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Silvija Sėrikovienė

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RESEARCH ON APPLICATION OF LEARNING OBJECTS REUSABILITY AND QUALITY EVALUATION METHODS

Summary of Doctoral Dissertation
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Address: Akademijos st. 4, LT – 08663, Vilnius, Lithuania.

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A copy of the doctoral dissertation is available for review at the Library of Vilnius University.

General Characteristic of the Dissertation

Topicality of the problem

Learning Object (LO) is referred here as any digital resource that can be reused to support learning. LOs should be qualitative i.e. suitable for learning but at the same time they should fit reusability requirement. Therefore, reusability of LOs (or their ability to "travel well" between different contexts and education systems) is considered in the work as a part of the overall quality of LOs. This means that any high quality LO has some reusability level (or potential to "travel well"), but this does not mean that any reusable LO is qualitative one. Therefore, in the work, the problem of LOs quality is analysed paying special attention to LOs reusability aspects.

Qualitative learning material is one of the main factors of learning quality. Therefore, evaluation of LOs quality is one of the most relevant education problems. The problem is relevant for all participants of the educational sector – for educational institutions (e.g. schools) that have to select qualitative learning material for their needs, for education policy makers who need clear quality criteria while implementing LOs tenders, for authors of learning material (e.g. publishers) who need to know quality requirements to create LOs etc.

LOs creation is complicated, expensive, and time-consuming process. Therefore, small countries (e.g. Lithuania) have no possibilities to create a lot of LOs in Lithuanian language and fitting their education systems. Thus, it is very relevant for them to find LOs that could be applied for their learning goals in the other countries repositories. Such LOs are named reusable.

Currently, there are millions of LOs stored in international repositories. Majority of those LOs could be used many times in different countries and in different pedagogical situations. Those LOs could be easily modified, localised, and applied for particular educational context. Thus, reusable LOs are usually considerably cheaper (since they could be used in different systems and different pedagogical situations) and considerably qualitative (since a broad group of experts and practitioners can contribute to their refinement).

Therefore, evaluation of the quality of reusable LOs is a problem that should be solved constantly by each participants of educational sector. They should refer scientific LOs quality systems (i.e. models) and practically applicable (i.e. simple and effective) evaluation methods.

It is obvious that some LOs could be very qualitative against some quality criteria, and the others – against the other criteria, and vice versa.

Therefore, LOs quality evaluation is a typical case where one should apply multiple criteria decision analysis (MCDA) theory. In the work, MCDA principles are applied to create an objective rank of LOs alternatives according to their quality, and to evaluate each alternative‘s quality against „ideal“ quality. In the work, LOs reusability and quality criteria system (i.e. model) is presented, as well as created expert quality evaluation method based on fuzzy numbers theory.

Aim of the work – to propose and pilot LOs reusability and quality evaluation methodology, i.e., quality model, and simple and effective expert evaluation methods, thus improving solution of educational tasks using informatics engineering methods.

Tasks of the work

1. To analyse the notions of LOs reusability and expert evaluation of quality.
2. To analyse principles of creating LOs reusability and quality model.
3. To analyse possible simple and effective methods for the expert evaluation of LOs quality and reusability.
4. To create LOs quality and reusability model.
5. To create simple and effective expert evaluation method suitable for evaluating LOs quality and reusability.
6. To perform experimental piloting of the model and method (i.e. to introduce examples of practical evaluation of LOs alternatives).
7. To create an Internet tool for evaluating LOs quality and reusability.

Scientific novelty

- LOs quality and reusability model is created in conformity with scientific principles of creating the quality model.
- LOs quality and reusability evaluation methodology (i.e. LOs quality and reusability model and quality evaluation method) is presented and practically piloted. Quality evaluation methodology consists of consecutively applied methods, principles, and standards.

Methodology of research

Systematic Review method is used to fulfil literature analysis.

To create LOs quality model, MCDA theory based principles for creating a model as well as quality criteria division principle based on quality standard ISO/IEC 9126–1:2001(E), and sets portrait method are applied. There are identified those LOs quality criteria that mostly influence LOs reusability possibilities.

Expert evaluation based on numerical evaluation of LOs quality performed by selected experts is used for simple and effective evaluating LOs quality and reusability. The experts evaluate each criterion‘s weight and rating (value) according to selected linguistic variables system that is further converted to numerical values. Thus, fuzzy numbers method is selected, and scalarisation method is applied.

LOs reusability level is evaluating by providing higher weights to LOs quality criteria that mostly influence LOs reusability possibilities. For this purpose, evaluation methodology based on scalarisation and fuzzy numbers theory is created and piloted.

The fact that many experts having their own opinions and creeds participate in decision making is also taken into account. Thus, several problems arise:

1. how to present in numerical way the experts‘ opinion on LOs alternatives quality criteria importance;
2. how to compare the experts ratings (values);
3. how to make a decision based on those ratings (values) and weights.

In the work, these problems are solved with the help of fuzzy numbers theory. The first problem is solved using fuzzy numbers (i.e. linguistic variables are converted to numerical variables), the second is solved by verification of the experts‘ evaluation compatibility, and the third – by using the experts‘ utility function (i.e. scalarisation method) which value gives the possibility to evaluate the results obtained.

Practical value

Practical value of the work results suitability of LOs quality and reusability model and evaluation method created and piloted during the research for all participants of educational sector – educational institutions, education policy makers, creators of learning material – for solving cheap and qualitative learning material selection, creation, and application problems.

Work results were tested:

- on European level – during eQNet project: LOs reusability criteria were created;
- on Lithuanian level – during the tender announced by Education development Centre under the Ministry of Education and Science: textbooks / digital teaching aids quality model and evaluation methods were created.

Defended propositions

- Created LOs quality and reusability models conform with scientific principles for creating a quality model.
- Created LOs expert evaluation method based on fuzzy numbers theory and scalarisation method is simple and effective i.e. suitable and applicable in educational institutions while evaluating LOs quality and reusability.

The scope of the scientific work. The scientific work consists of the General Characteristic of the Dissertation, 4 Chapters, Conclusions, List of literature, and Appendixes. The total scope of the dissertation is 120 pages, 27 pictures, and 21 tables.

Learning Objects and Reusability

Learning objects are the elements of a new type of computer-based instruction grounded in the object-oriented paradigm of computer science. Object-orientation highly values the creation of components (called “objects”) that can be reused in multiple contexts. This is the fundamental idea behind LOs: instructional designers can build small (relative to the size of an entire course) instructional components that can be reused a number of times in different learning contexts.

Additionally, LOs are generally understood to be digital entities deliverable over the Internet and any number of people can access and use them simultaneously. Moreover, those who incorporate LOs can collaborate on and benefit immediately from the new versions.

When teachers first gain access to the instructional materials, they often break the materials down into their constituent parts. They then reassemble these parts in the ways that support their individual instructional goals. This suggests one reason why reusable instructional components (i.e. LOs) may provide instructional benefits: if instructors received the instructional resources as the individual components, this initial step of decomposition could be bypassed, potentially increasing the speed and efficiency of instructional development.

Examples of LOs can include multimedia content, instructional content, learning objectives, instructional software and software tools, as well as persons, organizations or events referenced during technology supported learning.

The various approaches to LOs attempt to meet two common objectives: (1) to reduce the overall costs of LOs, and (2) to obtain better LOs.

