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QUALITY EVALUATION MODEL OF INTERACTIVE DISTANCE LEARNING COURSE

Currently various models are used for distance learning quality evaluation. The main issues with these models deal with the amount of time required for implementation and absence of the main factors involved in the distance learning organization process. Therefore, they cannot be used for quality evaluation of interactive distance learning courses.

The multicriteria model of quality evaluation of the interactive distance learning course (IDLC) is considered. It includes the following criteria: the quality level of educational materials; the quality level of staffing; the quality level of software and hardware. An automated system "IDLC Quality Assessment" has been developed, which offers both numerical values and fuzzy interpretations.

Keywords: *distance learning courses; model of course quality evaluation; fuzzy logic.*
Fig.: 5. Table: 6. References: 27.

Relevance of the research topic. The growing number of distance learning courses and its suitability to commercialization lead to the urgency of quality evaluation. Usually the criteria and methods of such evaluation have their own specifics, which significantly differs from the known methods of assessing the quality of traditional courses in many respects [1].

The task of quality evaluation of training courses in remote education becomes more important every year. Unfortunately, Ukraine does not yet have state standards and methods for assessing the quality of distance learning courses. This situation justified the necessity and importance of criteria and methods development to solve this issue.

The problem formulation. Distance learning was often perceived as an additional element of the educational services provided by higher education institutions (HEIs). But the current state of higher education, including the Covid-19 pandemic restrictions, has changed attitudes towards distance learning, giving it the status of a primary form of educational services. For now, the quality of educational services has become the main indicator of HEIs activity.

It is possible to solve these actual problems by creating interactive learning systems (interactive courses) and improving the quality of educational material in existing courses on a regular basis.

Interactive learning course is a system of hardware and software components. It receives information entered by a user and transmits their answers assisting with some work or task.

Interactive distance learning courses (IDLC) combine a set of lectures, practical classes, manuals, electronic information, and additional materials. The IDLC structure is aimed to ensure that students not only memorize information but associate it with life and professional cases. The main criterion for assessing the course mastering is not the reproduction of theoretical materials, but the demonstration of the acquired knowledge in practice. Thus, the issue of IDLC quality evaluation becomes leading in quality maintenance of HEIs services.

Analysis of recent research and publications. The quality of distance learning relates to all educational processes, results and services provided through information and communication systems [2]. It can be improved during the process of developing the educational component by choosing appropriate IT tools for the distance learning process implementation and during the course presentation using the effectiveness of the virtual learning environment. In quality evaluation of distance learning, the main attention in the development of distance learning and training is paid to the educational materials designing [3]. Airina Volungeviciene and Margarita Tereseviciene [4] proposed the model for educational component programs development based on factors for assessing the quality of distance learning content. Among the factors determined by the authors to assess the distance learning quality the expert evaluation is mentioned [5].

Achieving the learning content quality requires a number of essential activities: regular student preferences analysis [6], setting learning goals, applying appropriate methods of learning organization, proper planning of learning outcomes evaluation; applying of appropriate curriculum; and specific technological means [7].

Currently various models are used for distance learning quality evaluation. Among them are a neural network model based on an optimization approach [8]; a model based on a fuzzy analytical hierarchy (FAHP) [9]; a model grounded on the Bayesian formula and Multiple Criteria Decision Making (MCDM) methods to determine the best course [10]. To estimate the criterion`s importance weights, the Analytical Hierarchy Process Fuzzy (AHPF) method is used [11]. Problems of the distance learning materials quality examination also were considered in [12].

Selection of unexplored parts of the general problem. For distance learning quality evaluation most researchers considered the courses quality evaluation by students as the most valuable factor. The literature review shows the dependency of the proposed distance learning courses quality on a bunch of factors (criteria) [10]. The main issues with proposed models despite requiring an unreasonable amount of time for implementation is the absence of the main factors used in the distance learning organization process. Therefore, they cannot be used for IDLC quality evaluation.

