zadeh was solving a problem how to cope with the indefinite human thinking (Podvezko, 2009). Uncertainty allows one to evaluate not only one point, but also the appropriate range of values. The fuzzy triangular numbers are three parameters *(l,m,u)*, which define the quality between 0 and 1 within the membership function. The Pairwise comparison matrix of expressionless parameters is set by a panel of experts from the individual agreement of experts on pairwise comparison matrices. Concerted decision matrix mean values of the matrix is calculated by the experts when $j \geq i$, as the matrix is inverse (Belton & Stewart, 1992).

$$\bar{p}_{ij} = \frac{\sum_{k=1}^{r} p_{ij}^{k}}{r} \tag{1}$$

Then, the matrix standard deviation is calculated when $j \geq i$:

$$S_{\bar{p}_{ij}} = \sqrt{\frac{\sum_{k=1}^{r} (p_{ij}^{k} - \bar{p}_{ij})^2}{r}} \tag{2}$$

After that, the expressionless number of parameters of a triangular matrix of the expert group is set as follows:

$$m_{ij} = \bar{p}_{ij};\ l = m - S_{\bar{p}_{ij}};\ u = m + S_{\bar{p}_{ij}}; \tag{3}$$

After that, Chang‘s (1996) proposed advanced method of analysis of the expressionless fusion extension in order to calculate the S_i value of calculating the weighting set is applicable as follows.

$$S_i = \sum_{j=1}^{r} M_{gi}^{j} \otimes \left\{\sum_{i=1}^{n}\sum_{j=1}^{r} M_{gi}^{j}\right\}^{-1} \quad (4)$$

The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is expressed as:

$$V(M_2 \geq M_1) = hgt(M_1 \geq M_2) = 1, if\ \ m_2 \geq\ m_1, 0{,}001, if\ \ l_1\ \geq u_2, \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}\} \quad (5)$$

To compare $M_1\ and\ M_2$, both $V(M_2\ \geq\ M_1)\ ir\ V(\ M_1 \geq\ M_2)$ are required.
The degree of possibility for a convex Fuzzy number to be greater than k convex Fuzzy numbers $M_i\ (i = 1,2, \ldots, k)$ can be defined as follows:

$$V(M \geq\ M_1, M_2, \ldots, M_k) = V[(M\ \geq\ M_1)\ and\ (M\ \geq\ M_2)\ and\ \ldots\ and\ (M\ \geq\ M_k)] = \min V(M\ \geq\ \ M_i),\ = 1,2, \ldots, k$$

Let $d'(A_i) = \min V(S_i \geq S_k), k\ =\ 1,2, \ldots, n;\ k\ \neq n.$
Then the weight vector is given by $W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T$ (6)
The weight vector is normalized to get the normalized weights: $W = \left(d(A_1), d(A_2), .., d(A_n)\right)^T$ (7)

2.2. MCDM method verification of stability

MCDM methods are based on the decision matrix $r_{ij}$and criteria weights vector ω_j, *j=1,...,m*. In general, MCDM methods case can be mathematically formulated as:

$$i_{opt}(r) = arg\ max_i f_i(r, \omega), i = 1, \ldots, n \quad (8)$$

2.3. Pareto Solution

It maximizes the objective function vector $f(x) = f_i(x), i = 1, .., m$. The objective function vector elements are stable methods results. Pareto solution is set x^*(Mockus, 1999).
$x^* \in X^*$, if not occur as x, that

$$f_i(x) \geq f_i(x^*), \forall i$$
$$f_j(x) > f_j(x^*), \exists j \quad (9)$$

2.4. The use of Bayes' formula in criteria weight recalculation

A formula for determining conditional probability was named after 18th-century British mathematician Thomas Bayes. The theorem provides a way to revise existing predictions or theories given new or additional evidence. Bayesian idea is that the probability value is adjusted after the new information has been received.

$$P(\theta_j|X) = \frac{P(X|\theta_j)P(\theta_j)}{P(X)}, \qquad P(X) = \sum P\left(X\middle|\theta_j\right)P(\theta_j)$$

In our case $\theta_j -$ valuable course quality criteria. Criteria probability, which is criteria weights, is adjusted after the new information has been received. The weight of criteria ω_j (analogue of probability $P(\theta_j)$), shows the influence degree of the j-th criterion on the evaluation result, $P(\theta_j) \sim \omega_j$ and $\sum P(\theta_j) = 1$. $\omega\left(X\middle|\theta_j\right)$ is the influence degree of j-th criterion on the evaluation result.