Both these objectives agree with the notion of LOs reusability. LOs reusability is one of the main features achieving the high LOs effectiveness and efficiency level. The need for reusability of LOs has at least three elements:

Table 1. Basic principles of LOs reusability

Principles	Explanation
Interoperability	LO is interoperable and can be used in different repositories and platforms
Flexibility in terms of pedagogic situations	LO can fit into a variety of pedagogic situations
Modifiability to suit a particular teacher's or student's needs	LO can be made more appropriate to a pedagogic situation by modifying it to suit a particular teacher's or student's needs

Overview of Existing Learning Objects Quality Criteria

There is a wide range of LOs quality criteria presented in scientific literature as well as a wide range of nationally recognised LOs quality criteria which reflect different subjective approaches of European countries' national authorities based on their experience and national education culture. Most of these quality criteria deal with technological, pedagogical and intellectual property rights (IPR) issues (Table 2). There are a number of limitations in all of these models. Some of the presented frameworks deal with the overall groups of LOs quality evaluation criteria, and some of them present the brief descriptions of the criteria containing the different attributes of the criteria that can be considered sub-criteria. Many presented criteria overlap and depend one from another. There are the cases where the different criteria measure the same factor.

Almost all of the presented approaches lack completeness or conciseness. Several frameworks (e.g. [LN07]) propose the experts some kind of numeric values for evaluation of LOs quality, and some of them operate with linguistic

variables. In the majority of literature, no weights of quality criteria are proposed to use by the experts in order to express their opinion on the criterion's importance level in comparison with the other criteria for the particular needs. Finally, it is completely unclear how to measure the difference between the quality of the particular LO under judgement, and the highest, i.e., 'ideal' LO quality. On the other hand, the majority of the stakeholders would like to see the evaluation results reflecting the percentage of quality that meets the particular LO in comparison with the 'ideal'. Therefore, the evaluation of LOs in the real life situations is often inaccurate and highly depends on the experts' subjectivity level.

All these shortages lead us to the conclusion that some kind of scientific approaches are necessary to be applied in LOs quality evaluation in order to maximise the accuracy of the evaluation results and to minimise the experts' subjectivity. Those applicable scientific approaches are MCDA principles proposed by [BS02] and technological quality division principle proposed by [GC06].

European nationally recognised (i.e., approved on the national level) LOs quality criteria have been analysed by [KD09]. The analysis has shown that nationally recognised LOs quality criteria are often divided into several criteria groups such as Scope and Quality criteria (e.g., in Belgium – Flanders), different domains such as Technical, Scientific, Educational, Language, and Values and Attitudes (e.g., in Portugal), and different levels such as National and Local / partner level (e.g., in Switzerland). It has been also identified that almost all nationally recognised sets of criteria include Technological, Pedagogical and IPR quality criteria.

Table 2: Overview of existing LOs quality criteria

LOs quality criteria	Authors
Model on LOs technological quality is based on six areas: (1) Definition of what is, and what is not a LO. (2) A taxonomy that is reflected in the definition where granularities as well as special properties are regarded. (3) Standards used for LOs should be extended to go beyond descriptive information, such as metadata, sequencing, and packaging to also embrace standards for interfaces, 'machine readable' descriptions of technical properties and interaction interfaces. (4) Standards and recommendations that address the internal use of data formats and data structure. (5) The architecture of LOs should be layered as a part of best practice, in order to separate data, presentation and application logics. (6) Pedagogy should preferably be kept outside the LOs in order to facilitate pedagogical context independence.	[PN06]
Learning Object Review Instrument (LORI) model: (1) Presentation: Aesthetics; (2) Presentation: Design for learning; (3) Accuracy of content; (4) Support for learning goals; (5) Motivation; (6) Interaction: Usability; (7) Interaction: (8) Feedback and adaptation; (9) Reusability; (10) Metadata and interoperability compliance; (11) Accessibility.	[VNB03]
(1) Content quality: veracity, accuracy, balanced presentation of ideas, and appropriate level of detail. (2) Learning goal alignment: alignment	[LN07]

among learning goals, activities, assessments, and learner characteristics. (3) Feedback and adaptation (adaptive content or feedback driven by differential learner input or learner modelling). (4) Motivation (ability to motivate and interest an identified population of learners). (5) Presentation design (design of visual and auditory information for enhanced learning and efficient mental processing). (6) Interaction usability (ease of navigation, predictability of the user interface, and the quality of the interface help features). (7) Accessibility (design of controls and presentation formats to accommodate disabled and mobile learners). (8) Reusability (ability to use in varying learning contexts and with learners from different backgrounds). (9) Standards compliance (adherence to international standards and specifications).	
BECTA model is based on 16 principles: Core pedagogic principles: (1) Inclusion and access; (2) Learner engagement; (3) Effective learning; (4) Assessment to support learning; (5) Robust summative assessment; (6) Innovative approaches; (7) Ease of use; (8) Match to the curriculum. Core design principles: (9) Digital learning resource design; (10) Robustness and support; (11) Human-computer interaction; (12) Quality of assets; (13) Accessibility; (14) Interoperability; (15) Testing and verification; (16) Effective communication.	[Bec07]
MELT model is based on five categories: (1) Pedagogical; (2) Usability; (3) Reusability; (4) Accessibility; (5) Production.	[MEL08]
'Quality for Reuse' model is based on three strategies: (a) Strategies before LO inclusion in the LOR are based on the principles: (1) Only build or integrate LOs, which can be certified for quality; (2) Interactive LOs are software and as such should answer to software quality criteria. (b) Strategies during LO inclusion in the LOR are based on (1) The principle of reducing form-filling; and (2) Use of guiding wizards, smart automatic and semi-automatic computer agents to assist in assuring technical interoperability. (c) Strategies after LO inclusion in the LOR are based on (1) Provide interesting and easily understood user statistics, such as stars, percentages, voting systems, and (2) Include recommendations for reuse by the user, both to the next user and the designer.	[Q4R08]

Methodology for Expert Evaluation of Learning Objects Quality

Proposed Quality Model

In order to create comprehensive LOs quality model, first of all MCDA principles for identifying quality criteria are applicable. According to [BS02], in identifying quality criteria for the decision analysis, the following considerations (principles) are relevant to all multiple criteria decision analysis approaches: Value relevance, Understandability, Measurability, Non-redundancy, Judgmental independence, Balancing completeness and conciseness, Operationality, Simplicity versus complexity.

LOs quality model created according to MCDA criteria identification principles is presented in the Table 3. This model includes three groups of criteria: (1) technological, (2) pedagogical and (3) IPR criteria. The model consists of 9 quality criteria, 4 of them dealing with technological quality, 4 – with pedagogical quality of LOs, and 1 – with IPR issues.

According to the technological quality criteria division principle, technological criteria are divided into two groups, namely 'internal quality' and 'quality in use' criteria.

Table 3. Learning objects quality model

Criteria group	Nr.	Quality criteria
Technological criteria		
"Internal" quality	1	Interoperability
	2	Architecture
	3	Interactivity
Quality "in use"	4	Design and usability: aesthetics, navigation, user-friendly interface and information structure, personalisation
Pedagogical criteria		
LO relevance to educate basic subject competences criteria:		
	5	LO textual and visual material are suitable to acquire knowledge, and to educate understanding, skills and values defined in the curriculum
	6	Assignments provided in LO are suitable to acquire knowledge, and to educate understanding, skills and values defined in the curriculum
	7	LO methodological structure is suitable to acquire knowledge, and to educate understanding, skills and values defined in the curriculum
Criterion of LO material suitability to educate general competences defined in the curriculum:		
	8	LO textual and visual material, assignments and methodological structure suitability to educate general competences
IPR criterion		
	9	Clear license: LO is open, free to use, and cost-effective

Sets portrait method was applied to identify which LO quality criteria mostly influence LO reusability level, and it was estimated that LO reusability level mostly depends on the 1st, 2nd , 3rd , and 4th LO quality criteria presented in Table 3.