The aim of the work is to create a multi-criteria model for IDLC quality evaluation to support the quality monitoring of HEI distance learning systems.

Main material. The main regulatory and legal provisions for standardizing the quality of educational services by HEI in the process of distance learning include:

- Law of Ukraine "On Higher Education" [13];
- Law of Ukraine "On the National Informatization Program" [14];
- Order of Ministry of Education and Science of Ukraine "Regulations on Distance Learning" [15];
- Order of Ministry of Education and Science of Ukraine "On approval of Amendments to the Regulation on Distance Learning" [16];
- Order of Ministry of Education and Science of Ukraine "On approval of Requirements to higher educational institutions and establishments of postgraduate education, scientific, educational and scientific establishments providing educational services on a distance form of training on preparation and advanced training of experts on the accredited directions and specialties" [17];

State standards for quality management system:

- DSTU ISO 9000:2015 Quality Management Systems. Fundamentals and Vocabulary [18];
- DSTU EN ISO 9001:2018 Quality Management Systems. Requirements [19].

The level of an interactive distance learning course quality may be considered as a set of properties reflecting the degree of suitability of specific information about objects and their relationships to achieve the user's goals in the implementation of certain activities.

IDLC is an information product, therefore to evaluate its quality it is natural to use approaches for quality evaluation of the information products such as software. In this case, an IDLC is subject to a number of state standards of Ukraine related to software quality assessment:

- DSTU 2844-94 Software. Software Quality Assurance. Terms and Definitions [20];
- DSTU ISO/IEC 9126-1:2013 Software engineering – Product Quality – Part 1: Quality model [21];
- DSTU ISO/IEC 25051:2016 Software engineering – Systems and Software Quality Requirements and Evaluation (SQuaRE) - Requirements for quality of Ready to Use Software Product (RUSP) and instructions for testing [22].

The following state standards related to software quality assessment are in force in Ukraine: DSTU 2844-94 [20], DSTU ISO/IEC 25010:2016 Systems and Software Engineering – Systems And Software Quality Requirements And Evaluation (SQuaRE) – System and software quality models [23].

To evaluate the IDLC quality the ISO/IEC 25010 standard [23] quality criteria are used. Among all quality criteria it is necessary to choose ones that meet the requirements for the IDLC formation as a software.

For building an IDLC quality model it is necessary to keep in mind:

- quality of educational materials;
- quality of staffing;
- quality of software and hardware support of the distance learning process (Fig. 1).