The expert groups evaluate the stages in 10-score system. $\boldsymbol{e_{jk}}$ –– evaluation matrix of experts $\omega\left(X\middle|\theta_j\right) = \frac{\sum_{k=1}^{r} e_{jk}}{10r}$
The Bayes' formula may be re-written in the following way:

$$\omega\left(\theta_j\middle|X\right) = \frac{\omega(X|\theta_j)\omega(\theta_j)}{\sum_{j=1}^{n}\omega(X|\theta_j)\omega(\theta_j)} \quad (10)$$

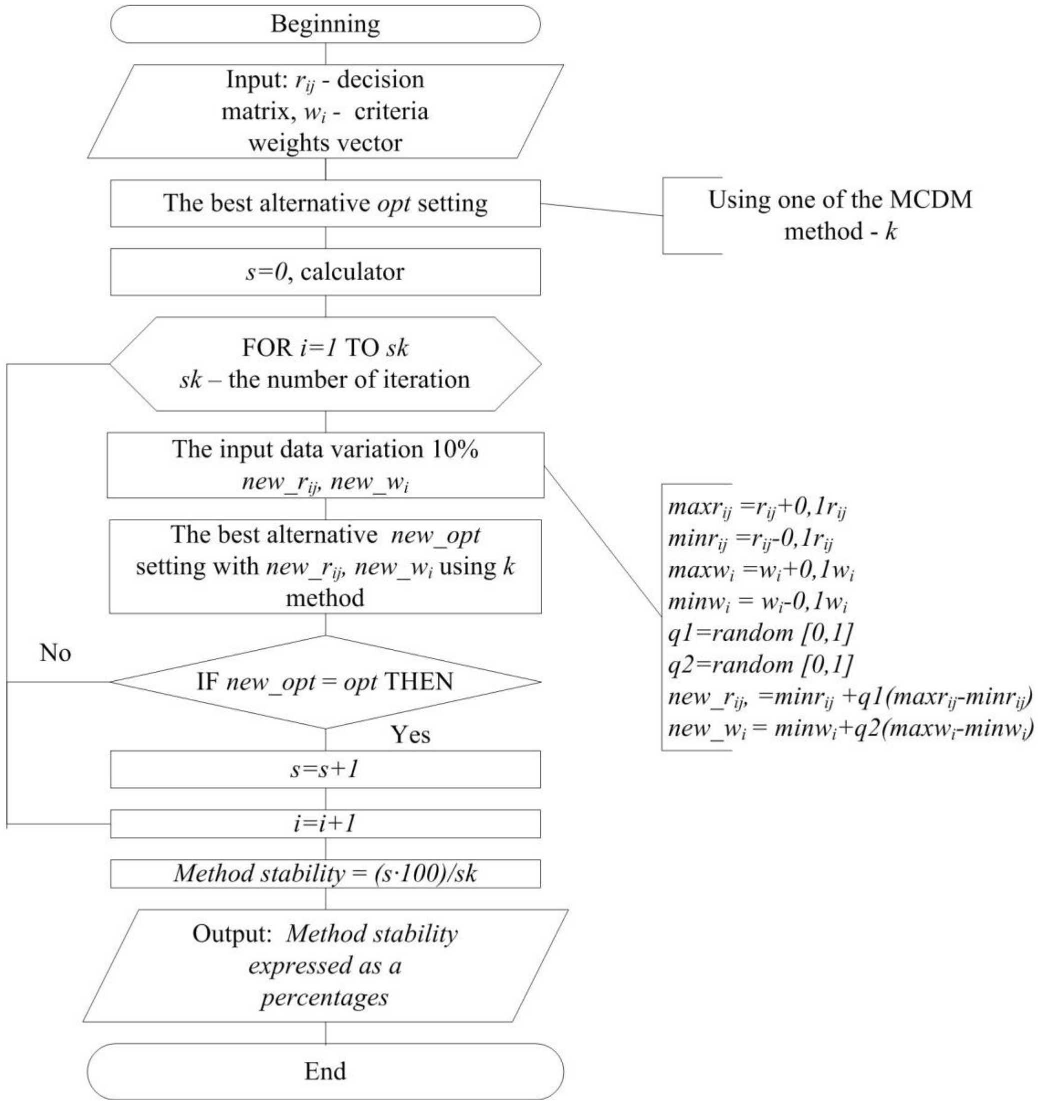

Fig. 1. The stability of random data method's uncertainty conditions

2.5. The System of Criteria for Course Quality Evaluation

According to Belton and Stewart's principles of identification of quality evaluation criteria, such a group of criteria for each stage of the evaluation process was offered (Vinogradova, 2012).