Learning Objects Quality Evaluation Method

Performed Analytic Review has not indentified any existing simple and effective method suitable for evaluating LOs quality and reusability.

Analytic Review has also shown that fuzzy numbers and scalarisation methods are applicable for LOs quality and reusability evaluation in terms of its simplicity and effectiveness. Scalarisation method is referred here as the experts' additive utility function represented by the formula (1). According to this method, a possible decision here could be to transform a multi-criteria task into one-criterion task obtained by adding all the criteria ratings (values) together with their weights.

$$f(X) = \sum_{i=1}^{m} a_i f_i(X) \ , \ \sum_{i=1}^{m} a_i = 1, \ a_i > 0. \qquad (1)$$

Here $f_i(X)$ is the rating (i.e. non-fuzzy value) of the criterion i for the each of the examined LOs alternatives X_j, and a_i are the weights of the quality criteria.

Thus, according to scalarisation method, one needs to know LOs quality criteria ratings (values) and weights to evaluate quality and reusability of LOs

Estimation of Learning Objects Quality Criteria Ratings (Values)

The widely used measurement criteria of the decision attributes' quality are mainly qualitative and subjective. Decisions in this context are often expressed in natural language, and evaluators are unable to assign exact numerical values to the different criteria. Assessment can be often performed by linguistic variables: 'bad', 'poor', 'fair', 'good' and 'excellent'. These values are imprecise and uncertain: they are commonly called 'fuzzy values'. Integrating these different judgments to obtain a final evaluation is not evident.

Therefore, the author has proposed to use fuzzy group decision making theory [OJB09] to obtain final assessment measures. The fuzzy numbers are: (1) triangular fuzzy numbers, (2) trapezoidal fuzzy numbers, and (3) bell-shaped fuzzy numbers. In the presented work, the author uses triangular and trapezoidal fuzzy numbers for evaluating quality and reusability of LOs.

Use of Triangular Fuzzy Numbers

According to scalarisation method represented by the formula (1), we need LOs evaluation criteria ratings (values) and weights.

The widely used measurement criteria of the decision attributes' quality are mainly qualitative and subjective. Decisions in this context are often expressed in natural language, and evaluators are unable to assign exact numerical values to the different criteria. Assessment can be often performed by linguistic variables: 'bad', 'poor', 'fair', 'good' and 'excellent'. These values are imprecise and uncertain: they are commonly called fuzzy values. Integrating these different judgments to obtain a final evaluation is not evident. Therefore, [OJB09] propose to use fuzzy group decision making theory to obtain final assessment measures, with the non-fuzzy values for all aforementioned linguistic variables. Linguistic variables conversion into triangle or non-fuzzy values

According to [ZC92], triangular fuzzy numbers are a class of the fuzzy set representation. A triangular fuzzy number is expressed by three real numbers $M = (l, m, u)$; the parameters l, m and u, respectively, indicate the lower, the mean and the upper possible values. Triangular fuzzy numbers membership functions are as follows:

$$\mu_M(x) = \begin{cases} \dfrac{x-l}{m-l}, & if \quad x \in [l, m], \\ \dfrac{x-u}{m-u}, & if \quad x \in [m, u], \\ 0, & if \quad x \notin [l, u]. \end{cases} \tag{2}$$

Conversion of these qualitative values into fuzzy numbers is shown in Table 4.

Table 4. Linguistic variables conversion into triangular fuzzy numbers

Linguistic variables	Triangular fuzzy numbers
Excellent	(0.700, 0.850, 1.000)
Good	(0.525, 0.675, 0.825)
Fair	(0.350, 0.500, 0.650)
Poor	(0.175, 0.325, 0.475)
Bad	(0.000, 0.150, 0.300)

Therefore, in the case of using average triangular fuzzy numbers, linguistic variables conversion into non-fuzzy values of the evaluation criteria should be as follows: 'excellent'=0.850; 'good'=0.675; 'fair'=0.500; 'poor'=0.325; and 'bad'=0.150.

Use of trapezoidal fuzzy numbers

A trapezoidal fuzzy number is a fuzzy number represented by four points as follows: $M = (a, b, c, d)$. In this case, a membership function can be attached to the level fuzzy function (3):

$$\mu_M(x) = \begin{cases} 0, & if \quad x < a, \\ \dfrac{x-a}{b-a} & if \quad a \le x \le b, \\ 1, & if \quad b \le x \le c, \\ \dfrac{d-x}{d-c} & if \quad c \le x \le d, \\ 0, & if \quad x > d. \end{cases} \tag{3}$$

Conversion of these qualitative values into fuzzy numbers is shown in Table 5.

Table 5. Linguistic variables conversion into trapezoidal fuzzy numbers

Linguistic variables	Trapezoidal fuzzy numbers
Excellent	(0.800, 1.000, 1.000, 1.000)
Good	(0.600, 0.800, 0.800, 1.000)
Fair	(0.300, 0.500, 0.500, 0.700)
Poor	(0.000, 0.200, 0.200, 0.400)
Bad	(0.000, 0.000, 0.000, 0.200)

Therefore, in the case of using secondary trapezoidal fuzzy numbers, linguistic variables conversion into non-fuzzy values of the evaluation criteria should be as follows: 'excellent'=1.000; 'good'=0.800; 'fair'=0.500; 'poor'=0.200; and 'bad'=0.000.

Experts Evaluation Compatibility Check

One more problem for such multiple criteria evaluation tasks is minimisation of the experts' (decision makers') subjectivity. The experts' subjectivity can influence the quality criteria ratings (values) and their weights.

There are some scientific approaches concerning this item. One of them is formulated in [Ken79]. According to [Ken79], in general, the experts influence importance is different, and therefore this importance should be assessed using the appropriate methodology. It is important to form the experts group purely by their competence. Furthermore, we should eliminate the extreme experts' assessments of the criteria ratings and weights. In order to pursue the compatibility of the experts' assessments we should calculate so-called concordance rates W and distributions λ^2:

$$W = \frac{12S}{r^2(m^3 - m)} \tag{4}$$

where r – the number of experts; m – the number of the parameters under evaluation; S – the square sum of evaluated importance rates' values deviations from the experts' aggregate average.

In its turn,

$$\lambda^2 = Wr(m-1) = \frac{12S}{rm(m+1)} .$$

If the experts' opinions are compatible, the value of the concordance rate W is close to 1, and if their opinions are very different, the value of W is close to 0. The compatibility of the experts' assessments is considered sufficient if the value of concordance rate W is 0.6–0.7.

Estimation of the Weights of Learning Objects Quality Criteria

The weights of LOs quality criteria could be selected by the experts. If we have e.g. r experts and n criteria, the expert k can point the importance (i.e. weight) of the criterion j. There are two possible ways to evaluate the importance (weight) of the particular criterion. They are:

1. The expert k should point the importance of the criterion j by fuzzy number $M_k^j = \left(l_k^j, m_k^j, u_k^j\right)$. Here m_k^j is the main value, while l_k^j and u_k^j reflect the experts' uncertainty.

2. The expert k should point the importance of the criterion j by the only number m_k^j from the particular interval.

If there are r experts, each criterion's importance (weight) is calculated as the average of the experts' values [Upp89] as follows:

$$m_f^i = \frac{1}{t}\sum_{k=1}^{r} m_k^i \tag{5}$$

The weights are normalised according to formula (6):

$$a_i = \frac{m_f^i}{\sum_{s=1}^{r} m_f^s} \tag{6}$$

Thus, $\sum_{i=1}^{n} a_i = 1$.