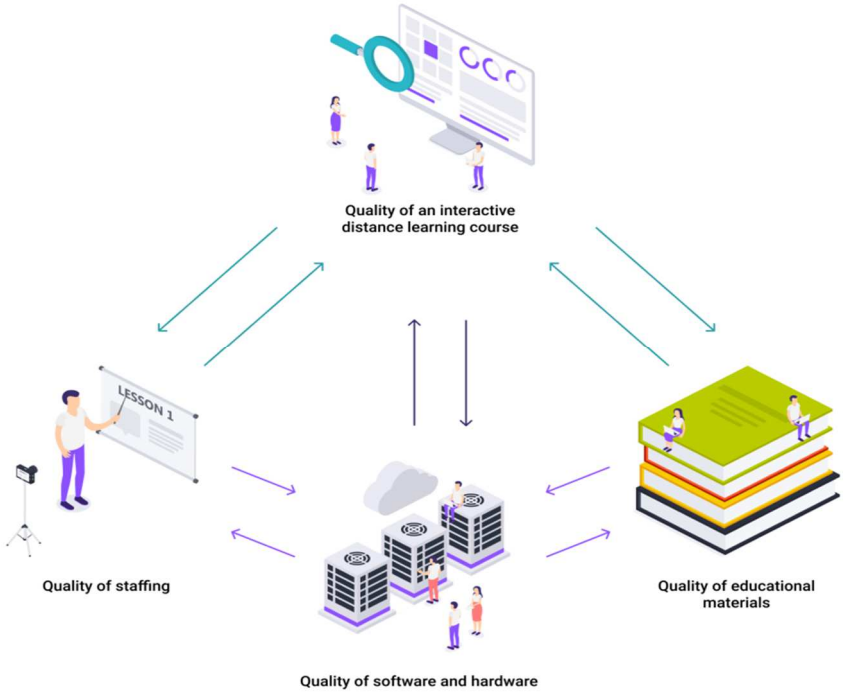

Fig. 1. IDLC Quality model

According to international standards, each of the quality categories describes properties as sets of attributes that can be represented both quantitatively and qualitatively. In the common case, the IDLC quality evaluation model can be provide as a cortege of functions defined by the relevant criteria:

$$\boldsymbol{Q_{IDS} = (Q_{SM}, Q_T, Q_S)}, \quad (1)$$

whereQ_{IDS} is the IDLC quality level;

Q_{SM} – quality level of educational materials;

Q_T – quality level of staffing;

Q_S – quality level of software and hardware support of the distance learning process.

The quality level of educational materials is usually represented by sets of attributes. In this case, each attribute must be matched to a metric to quantify the measure of the attribute. Therefore, to formalize the model of quality of educational materials, the basics of Set theory may be used:

$$Q_{SM} = \{H_i^{SM}, A_{ij}^{SM}, M_{ij}^{SM}\}, \quad (2)$$

where H_i^{SM}– characteristics of the educational material quality, $i = \overline{1,n}$ – the number of characteristics of the educational material quality;

A_{ij}^{SM} – attribute of the educational material quality, $j = \overline{1,n}$ – the number of attributes of the educational material quality;

M_{ij}^{SM} – quality metrics of educational material.

In common case, the model of quality of educational materials is presented as:

$$Q_{SM} = \left(A_{i1}^{SM}, A_{i2}^{SM}, \dots, A_{in}^{SM}\right), \quad (3)$$

where A_{ij}^{SM} – attribute of the educational material quality;

$j = \overline{1,n}$ – the number of attributes of the educational material quality.

To evaluate the quality level of educational materials, the evaluation method of the course content in the educational and methodological academic disciplines support system at the Chernihiv Polytechnic National University [24] is used. This methodology was developed by the commission for teaching and methodological support of educational components web resources to assist in the practical application of quality criteria for its provision in the Moodle learning management system.

The methodology is intended for evaluation of only those courses that are taught or planned to be taught at the university in the framework of existing educational programs at all levels of higher education (Table 1).

Table 1 – Attributes, characteristics, methods of quality of educational material

№	Attribute of quality of educational material, (A_{ij}^{SM})	Metrics of the level of quality of educational material, (M_{ij}^{SM})
1.	Syllabus	0-5
2.	Education program	0-5
3.	Recommended resources	0-5
4.	Evaluation criteria	0-5
5.	Laboratory works, practical classes, seminars and other activities provided by the education program	0-20
6.	Theoretical materials	0-20
7.	Individual tasks provided by the education program	0-5
8.	Self-study	0-5
9.	Current control	0-15
10.	Final control	0-15
Total		0-100

So, for this case, the model of quality of educational materials will look like:

$$Q_{SM} = \left(A_{i1}^{SM}, A_{i2}^{SM}, \dots, A_{i10}^{SM}\right). \quad (4)$$

The level of quality of the component of staffing of distance learning is determined by a cortege of functions:

$$Q_T = (Q_{Ed}, Q_{Sc}, Q_M), \quad (5)$$

where Q_{Ed} – the level of quality of educational work;

Q_{Sc} – the level of quality of scientific work;

Q_M – the level of quality of methodical work.

To describe the software and hardware components, it is proposed to use the international standard for quality evaluation of software systems ISO/IEC 25010 [23]. In this case, for the mathematical description of models, it is proposed to use Set-theoretic Notation or Category theory approach [25].