The first group of criteria: Evaluation of the course content.

1) Course structure – general structure of the course, integrity of the content, and clarity. 2) Correspondence of material to the program – the content and scope of the material (purpose, tasks, number of hours) have to correspond to the program of the subject taught. 3) Relevance of material – the material has to be relevant and the data and quoted publications cannot be out-of-date. 4) Testing of knowledge – tasks of various types, which help to master difficult material, and tests with feedback – correct answers to test one's own knowledge; tests for the lecturer to

evaluate the student's knowledge; a clear system of knowledge assessment. 5) Clarity of material presentation – the teaching material needs to be presented in a clear and understandable mode.

The second group of criteria: Effective use of tools.

1) Studying community – usage of synchronous and asynchronous communication means; easy going communication in group; testing of effectiveness of video conferences according to the number of logged-in students during one session. 2) Means of knowledge testing and calculation of the grade – usage of tests and tools of work presentation and checking of the system's calculation of the final grade. 3) Personalization – teaching interface; the teaching process is personalized according to the needs of the students. 4) Information downloading speed – good speed of information transfer and connection. 5) Reading of material with widely used tools – the format of the material recorded is read using the widely used tools. 6) Help to the student – comprehensive information and availability of instructions how to start the course and participate in the virtual lecture as well as the schedule and calendar of studies.

The third group or criteria: Course teaching.

1) Professionalism of lecturers – the lecturer's ability to present the material in an interesting and clear way; 2) Organization of teaching and help to the students – organization of the teaching process is well implemented and the most important information is presented; the lectures are conducted smoothly and on time; clear structure of the material. 3) Feedback of independent learning and testing activities – useful exercises of independent learning; fast feedback. 4) Practical benefit of the course – the course's benefit to the student, acquisition of knowledge, practical skills, and competences. 5) Comfortable and suitable usage of information technologies – the material is easy to open and fast to download; intuitive, simple usage, comfortable communication means, and good connection.

3. Distance course quality evaluation by proposed methodology

The methodology has been tested in the evaluation of three courses, alternatives to be noted as 1A, 2A, 3A. The group of experts set that the criteria weights ω in each of the consecutive stages of the assessment. The experts evaluated the quality of the courses in a 10-score system. The sum of criteria weights for each individual is 1. The administration determines which of the stages in their opinion is more important than others. To get the weights ω and w ADM AHPF method was used (calculating in accordance with (1) - (7) formulas). All criteria are recalculated according to the weights importance of stages accepted by the administration. The evaluation results are shown in Table 1.

Table 1. The results of distance course evaluation.

ω ADM	ω TCH	ω IT	ω ST	ω		1A	2A	3A
0,402	0,438	0,394	0,412		1 STAGE: The course content evaluation			
0,064	0,070	0,063	0,066	0,1591	Course structure	9,2	8,6	9,4
0,063	0,068	0,062	0,064	0,1561	Correspondence of material to the program	9,2	9,4	9,8
0,101	0,110	0,099	0,104	0,2514	Relevance of material	7,6	8,6	7,6
0,081	0,088	0,079	0,083	0,201	Testing of knowledge	8,2	7,2	8,2
0,093	0,102	0,092	0,096	0,2324	Clarity of material presentation	9,1	8,6	8,2
0,297	0,255	0,304	0,292		2 STAGE: Effective use of tools			
0,051	0,044	0,052	0,050	0,172	Studying community	8,2	8,4	8,4
0,057	0,049	0,059	0,056	0,193	Means of knowledge testing and calculation of the grade	7,4	9	8,8
0,046	0,039	0,047	0,045	0,155	Personalization	7,6	8,6	7,6
0,058	0,050	0,060	0,057	0,196	Information downloading speed	7,8	7,8	8
0,046	0,039	0,047	0,045	0,155	Reading of material with widely used tools	8,2	8,2	8,4
0,038	0,033	0,039	0,038	0,129	Help to the student	8,6	9,4	9,6
0,301	0,307	0,302	0,296		3 STAGE: Course teaching			
0,085	0,087	0,086	0,084	0,2837	Professionalism of lecturers	9,33	8,83	8,65
0,079	0,086	0,084	0,083	0,279	Organization of teaching and help to the students	9,2	9,17	9,1
0,034	0,037	0,037	0,036	0,1217	Feedback of independent learning and testing activities	8,5	8,17	8,5
0,03	0,077	0,075	0,074	0,2496	Practical benefit of the course	8,2	8,7	8,5
0,016	0,020	0,020	0,019	0,0658	Comfortable and suitable usage of information technologies	7,66	7,62	8,2