Calculation of Values of the Alternatives and Decision Making

After estimating the ratings (values) and weights of LOs quality criteria, one should apply the experts' additive utility function (1), i.e. add together all LOs quality criteria ratings (values) multiplied by their weights. The major is the meaning of the experts' additive utility function (1) the better LOs meet the quality requirements in comparison with the ideal (100%) quality.

The weight of the evaluation criterion reflects the experts' opinion on the criterion's importance level in comparison with the other criteria for the particular needs. In our case, higher weights are estimated for those quality criteria that mostly influence LOs reusability level (i.e. criteria 1 – 4 in Table 3). The weights are estimated according to formulas 5 – 6.

Examples

Application of LOs quality and reusability MO evaluation method: use of triangle and trapezoidal fuzzy numbers to estimate importance of the groups of LOs reusability criteria.

The method is used to evaluate the importance of the groups of criteria of the following Math learning objects:

- LO_1: „Tangents through an external point“ (available at: http://www.mathopenref.com/consttangents.html);
- LO_2: „Tangent to a circle at a point“ (available at: http://www.mathopenref.com/consttangent.html);
- LO_3: „Secant“ (available at: http://www.mathopenref.com/secant.html).

Table 6. Evaluation of the importance of the groups of criteria of Math LOs by 3 experts

	LO_1				LO_2			LO_3		
Expert Nr. / Criterion Nr.	1	2	3	Sum	1	2	3	1	2	3
1	5	3	3	**11**	4	4	4	5	5	5
2	5	4	4	**13**	4	4	4	5	5	5
3	4	3	3	**10**	5	5	4	5	5	5
4	4	4	4	**12**	4	4	4	5	4	4
5	4	5	4	**13**	5	5	4	5	5	5
6	5	5	5	**15**	5	4	4	3	4	4
7	4	4	4	**12**	5	4	5	4	3	3
8	3	4	4	**11**	4	4	4	4	4	3
9	5	5	5	**15**	5	5	5	5	5	5
			Total sum:	**112**						

In eQNet, the experts evaluated selected LOs quality criteria groups importance in per cent paying special attention to LOs reusability criteria "Interoperability", "Architecture", "Interactivity" and "Design and User Interface":

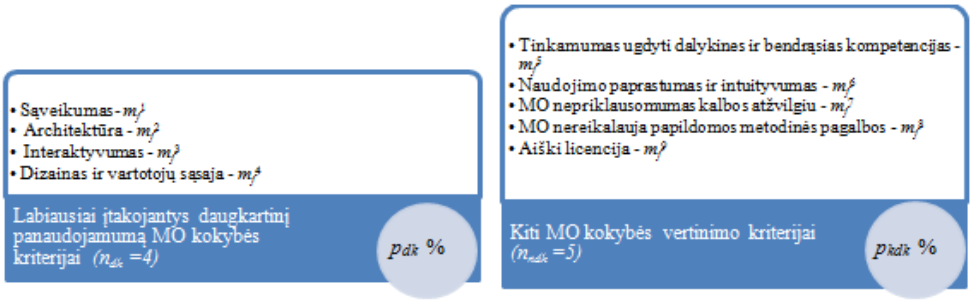

Fig. 1. Expert evaluation of importance of LOs criteria groups in eQNet

After that, the value of the most important criteria is increased by $\frac{p_{dk}}{n_{dk}}$, and the value of the others – by $\frac{p_{kdk}}{n_{kdk}}$ part of the per cent:

$$\left(m_f^{1,2,3,4} = \frac{1}{t}\sum_{k=1}^{t}\left(m_k^i + m_k^i \cdot \frac{p_{dk}}{n_{dk}} \right), \text{ and } \; m_f^{5,6,7,8,9} = \frac{1}{t}\sum_{k=1}^{t}\left(m_k^i + m_k^i \cdot \frac{p_{kdk}}{n_{kdk}} \right) \right) \tag{7}$$

LOs quality criteria importance established by 3 eQNet experts in per cent is presented in Table 7:

Table 7. LOs quality criteria importance values in per cent

Experts Nr. / *Criteria groups*	*1*	*2*	*3*	*Experts Nr.* / *Quality criteria*	*1*	*2*	*3*
Criteria most important for LOs reusability	*80%*	*60%*	*70%*	- Interoperability	5	4	4
				- Architecture	4	4	4
				- Interactivity	4	4	5
				- Design and User Interface	3	3	3
Other LOs quality criteria	*20%*	*40%*	*30%*	- LO suitability to educate subject and general competences defined in the curriculum	5	5	4
				- Simplicity and intuitiveness in use	4	4	4
				- Independence in terms of language	5	5	5
				- Additional methodological support is not needed	5	5	5
				- Clear licence	5	5	5

Using triangle fuzzy numbers (Table 4) and criteria importance level (Table 7), one should obtain the matrix of LOs quality criteria weights A_{dk_trik}:

$$A_{dk\_trik} = (0{,}1170 \quad 0{,}1077 \quad 0{,}1170 \quad 0{,}0798 \quad 0{,}1140 \quad 0{,}0972 \quad 0{,}1224 \quad 0{,}1224 \quad 0{,}1224) \tag{8}$$

Using triangle fuzzy numbers (Table 5) and criteria importance level (Table 7), one should obtain the matrix of LOs quality criteria weights A_{dk_trap}:

$$A_{dk\_trap} = (0{,}1187 \quad 0{,}1095 \quad 0{,}1187 \quad 0{,}0685 \quad 0{,}1153 \quad 0{,}0988 \quad 0{,}1235 \quad 0{,}1235 \quad 0{,}1235) \tag{9}$$

Let us multiply the values of those matrixes by LO_1, LO_2, and LO_3 criteria ratings established by the experts (Formula 10).

The result functions using triangle and trapezoidal fuzy numbers are presented accordingly in Formulas 11 and 12.

$$f(x_{ij}) = \begin{pmatrix} 0{,}6167 & 0{,}6750 & 0{,}8500 \\ 0{,}7333 & 0{,}6750 & 0{,}8500 \\ 0{,}5583 & 0{,}7917 & 0{,}8500 \\ 0{,}6750 & 0{,}6750 & 0{,}7333 \\ 0{,}7333 & 0{,}7917 & 0{,}8500 \\ 0{,}8500 & 0{,}7333 & 0{,}6167 \\ 0{,}6750 & 0{,}7917 & 0{,}5583 \\ 0{,}6167 & 0{,}8500 & 0{,}6167 \\ 0{,}8500 & 0{,}8500 & 0{,}8500 \end{pmatrix} \quad (10)$$

$$A_{dk\_trik} \cdot f(x_{ij}) = (0{,}5896 \quad 0{,}6405 \quad 0{,}6565) \quad (1)$$

$$A_{dk\_trap} \cdot f(x_{ij}) = (0{,}5899 \quad 0{,}6453 \quad 0{,}6602) \quad (12)$$

LOs reusability level evaluation results (Matrix 11) show that LO_1 matches *58,96%* quality level in comparison with the „ideal", LO_2 *– 64,05%,* and MO_3 *– 65,65%.* Matrix 13 results show that LO_1 matches *58,99%* quality level in comparison with the „ideal", LO_2 *– 64,53%,* and LO_3 *– 66,02%,*. Therefore, LO_3 is the best alternative in terms of selected LOs reusability.

These results also show that LO_3 is the best evaluated alternative in terms of reusability using both triangle and trapezoidal fuzzy numbers.