Analysis of metrics that meet the criteria/subcriteria of software quality according to ISO/IEC 25010 shows the following ones are suitable for assessing the IDLC quality [26]:

1. Functional suitability:

1.1 Appropriateness;

1.2 Interoperability.

2. Usability:

2.1 Understandability;

2.2 Learnability.

The functionality of IDLC shows the compliance of the available information content of the educational component to the curriculum and the level of interaction of all educational process participants. Appropriateness is a measure of compliance of software product`s functions with the defined and predicted needs of users:

$$Q_{App} = \frac{N_{App}(Content)}{N_{App}(AllContent)} \to 1, \quad (6)$$

$N_{App}(Content)$– the number of elements in the set of information content of the *i*-th IDLC;

$N_{App}(Content)$– the number of all elements in the set of information content, which are provided by the curriculum for training students of the *i*-th IDLC, the function of the availability of appropriate information elements, which are provided by the relevant curriculum.

Interoperability – the mean displayed the degree a software product provides data exchange between a teacher and consumers of educational services:

$$Q_{In} = \frac{N_{In}(Content)}{N_{In}(AllContent)} \to 1, \quad (7)$$

$N_{In}(Content)$– the number of elements in the set of information content of the *i*-th IDLC, according to which consumers of educational services exchanged data with the teacher;

$N_{In}(AllContent)$ – the number of all elements in the set of information content of the *i*-th IDLC, which provides the data exchange.

The usefulness of the given information content shows how clear the presented material is for consumers of educational services and suitable for self-study.

Understandability is the degree to which a software product is user-friendly:

$$Q_{Un} = \frac{N_{Un}(Content)}{N_{Un}(AllContent)} \to 1, \quad (8)$$

$N_{Un}(Content)$ – the number of elements in the set of information content of the *i*-th IDLC, which are clear to consumers of educational services;

$N_{Un}(AllContent)$ – the number of all elements in the set of information content, which are provided by the curriculum for training students for the *i*-th IDLC. The number of elements in the set of clear information content of the distance course is determined by conducting control testing among consumers of educational services.

Learnability – the degree to which a software product allows self-study on provided content:

$$Q_L = \frac{N_L(Content)}{N_L(AllContent)} \to 1, \quad (9)$$

$N_L(Content)$ – the number of elements in the set of information content of the *i*-th discipline of distance learning, which the user may master on his/her own;

$N_L(Content)$ – the number of all topics of the *i*-th distance learning discipline.

The level of quality of software and hardware for distance learning is determined by a cortege of functions:

$$Q_S = (Q_{App}, Q_{In}, Q_{Un}, Q_L). \quad (10)$$

The level of staffing quality can be formally described using Set theory and the calculation of statistical indicators for the educational, scientific and methodological work of the course instructor.

Based on considered factors the basic equation for an IDLC quality level integrated indicator calculation is:

$$Q_{IDS} = w_{SM} \cdot Q_{SM} + w_T \cdot Q_T + w_S \cdot Q_S, \quad (11)$$

where w_i is the weight (significance) of the *i*-th factor.

When calculating the quantitative indicators are getting normalized. Calculation of the factors' significance carried out with the Saati method. The disadvantage of the Hierarchy Analysis method is the large amount of information given by experts. The method is most suitable for those cases where the main part of the data is based on the preferences of the decision maker in the process of choosing the best solution from a set of existing alternatives [27]. The numerical value of the integrated quality indicator of the IDLC system varies from 0 to 1. Based on its numerical value the IDLC can be in one of five states:

– critical quality level, $0 \leq Q_{IDS} < 0{,}4$;
– lower than the average quality level, $0{,}4 \leq Q_{IDS} < 0{,}55$;
– average quality level, $0{,}55 \leq Q_{IDS} < 0{,}7$;
– higher than average quality level, $0{,}7 \leq Q_{IDS} < 0{,}85$;
– high quality level, $0{,}85 \leq Q_{IDS} < 1{,}0$.