For setting the best course, the group MCDM methods are used (8). Linear scaliarization SAW, COPRAS, TOPSIS, PROMETHEE Moore methods are used for the evaluation. Using the stability of random data method's uncertainty conditions algorithm, see Fig 1, the stability of the methods described in it is checked.

Table 2. The stability of MCDM methods expressed as a percentage.

Number of iteration	Linear scaliarization, SAW, COPRAS	TOPSIS	PROMETHEE	MOORA
100	43%-60%	47%-65%	56%-76%	45%-56%
10 000	52%-54%	57%-59%	65,3%-66,7%	42%-65%
100 000	53,2%-53,5%	58,37%-58,56%	65,64%-65,95%	46%-65%
1000 000	53,43%-53,45%	58,46%-58,54%	65,8%-65,9%	44%-58%

Whereas only maximized criteria in the tasks are used, linear scaliarization SAW, COPRAS calculation methods coincide (furthermore, we mention only one: the SAW method). The methods stability results are shown in Table 2. After getting them, the MOORA method appears to be the most volatile, and it is not used in further calculations. The results of the mentioned methods, when evaluation stages have equal importance, are shown in Table 3. The best alternative is A1.

Table 3. The result of best alternative when evaluation stages equal importance.

1 stage	SAW	TOPSIS	PROMETEE
1 A	8,5735	0,5241	0,178
2 A	8,4435	0,5063	-0,289
3 A	8,4898	0,4356	0,110
Pareto 1A			
2 stage			
1 A	8,0042	0,1746	-1.434
2 A	8,5465	0,8067	0.421
3 A	8,4688	0,6392	1.013
Pareto 2A			
3 stage			
1 A	8,7989	0,5913	0.472
2 A	8,7307	0,4797	-0.052
3 A	8,6885	0,331	0,390
Pareto 1A			

The best alternatives to the application of stable MCDM methods are determined after reweighing and considering the importance of the stage set by the administration. Table 4 shows the best course set at different stages of evaluation, when the importance of each stage is equal and measured by the administration. The result of the evaluation is diverse. The best course from the administration's point of view is A2.

Table 4. The result of best alternative in evaluation stages.

Evaluation stages	The best alternative when evaluation stages equal importance	The best alternative when evaluation stages measured by administration
1 stage	1A	1A
2 stage	2A	2A
3 stage	1A	2A

The best alternatives to the application of stable MCDM methods are determined after reweighing and considering the importance of the stage set by the department. The results show that the choice of the course changes when the importance of each stage is recalculated, revised, and changed. Although when selecting a course another group's opinion is important, but they do not make up decisions, instead of reweighing stages they are suggested to recalculate administration experts sets stages weights. Reweighing is carried out using the Bayes formula (10). In Table 5 the best course setting after having calculated the weighting of the criteria for each group of experts is shown.

Table 5. The result of the best alternative when evaluation stages are measured by a different expert group.

Expert group	Pareto solution
Teacher	1A, 2A, 3 A
IT specialist	2A
Student	2A
Administration	2A

4. Conclusion

The clearly presented and interestingly taught material, a well-organized teaching process, and correctly selected information tools have a big impact on the quality of distance learning courses. When the course's material is relevant for the group of students, the studying results are much higher. The suggested methodology for evaluating distance courses is described offering the evaluating criteria of quality. The named publication methodology is based on mathematical AHPF, MCDM, stability determination method, and the Bayes methods calculations. Using the methodology for course evaluations, we can see that the results are changing according to the revised criteria weights of the different groups of experts. The methodology can be applied to evaluate and select other alternatives if the evaluation takes place at different stages in different groups of experts. Methodology suggests a new use of the Bayesian formula, qualifying the main decision-maker's decisions.

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