General Conclusions

Using Systematic Review of scientific literature method, it was not managed to find neither suitable LOs quality and reusability model nor evaluation method. Therefore it was necessary to create both model matching scientific principles of creating a model as well as simply and effective evaluation method.

LOs reusability is one of the main features of LOs quality, i.e. each LO has some reusability level but not each reusable LO is qualitative one. Therefore, in the work, the problem of LOs quality is analysed paying special attention to LOs reusability aspects.

Education institutions have to often deal with LOs quality and reusability problems. In practice, educational institutions deal with (a) finite but (b) wide choice of LOs. Therefore, we have to analyse (a) vector optimisation methods, and (b) fuzzy numbers method. The reason is that both Pareto and paired comparison methods are obviously hardly applicable for the aim of the research in terms of simplicity and effectiveness of the evaluation methodology applied.

In the work, evaluation methodology for evaluating quality and reusability of LOs i.e. both created model and method are presented.

The LOs quality model created consists of 9 quality criteria divided into 3 groups i.e. technological, pedagogical, and IPR criteria. This model is comprehensive and matches scientific principles of creating a model.

LOs quality and reusability model is created having in mind MCDA principles of creating a model i.e Value relevance, Understandability, Measurability, Non-redundancy, Judgmental independence, Balancing completeness and conciseness, Operationality, Simplicity versus complexity.

While creating a model, requirements of software quality standard ISO/IEC 9126–1:2001(E) have been taken into account incl. technological criteria division principle.

LOs reusability is mostly influenced by the following LOs quality criteria: Interoperability, Architecture, Interactivity, and Design and User Interface.

Following methods are selected and consecutively applied in the research while evaluating LOs quality and reusability level:

– Scalarisation. The experts' additive utility function is used, i.e. the sum of all criteria ratings (values) multiplied by their weights.

– The experts' opinions on importance of LOs reusability criteria is converted into numerical information using fuzzy numbers theory principles (both triangle and trapezoidal).

– Before MCDA calculations, the experts' evaluation compatibility is checked, i.e. concordance rates are calculated.

– The results obtained while applying the experts' additive utility function are compared in terms of LOs alternatives general quality and reusability level.

The method for estimating final weights of LOs quality and reusability criteria using fuzzy numbers is newly created and practically applied in the research.

LOs expert evaluation method created based on fuzzy numbers and scalarisation methods is simply and effective while evaluating LOs alternatives in the market or creating qualitative LOs. The method created is suitable and practically applicable in education institutions for evaluating LOs quality and reusability.

LOs quality and reusability evaluation method was created by improving scalarisation and fuzzy numbers methods. To evaluate LOs reusability level, higher weights of reusability criteria in the model were applied.

In the work, different examples of the model and evaluation method application are provided i.e. while selecting quality criteria weights, calculating those weights, applying triangle and trapezoidal fuzzy numbers, and creating PHP internet evaluation tool.

LOs quality and reusability evaluation results are similar in terms of using both triangle and trapezoidal fuzzy numbers. Application of trapezoidal fuzzy numbers shows a slightly larger difference in per cent while comparing final LOs evaluation results.

In order to practically evaluate LOs quality and reusability, internet tool was created PHP language (available at: http://www.kompiuteriams.com/upc_vert/). The tool presents LOs quality model, and all the calculations are performed automatically according to proposed method using trapezoidal fuzzy numbers.

Thus, the evidence of the work's scientific novelty is provided by the fact that simple and effective LOs quality and reusability evaluation methodology was created and piloted on the large scale for the first time. The methodology consists of LOs quality and reusability model and evaluation method.

List of Published Works on the Topic of the Dissertation

The main results of the thesis were presented and approved at the following conferences:

1. *„The 15th Conference of Lithuanian Computer Society "Computer Days – 2011""*, September 22–24, 2011, Klaipėda, Lithuania;
2. *„The 9th European Conference on e-Learning (ECEL 2010)",* November 4–5, 2010, Porto, Portugal (the best paper award, extended version is published in scientific journal *Electronic Journal of e-Learning*);
3. *„The 3rd World Summit on the Knowledge Society (WSKS 2010)",* September 22–24, 2010, Corfu, Greece (the best paper award, extended version is published in scientific journal *International Journal of Engineering Education*);
4. *„The 51th Conference of Lithuanian Mathematicians Society"*, June 17–18, 2010, Šiauliai, Lithuania;
5. *„The 4th International Conference on Informatics in Secondary Schools: Evolution and Perspectives (ISSEP 2010)",* January 13–16, 2010, Zurich, Austria;
6. *„The 5th International Conference on Sustainable Development "Knowledge-Based Technologies and OR methodologies for Strategic Decisions of Sustainable Development" (KORSD 2009)",* September 30 – October 3, 2009, Vilnius, Lithuania.

In the reviewed scientific periodical publications (Web of Science)

1. Kurilovas, E.; Serikoviene, S. (2012). New TFN Based Method for Evaluating Quality and Reusability of Learning Objects. *International Journal of Engineering Education*, Vol. 28, Issue 6, 2012, pp. 1288–1293. ISSN 0949-149X

In the reviewed scientific periodical publications

2. Kurilovas, E.; Vinogradova, I.; Serikoviene, S. (2011). Application of Multiple Criteria Decision Analysis and Optimisation Methods in Evaluation of Quality of Learning Objects. *International Journal of Online Pedagogy and Course Design*, October–December 2011, Vol. 1, Issue 4, pp. 62–76. *IGI Publishing, USA*. ISSN 2155–6873
3. Kurilovas, E.; Bireniene, V.; Serikoviene, S. (2011). Methodology for Evaluating Quality and Reusability of Learning Objects. *Electronic Journal of e-Learning,* Vol. 9, Issue 1, 2011, pp. 39–51. *Academic Publishing, UK*. ISSN 1479–4403
4. Sėrikovienė, S.; Kurilovas, E. (2010). Evaluation of Reusability and Quality of Mathematics Learning Objects in eQNet Project (Matematikos mokymosi objektų daugkartinio panaudojamumo kokybės vertinimas eQNet projekte). *Lietuvos matematikos rinkinys. Lietuvos matematikų draugijos darbai.* Volume 51, pp. 319–324. ISSN 0132–2818
5. Kurilovas, E.; Serikoviene, S. (2010). Application of Top-Down Approach for Evaluation of Quality of Learning Objects. In: *M.D. Lytras et al. (Eds.): WSKS 2010, Part I, Communications in Computer and Information Science (CCIS) 111*, pp. 437–443. *Springer, Heidelberg* (2010). ISSN 1865–0929

6. Kurilovas, E.; Serikoviene, S. (2010). Learning Content and Software Evaluation and Personalisation Problems. *Informatics in Education,* Vilnius*,* 2010, Vol. 9, Issue 1, pp. 91–114. ISSN 1648–5831

In the reviewed scientific publications of conference proceedings (ISI Web of Science):

7. Kurilovas, E.; Bireniene, V.; Serikoviene, S. (2010). Evaluation of Quality of Learning Objects: Several Scientific Approaches. In: *Proceedings of the 9th European Conference on e-Learning (ECEL 2010),* pp. 291–299. Porto, Portugal, November 4–5, 2010. ISBN 978–1–906638–82–5

In the reviewed scientific publications of conference proceedings

8. Kurilovas, E.; Serikoviene, S. (2010). Personalisation of Learning Objects and Environments for Informatics Science Education in Lithuania**.** In: *ISSEP2010 – Proceedings of Short Communications. Proceedings of the 4th International Conference on Informatics in Secondary Schools: Evolution and Perspectives (ISSEP 2010).* Zurich, Switzerland, January 13–16, 2010, pp. 52–72. ISBN 978–3909386–28–4