Fuzzy model for an interactive distance learning course quality evaluation. The following IDLC quality evaluation fuzzy model is proposed to speed up the quality monitoring of the HEIs distance learning system. This approach relies on a multidimensional expert evaluation.

The fuzzy IDLC quality level $\widetilde{\boldsymbol{Q}}_{\boldsymbol{IDS}}$ is evaluated by three group criteria:

$\tilde{Q}_{SM}$ – fuzzy quality level of educational materials;

$\tilde{Q}_{T}$ – fuzzy quality level of staffing;

$\tilde{Q}_{S}$ – fuzzy quality level of distance learning software and hardware.

Each of these criteria is crucial for making a positive or negative decision about the IDLC quality.

At the *First stage* a linguistic evaluation of the factors influencing the quality of the IDLC system will be conducted. Table 2 presents the general criteria hierarchy for the three group factors.

Table 2 – Criteria hierarchy for three group factors of IDLC fuzzy quality level ($\tilde{Q}_{IDS}$)

Aim	Criteria	Linguistic grade of the quality level
The level of quality of educational materials ($\tilde{Q}_{SM}$)	Syllabus	low, middle, high
	Education program	low, middle, high
	Recommended resources	low, middle, high
	Evaluation criteria	low, middle, high
	Laboratory works, practical classes, seminars and other activities provided by the education program	low, middle, high
	Theoretical materials	low, middle, high
	Individual tasks provided by the education program	low, middle, high
	Self-study	low, middle, high
	Current control	low, middle, high
	Final control	low, middle, high
The level of quality of staffing ($\tilde{Q}_{T}$)	Educational work	low, middle, high
	Scientific work	low, middle, high
	Methodical work	low, middle, high
The level of software and hardware quality component ($\tilde{Q}_{S}$)	Appropriateness	low, middle, high
	Interoperability	low, middle, high
	Understandability	low, middle, high
	Learnability	low, middle, high

At the *Second stage*, the expert quality evaluation of the IDLC in the context of three criteria is carried out. Each of the presented criteria has several subs; subcriteria also can have several levels of subs. It is important to take into account the different effects of subcriteria, i.e. their weight (significance). To formalize an expert knowledge (fuzziness of a linguistic variable) the set of membership functions is provided.

For factors influencing the IDLC quality level, the linguistic terms formalization is performed using a standard three-level fuzzy classifier for all variables, as shown in Table 3.

Table 3 – Three-level fuzzy classifier

Standard three-level classifier levels	$\tilde{Q}_{IDS}$ – term name
Low	$\tilde{Q}_{IDS}$ – 1
Middle	$\tilde{Q}_{IDS}$ – 2
High	$\tilde{Q}_{IDS}$ – 3

To construct the set of triangular membership functions, the set of parameters is determined and the results of classification on intervals are presented in Table 4.

Table 4 – Parameters of triangular membership functions

Term	Parameter		
	a	b	c
Low	–0.4	0	0.4
Middle	0.1	0.5	0.9
High	0.6	1	1.4

Analytically, this can be expressed as a formula (12):

$$f(x,a,b,c) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a < x \le b \\ \frac{c-x}{c-b}, & b < x \le c \\ 0, & c < x \end{cases} \quad (12)$$

or abbreviated:

$$f(x,a,b,c) = max\left(min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right), \quad (13)$$

where a, c set the points of intersection of the membership function with the abscissa axis; b – its peak.

The classification of the indicator level based on the standard three-level fuzzy classifier of triangular type is presented in Table 5.