9. Kurilovas, E.; Serikoviene, S. (2009). Application of Optimization Methods in Learning Software Packages Personalization Tasks. In: *M. Grasserbauer, L. Sakalauskas, E. K. Zavadskas (Eds.): KORSD–2009,* Selected papers, 2009, pp. 433–438. ISBN 978–9955–28–482–6

10. Kurilovas, E.; Serikoviene, S. (2009). Application of Optimization Methods in Learning Activity Personalization Tasks. In: *M. Grasserbauer, L. Sakalauskas, E. K. Zavadskas (Eds.): KORSD–2009,* Selected papers, 2009, pp. 427–432. ISBN 978–9955–28–482–6

About the Author

Silvija Sėrikovienė was born in Lithuania in Radviliškis on 17th of June 1972. She has graduated from Kaunas University of Technology Faculty of Informatics in 1996 acquiring Bachelor's Degree in Informatics. She has gained Master's Degree in Mathematics at Kaunas University of Technology Faculty of Fundamental Sciences in 1998. Since 1999, she works as assistant in Department of Physical Sciences at Kaunas University of Technology Panevėžys Institute, and since 2007 works as lecturer. Since 2008 till 2012 she was a PhD student at Vilnius University Institute of Mathematics and Informatics.

Mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimo metodų taikymo tyrimas

Mokslo problemos aktualumas

Mokomasis objektas yra bet koks skaitmeninis išteklius, kuris gali būti naudojamas pakartotinai (iš naujo) mokymuisi palaikyti. MO turi būti kokybiški, t.y., tinkami mokymui(-si) bei atitikti daugkartinio panaudojamumo reikalavimą. Tokiu būdu, daugkartinis panaudojamumas yra viena iš pagrindinių MO kokybės savybių, t.y., kiekvienas kokybiškas MO turi tam tikrą daugkartinio panaudojamumo lygį, tačiau ne visi MO pasižymintis aukštu daugkartinio panaudojamumo lygiu yra kokybiški. Todėl darbe yra nagrinėjama MO kokybės problema, ypatingą dėmesį skiriant MO daugkartinio panaudojamumo aspektams.

Kokybiška mokomoji medžiaga yra viena svarbiausių mokymo(-si) kokybės veiksnių, todėl mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimas yra viena opiausių švietimo problemų. Problema yra aktuali visiems švietimo dalyviams – švietimo įstaigoms (pvz., mokykloms), kurios turi išrinkti kokybišką mokomąją medžiagą savo tikslams pasiekti, švietimo politikams, kuriems reikia aiškių kokybės kriterijų vykdant MO viešuosius pirkimus, mokomosios medžiagos autoriams (pvz., leidykloms), kurie turi žinoti kokybės reikalavimus, remdamiesi kuriais jie kurs MO, ir pan.

Mokomųjų objektų kūrimas yra sudėtingas, brangus ir darbui imlus procesas, todėl mažos šalys (pvz., Lietuva) neturi galimybių sukaupti daug MO, sukurtų jų kalba ir pritaikytų jų švietimo sistemoms. Todėl joms ypač aktualu surasti kitose saugyklose (pvz., užsienio) MO, kuriuos galima būtų lengvai pritaikyti savo švietimo tikslams pasiekti. Tokio tipo MO vadina daugkartinio panaudojamumo mokomaisiais objektais.

Šiuo metu tarptautinėse saugyklose yra sukaupta milijonai objektų, kurių didelę dalį galima naudoti iš naujo skirtingose šalyse skirtingose pedagoginėse situacijose, lengvai juos modifikuojant, lokalizuojant ir kitaip pritaikant konkrečiam švietimo kontekstui. Tokiu būdu, daugkartinio panaudojamumo MO paprastai yra žymiai pigesni (nes jais galima naudotis įvairiose sistemose ir pedagoginėse situacijose) ir žymiai kokybiškesni (nes prie jų tobulinimo prisideda platus ekspertų ir praktikų ratas).

Todėl MO daugkartinio panaudojamumo kokybės vertinimas yra ta problema, kurią turi kasdien spręsti visi švietimo sektoriaus dalyviai. Jie turi remtis mokslinėmis MO kokybės sistemomis (modeliais) ir praktiškai tinkamais (t.y., paprastais ir efektyviais) vertinimo metodais.

Vieni mokomieji objektai gali būti labai kokybiški vertinant pagal tam tikrus kokybės kriterijus, bet nekokybiški pagal kitus.

Todėl mokomųjų objektų kokybės vertinimas yra tipiškas atvejis, kai turime naudoti daugiakriterinių sprendimų analizės (angl. k. *MCDA – Multiple Criteria Decision Analysis*) teoriją. MCDA darbe naudojama tam, kad sudaryti objektyvią mokomųjų objektų alternatyvų eilę pagal jų kokybę bei įvertinti kiek kiekviena alternatyva yra kokybiška lyginant su „idealia“ kokybe. Šiame darbe yra pristatoma sudaryta mokomųjų objektų daugkartinio panaudojamumo kokybės

kriterijų sistema (kokybės modelis). Darbe taip pat yra sukurtas ekspertinio kokybės vertinimo metodas, pagrįstas neraiškiųjų skaičių teorija.

Darbo tikslas ir uždaviniai

Darbo tikslas yra pasiūlyti ir išbandyti MO daugkartinio panaudojamumo kokybės vertinimo metodiką: kokybės modelį ir paprastus bei efektyvius ekspertinio kokybės vertinimo metodus (t.y., pagerinti edukologinių uždavinių sprendimo galimybes naudojant informatikos inžinerijos metodus).

Siekiant šio tikslo yra sprendžiami tokie uždaviniai:

1. Išanalizuoti MO daugkartinio panaudojamumo ir ekspertinio kokybės vertinimo sąvokas.
2. Išanalizuoti MO daugkartinio panaudojamumo kokybės modelio sudarymo principus.
3. Išanalizuoti galimus paprastus ir efektyvius MO daugkartinio panaudojamumo kokybės ekspertinio vertinimo metodus.
4. Sukurti MO daugkartinio panaudojamumo kokybės modelį.
5. Sukurti paprastą ir efektyvų MO ekspertinio kokybės vertinimo metodą tinkamą MO kokybei ir daugkartiniam panaudojamumui įvertinti.
6. Atlikti modelio bei metodo taikymo eksperimentinį aprobavimą (pateikti realiųjų MO alternatyvų įvertinimo pavyzdžių).
7. Sukurti MO daugkartinio panaudojamumo kokybės vertinimo internetinį įrankį.

Mokslinis naujumas

– Sukurtas MO daugkartinio panaudojamumo kokybės modelis atitinkantis mokslinius kokybės modelio sudarymo principus.

– Pateikta ir praktiškai išbandyta mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimo metodika, t.y., mokomųjų objektų daugkartinio panaudojamumo kokybės modelis bei kokybės vertinimo metodas. Kokybės vertinimo metodiką sudaro taikomų metodų, principų ir standartų visuma bei jų taikymo nuoseklumas.

Tyrimų metodika

Literatūros analizei atlikti naudojamas sistemingos apžvalgos metodas.

MO kokybės modelio kūrimui naudojami MCDA teorija grįsti modelio kūrimo principai, kokybės kriterijų klasifikavimo principas grįstas kokybės standartu ISO/IEC 9126–1:2001(E) bei aibių atvaizdavimo metodas. MO kokybės modelyje identifikuojami tie kokybės kriterijai, kurie labiausiai lemia MO daugkartinio panaudojamumo galimybes.