Table 5 – Classification of the indicator level based on the standard three-level fuzzy classifier of triangular type

Value range x	Membership function		
	Low	Middle	High
$0 \le x < 0.1$	$1 - 2.5x$	0	0
$0.1 \le x < 0.4$	$1 - 2.5x$	$2.5x - 0.25$	0
$0.4 \le x < 0.5$	0	$2.5x - 0.25$	0
$0.5 \le x < 0.6$	0	$2.25 - 2.5x$	0
$0.6 \le x < 0.9$	0	$2.25 - 2.5x$	$2.5x - 1.5$
$0.9 \le x < 1$	0	0	$2.5x - 1.5$

The calculation of expert evaluation is proposed to be performed by the Hierarchy Analysis method. For each proposed group criterion, a hierarchy of criterion will be developed [27].

According to the calculation results, each IDLC will receive a score in the form of a fuzzy vector:

$$\tilde{Q}_{IDS} = (\tilde{Q}_{SM}, \tilde{Q}_T, \tilde{Q}_S). \quad (14)$$

At the *Third stage*, after the Hierarchy Analysis assessment, the scores are converted into linguistic grade, and the decision matrix based on previous scores (Table 6) forms decisions for the IDLC quality improvement.

Table 6 – An example of an IDLC quality decisions matrix

	Linguistic grade of the quality level			
	Training materials, $\tilde{Q}_{SM}$	Staffing, $\tilde{Q}_T$	Software and hardware, $\tilde{Q}_S$	IDLC, $\tilde{Q}_{IDS}$
1	High	High	High	High
2	High	High	Middle	High
3	High	High	Low	High
4	High	Middle	High	High
5	High	Middle	Middle	Middle
6	High	Middle	Low	Middle
7	High	Low	High	Middle
8	High	Low	Middle	Middle
9	High	Low	Low	Low
10	Middle	High	High	Middle
11	Middle	High	Middle	Middle
12	Middle	High	Low	Middle
13	Middle	Middle	High	Middle
14	Middle	Middle	Middle	Middle
15	Middle	Middle	Low	Middle
16	Middle	Low	High	Middle
17	Middle	Low	Middle	Middle
18	Middle	Low	Low	Low
19	Low	High	High	Low
20	Low	High	Middle	Low
21	Low	High	Low	Low
22	Low	Middle	High	Low
23	Low	Middle	Middle	Low
24	Low	Middle	Low	Low
25	Low	Low	High	Low
26	Low	Low	Middle	Low
27	Low	Low	Low	Low

At the *Fourth stage*, an integrated evaluation is carried out taking into account the main criteria weights:

$$Q_{IDS} = w_{SM} \cdot \tilde{Q}_{SM} + w_T \cdot \tilde{Q}_T + w_S \cdot \tilde{Q}_S, \quad (15)$$

where w_i – weight (significance) of the *i*-th factor;

$\tilde{Q}_{SM}, \tilde{Q}_T, \tilde{Q}_S$ – fuzzy grades of IDLC quality criteria;

An Automated "IDLC Quality Assessment" system. To implement the IDLC quality level model, an automated “IDLC Quality Assessment” system in Python has been developed.

The graphical interface is created with Figma online editor and consists of six tabs: "Expert assessment", "Factor assessment", "Quality level of training materials", "Quality level of staffing", "Quality level of distance learning software and hardware", "Level of quality of the distance learning system".

The "Expert Assessment" tab contains matrices of criteria pairwise comparisons and must be filled in by experts.

The next step is to calculate the criteria and subcriteria weights. Experts may rank criteria by moving them lower or higher relative to others.

The "Expert Assessment" and "Factor Assessment" tabs are shown in Fig. 2 and Fig. 3, respectively.