Paprastam ir efektyviam MO daugkartinio panaudojamumo kokybės vertinimui naudojamas ekspertinis vertinimas, kuriame parinkti ekspertai vertina MO kokybę skaičiais. Ekspertai kiekvieno kriterijaus svorį ir reikšmę (įvertį) įvertina pagal pasirinktą lingvistinių kintamųjų sistemą, kuri po to konvertuojama į kiekybines išraiškas. Pasirenkamas neraiškiųjų skaičių metodas ir taikomas skaliarizacijos metodas.

MO daugkartinio panaudojamumo lygis vertinamas, skiriant didesnius svorius tiems kokybės kriterijams, kurie labiausiai lemia MO daugkartinio panaudojamumo galimybes. Tam sudarysime ir išbandysime vertinimo metodiką, taikydami skaliarizaciją bei neraiškiųjų skaičių teoriją.

Įvertinama ir tai, jog priimant sprendimą dalyvauja daug ekspertų, turinčių savo nuomonę ir pažiūras. Tad iškyla kelios problemos:

1. ekspertų nuomonę apie MO alternatyvų kokybės kriterijų svarbą paversti skaitine informacija;
2. palyginti tarpusavyje ekspertų įverčius;
3. priimti sprendimą šių įverčių bei svorių pagrindu.

Išvardintos problemos darbe sprendžiamos pasitelkus neraiškiųjų skaičių idėją. Pirmoji problema sprendžiama naudojant neraiškiuosius skaičius (lingvistinius kintamuosius konvertuosime į kiekybines išraiškas), antroji – ekspertų įvertinimų suderinamumas yra patikrinamas skaičiuojant konkordancijos koeficientą, o trečiajai spręsti naudojama ekspertų naudingumo funkcija (skaliarizacijos metodas), kurios reikšmė leidžia įvertinti gautas alternatyvas.

Rezultatai

Darbo rezultatų praktinė reikšmė yra ta, kad tyrimo metu sukurti ir išbandyti mokomųjų objektų daugkartinio panaudojamumo kokybės modelis ir vertinimo metodas yra tinkami visiems švietimo sektoriaus dalyviams – švietimo įstaigoms, švietimo politikams, mokomosios medžiagos kūrėjams – sprendžiant pigios ir kokybiškos mokomosios medžiagos parinkimo, kūrimo bei taikymo klausimus.

Darbo rezultatai buvo išbandyti:

– Europos mastu – eQNet projekte: sukurti MO daugkartinio panaudojamumo kokybės vertinimo kriterijai.

– Lietuvos mastu – ŠMM UPC konkurse: sukurtas vadovėlių / skaitmeninių mokymo priemonių (SMP) kokybės vertinimo modelis ir metodai.

Ginamieji teiginiai

– Sukurtas MO daugkartinio panaudojamumo kokybės modelis atitinka mokslinius kokybės modelio sudarymo principus.

– Sukurtas MO ekspertinio kokybės vertinimo metodas, pagrįstas neraiškiųjų skaičių teorija bei skaliarizavimo metodu, yra paprastas ir efektyvus, t.y. tinkamas ir praktiškai taikytinas švietimo įstaigose MO daugkartinio panaudojamumo kokybei įvertinti.

Darbo rezultatų aprobavimas

Tyrimų rezultatai buvo pristatyti ir aptarti šiose nacionalinėse ir tarptautinėse konferencijose Lietuvoje ir užsienyje:

1. *Konferencijoje „XV Kompiuterininkų dienos 2011“*. Klaipėdos Universitetas, 2011 m. rugsėjo mėn. 22 – 24 d.
2. *Tarptautinėje konferencijoje „The 9th European Conference on e-Learning (ECEL 2010)“*. Porto, Portugalija, 2010 m. lapkričio 4 – 5 d.

(geriausio straipsnio apdovanojimas, išplėstas straipsnis išspausdintas mokslo žurnale *Electronic Journal of e-Learning*).

3. *Tarptautinėje konferencijoje „The 3rd World Summit on the Knowledge Society (WSKS 2010)"*. Corfu, Graikija, 2010 m. rugsėjo 22 – 24 d. (geriausio straipsnio apdovanojimas, išplėstas straipsnis išspausdintas mokslo žurnale *International Journal of Engineering Education*).
4. *Lietuvos matematikos draugijos 51-oje konferencijoje.* Šiaulių Universitetas, Šiauliai, 2010 m. birželio 17 – 18 d.
5. *Tarptautinėje konferencijoje „The 4th International Conference on Informatics in Secondary Schools: Evolution and Perspectives (ISSEP 2010)"*. Zurich, Austija, 2010 m. sausio 13 – 16 d.
6. *Tarptautinėje konferencijoje „The 5th International Conference on Sustainable Development "Knowledge-Based Technologies and OR methodologies for Strategic Decisions of Sustainable Development" (KORSD 2009)"*. Vilnius, 2009 m. rugsėjo 30 – spalio 3 d.

Tyrimų rezultatai pateikti 10 mokslinėse publikacijose:

- recenzuojamuose periodiniuose leidiniuose, įrašytuose į Mokslinės informacijos instituto (Web of Science) sąrašą:

1. Kurilovas, E.; Serikoviene, S. (2012). New TFN Based Method for Evaluating Quality and Reusability of Learning Objects. *International Journal of Engineering Education*, Vol. 28, Issue 6, 2012, pp. 1288–1293. ISSN 0949-149X

- kituose užsienio ar tarptautinių organizacijų leidžiamuose periodiniuose recenzuojamuose leidiniuose:

2. Kurilovas, E.; Vinogradova, I.; Serikoviene, S. (2011). Application of Multiple Criteria Decision Analysis and Optimisation Methods in Evaluation of Quality of Learning Objects. *International Journal of Online Pedagogy and Course Design*, October–December 2011, Vol. 1, Issue 4, pp. 62–76. *IGI Publishing, USA*. ISSN 2155–6873

3. Kurilovas, E.; Bireniene, V.; Serikoviene, S. (2011). Methodology for Evaluating Quality and Reusability of Learning Objects. *Electronic Journal of e-Learning,* Vol. 9, Issue 1, 2011, pp. 39–51. *Academic Publishing, UK*. ISSN 1479–4403

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Darbo apimtis ir struktūra

Darbą sudaro bendra darbo charakteristika, keturi skyriai, išvados ir rezultatai, naudotos literatūros sąrašas ir priedai. Bendra disertacijos apimtis yra 120 puslapių, 27 iliustracijos, 21 lentelė ir 4 priedai.

Pirmame disertacijos skyriuje pateikta bendra darbo charakteristika.

Antrame disertacijos skyriuje analizuojama mokomojo objekto sąvoka, daugkartinis panaudojamumas, mokomųjų objektų kokybės modelio sudarymo ir vertinimo metodo parinkimo principai. Skyriaus pabaigoje pateikiamas apibendrinimas.

Trečiame disertacijos skyriuje yra pateikiama mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimo metodika, t.y. sukurtas MO daugkartinio panaudojamumo kokybės modelis ir pritaikyti kokybės vertinimo metodai. Metodiką sudaro taikomų metodų, principų ir standartų visuma ir jų taikymo nuoseklumas. Taip pat pateikti mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimui parinkti metodai: skaliarizacija, neraiškiųjų skaičių teorija, ekspertų vertinimų suderinamumas ir naudingumo funkcija.

Ketvirtame disertacijos skyriuje yra pateikti sukurto mokomųjų objektų daugkartinio panaudojamumo kokybės modelio ir vertinimo metodo eksperimentinio taikymo pavyzdžiai: pasirenkant kokybės kriterijų svorius (vienodus ir skirtingus), skaičiuojant kokybės kriterijų svorius (taikant trapecijos ir trikampių neraiškiuosius skaičius), skaičiuojant MO kokybės vertinimo kriterijų grupių bei labiausiai įtakojančių daugkartinio panaudojamumo kriterijų grupės svarbą, taikant sukurtą internetinę priemonę PHP kalba. Pateiktuose pavyzdžiuose demonstruojamas mokomųjų objektų daugkartinio panaudojamumo modelio ir metodų taikymas realaus gyvenimo situacijose, kai švietimo institucijos turi priimti sprendimus dėl jų poreikių atitinkančius mokomųjų objektų įsigijimo rinkoje ar nemokamose saugyklose.

Bendrosios išvados

Taikant sistemingos apžvalgos metodą, mokslinėje literatūroje nepavyko rasti nei MO kokybės modelio, nei tinkamų vertinimo metodų, skirtų MO daugkartinio panaudojamumo kokybei įvertinti, todėl juos reikėjo sukurti.

Daugkartinis mokomųjų objektų panaudojamumas yra viena iš pagrindinių mokomųjų objektų kokybės savybių, t.y., kiekvienas kokybiškas mokomasis objektas turi tam tikrą daugkartinio panaudojamumo lygį, tačiau ne visi mokomieji objektai pasižymintis aukštu daugkartinio panaudojamumo lygiu yra kokybiški. Todėl darbe nagrinėjome mokomųjų objektų kokybės problemą, ypatingą dėmesį skiriant jų daugkartinio panaudojamumo aspektams.

Švietimo įstaigos dažnai susiduria su mokomųjų objektų kokybės problematika. Turint omeny, kad praktiškai švietimo įstaigos turi (a) baigtinį, tačiau (b) didelį mokomųjų objektų pasirinkimą mokomųjų objektų kokybei vertinti, turime nagrinėti (a) vektorinio optimizavimo metodus ir (b) neraiškiųjų skaičių metodą, kadangi Pareto ir porinio palyginimo metodai yra akivaizdžiai sunkiai taikytini vertinimo paprastumo ir efektyvumo sumetimais.

Darbe yra pateiktas sukurtas mokomųjų objektų daugkartinio panaudojamumo kokybės modelis ir vertinimo metodas.

Yra sukurtas mokomųjų objektų kokybės modelis, kurį sudaro devyni trijų grupių (technologiniai, pedagoginiai, intelektinių teisių) kokybės kriterijai. Šis kokybės modelis sudaro visapusišką kokybės kriterijų sistemą, kurioje yra svarbūs ne tik patys kriterijai, bet ir jų tarpusavio sąryšiai.

Mokomųjų objektų kokybės modelis yra sudarytas remiantis daugiakriterinių sprendimų analizės principais: sąvokos siejimas su tikslu, vienodas suprantamumas, matuojamumas, neperteklišKumas, vertinimo nepriklausomumas, išsamumo ir glaustumo balansas, operacionalumas, paprastumo ir sudėtingumo balansas.

Kuriant modelį yra atsižvelgta į ISO/IEC 9126–1:2001(E) standarto reikalavimus bei į technologinių kokybės kriterijų klasifikavimo principus.

Mokomųjų objektų daugkartinio panaudojamumo charakteristikas atspindi šie mokomųjų objektų technologiniai kokybės kriterijai: sąveikumas, architektūra, interaktyvumas bei dizainas ir naudotojo sąsaja.

Mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimui yra parinkti ir patobulinti šie nuoseklų ekspertinį vertinimą atliekantys metodai:

– skaliarizacija. Naudojama ekspertų naudingumo funkcija – kokybės vertinimo kriterijų įverčių padaugintų iš kriterijų svorių suma.

– ekspertų nuomonė apie mokomųjų objektų daugkartinio panaudojamumo kokybės kriterijų svarbą į skaitmeninę informaciją paverčiama neraiškiųjų skaičių teorijos principais (lingvistiniai kintamieji konvertuojami į trikampių ar trapecijos neraiškiųjų skaičių kiekybines išraiškas).

– prieš pradedant daugiakriterinio vertinimo skaičiavimus, nustatomas ekspertų vertinimų suderinamumas (skaičiuojamas konkordancijos koeficientas).

– naudingumo funkcijos rezultatais palyginamos gautos alternatyvos bendrosios mokomųjų objektų kokybės atžvilgiu bei jų daugkartinio panaudojamumo kokybės atžvilgiu.

Mokomųjų objektų kokybės kriterijų svorių nustatymo metodas naudojant neraiškiųjų skaičių teoriją yra naujas mokslo literatūroje. Jis buvo išbandytas šio tyrimo metu.

Sukurtas mokomųjų objektų ekspertinio vertinimo metodas grįstas neraiškiųjų skaičių teorija bei skaliarizavimo metodu, yra paprastas ir efektyvus vertinant mokomųjų objektų alternatyvas rinkoje arba kuriant kokybiškus mokomuosius objektus. Sukurtas mokomųjų objektų ekspertinio kokybės vertinimo metodas yra tinkamas ir praktiškai taikytinas švietimo įstaigose mokomųjų objektų daugkartinio panaudojamumo kokybei įvertinti.

Siūlomas kokybės vertinimo metodas yra patobulintas skaliarizacijos ir neraiškiųjų skaičių taikymo metodas. Mokomųjų objektų daugkartinio panaudojamumo galimybėms įvertinti nustatytiems daugkartinio panaudojamumo kriterijams yra taikomi didesni svoriai.

Darbe yra pateikti mokomųjų objektų daugkartinio panaudojamumo kokybės modelio ir vertinimo metodo taikymo pavyzdžiai: pasirenkant kokybės kriterijų svorius, skaičiuojant kokybės kriterijų svorius, taikant trapecijos ir trikampių neraiškiuosius skaičius, taikant sukurtą internetinę priemonę PHP kalba.

Mokomųjų objektų kokybės vertinimo rezultatai yra artimi naudojant tiek trikampius, tiek trapecijos neraiškiuosius skaičius. Tik trapecijos neraiškiųjų skaičių metodo taikymas rodo kiek didesnį skirtumą tarp mokomųjų objektų kokybės įvertinimo rezultatų.

Mokomųjų objektų daugkartinio panaudojamumo kokybei vertinti yra sukurta internetinė priemonė PHP kalba: http://www.kompiuteriams.com/upc_vert/, kurioje pateiktas mokomųjų objektų kokybės modelis, o skaičiavimai programoje atliekami pagal aprašytus metodus: kriterijų įverčių bei svorių nustatymas, jų „normalizavimas“ ir ekspertų naudingumo funkcijos reikšmių skaičiavimas yra atlikti naudojant trapecijos neraiškiuosius skaičius.

Taigi darbo mokslinis naujumas yra toks, kad pirmą kartą mokslo literatūroje yra pateikta ir praktiškai išbandyta mokomųjų objektų daugkartinio panaudojamumo kokybės vertinimo metodika. Šią metodiką sudaro mokomųjų objektų daugkartinio panaudojamumo kokybės modelis bei kokybės vertinimo metodas.

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RESEARCH ON APPLICATION OF LEARNING OBJECTS REUSABILITY AND QUALITY EVALUATION METHODS
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SILVIJA SĖRIKOVIENĖ
MOKOMŲJŲ OBJEKTŲ DAUGKARTINIO PANAUDOJAMUMO KOKYBĖS VERTINIMO METODŲ TAIKYMO TYRIMAS
Daktaro disertacijos santrauka
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