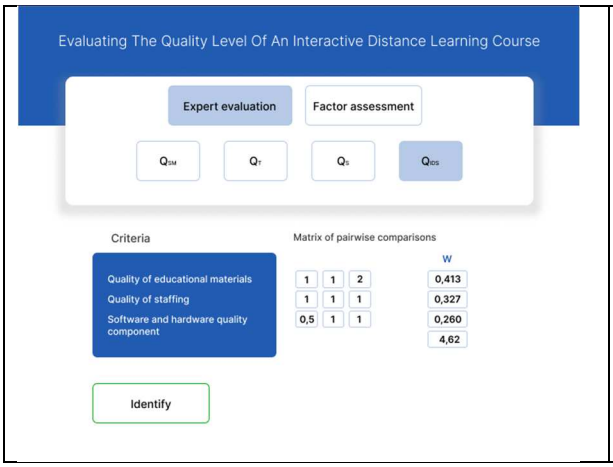

Fig. 2. "Expert Assessment" tab

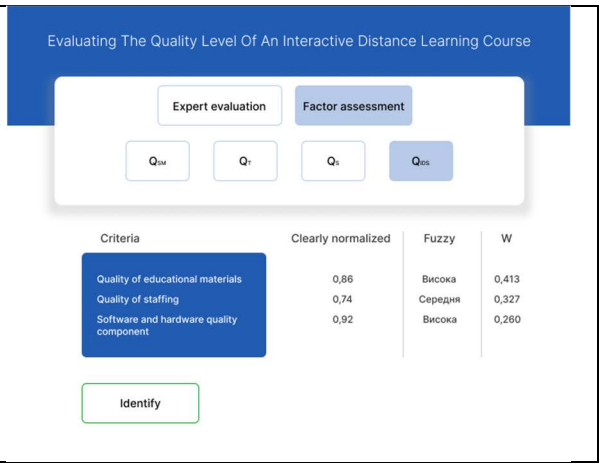

Fig. 3. "Factor Assessment" tab

After clicking the "Estimate factor" button and selecting the factors, the weights of the corresponding factors and empty fields for estimating the subfactors "Numeric normalized" and "Fuzzy", which are filled by the user, display on the screen. After clicking the "Define" button, next to the numerical value, a fuzzy grade of the IDLC quality level is displayed and decisions on improving the quality level of the educational component are displayed.

The field with decisions (conclusions and recommendations) is highlighted with color according to the fuzzy level: green – high, yellow – medium, red – low.

The experiment on IDLC quality level estimation for 10 educational components was carried out. For example, the "Web Technologies and Web Design" educational component IDLC quality level was studied. According to the evaluation, the quality level of the traditional course "Web Technologies and Web Design" for 2019 was equal to 0.54, which corresponds to an "Average quality level" fuzzy linguistic grade (Fig. 4). According to evaluation results, it was recommended to increase the quality of calculation and graphic works.

The quality level evaluation of the "Web technologies and web design" IDLC for 2020 is 0.84 and corresponds to the "High quality" fuzzy linguistic grade (Fig. 5). The system recommends improving the quality of methodical work.

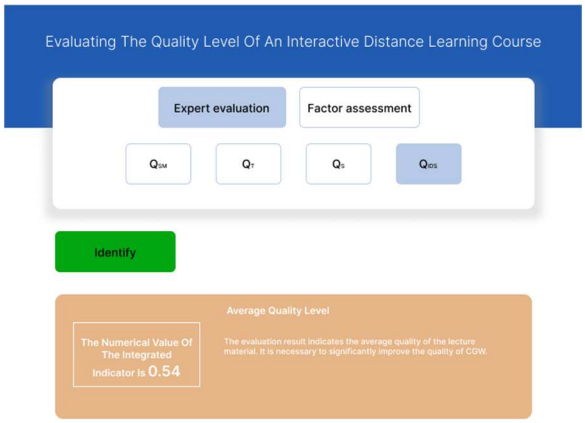

Fig. 4. Quality evaluation of "Web Technologies and Web Design" IDLC, 2019 (intermediate level)

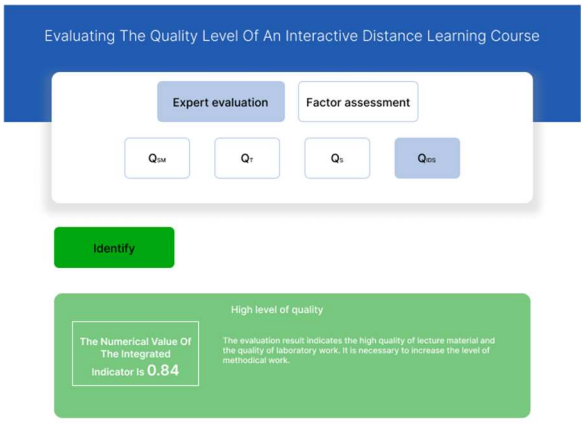

Fig. 5. Quality evaluation of "Web Technologies and Web Design" IDLC, 2020 (high level)

It's worse to mention that the fuzzy results correspond to a numerical IDNA quality level value. This leads to the possibility to use a fuzzy quality level evaluation for quick estimations.

Conclusions. The introduction of IDLC in the distance education system has significantly improved (30 %) the quality of the educational component "Web Technologies and Web Design", i.e. the system as a whole. This contributes to better training of higher education applicants and ensuring the quality of HEIs educational services. The implemented multicriteria model of IDLC quality evaluation includes the following criteria: the level of quality of educational materials; the level of staffing quality; the level of quality of software and hardware for distance learning. It is proposed to use both numerical (clear) and fuzzy interpretations. A comparative analysis of the differences between clear and fuzzy assessment of the 10 educational components showed that the fuzzy results correspond to a clear value of the IDLC quality level. Therefore, a fuzzy model can be used to speed up the educational courses quality monitoring.

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МОДЕЛЬ ОЦІНКИ ЯКОСТІ ІНТЕРАКТИВНОГО ДИСТАНЦІЙНОГО НАВЧАЛЬНОГО КУРСУ

Завдання оцінки якості навчальних курсів у дистанційній освіті з кожним роком стає дедалі актуальнішим. На жаль, в Україні поки що відсутні державні стандарти і методики для оцінки якості дистанційних курсів. Саме тому розробка критеріїв і методик, що дозволять вирішити цю проблему, є важливою та потрібною задачею.

На сьогодні якість наданих освітніх послуг навчання стала основним показником діяльності ЗВО. Вирішити ці актуальні проблеми можливо, на наш погляд, створюючи інтерактивні системи навчання (інтерактивні курси) та регулярно підвищуючи рівень якості навчального матеріалу в уже існуючих курсах. При цьому вирішення питання оцінки якості ІДНК становиться провідним у забезпеченні якості освітніх послуг ЗВО.

На даний час для оцінки якості дистанційного навчання використовуються різні моделі. Серед них: нейромережева модель на основі оптимізаційного підходу, модель на основі нечіткої аналітичної ієрархії (FAHP), модель, яка використовує формулу Байєса та багатокритеріальні методи прийняття рішень (MCDM) для визначення найкращого курсу. Для оцінки вагових коефіцієнтів критеріїв використовується метод нечіткого процесу аналітичної ієрархії (AHPF).

Головною проблемою є те, що у запропонованих моделях, що потребують невиправдано багато часу для їх реалізації, не враховані критерії, які є провідними чинниками організації інтерактивного навчання. Тому вони не можуть використовуватись для оцінки якості інтерактивних дистанційних навчальних курсів.

У роботі розглянута мультикритеріальна модель оцінки якості інтерактивного дистанційного навчального курсу, що включає такі критерії: рівень якості навчальних матеріалів; рівень якості кадрового забезпечення; рівень якості програмно-апаратного забезпечення дистанційного навчання. Запропонована як чітка (чисельна) так і нечітка інтерпретації. Розроблена автоматизована система «Оцінка якості ІДНК».

Порівняльний аналіз відмінностей чіткої і нечіткої оцінки показав, що нечіткі результати відповідають чіткому значенню рівня якості ІДНК. Тобто, для прискорення проведення моніторингу якості освітніх курсів можна користуватися нечіткою моделлю.

Ключові слова: *система дистанційного навчання; якість навчального курсу; нечітка модель якості.*
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