APPLICATION OF MULTIPLE CRITERIA DECISION ANALYSIS MODEL AND METHOD FOR EVALUATION OF QUALITY OF LEARNING OBJECTS FOR PHYSICS SUBJECT IN EQNET PROJECT

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Abstract

The paper is aimed to analyse the application of multiple criteria decision analysis model and method for evaluation of quality of digital learning resources (objects) for Physics subject. The applied model and method have been used practically for evaluation of learning objects while implementing European Lifelong Learning programme's eQNet project in Lithuanian comprehensive schools in winter 2010.

Introduction

eQNET is a three-year (September 2009–2012) Comenius Multilateral Network funded under the European Commission's Lifelong Learning programme. The project is coordinated by European Schoolnet and involves 9 Ministries of Education – AT, BE, CZ, IT, LT, NO, PT, SK, SE or agencies nominated to act of their behalf. The primary aim is to improve the quality of educational resources (i.e., learning objects – LOs) in European Schoolnet's Learning Resource Exchange (LRE, 2010) which currently offers almost 130,000 LOs and assets from over 25 providers. As a pan-European service, the LRE particularly seeks to identify LOs that „travel well" (i.e., reusable) across national borders and can be used in a cultural and linguistic context different from the one in which they were created (eQNet, 2010).

eQualityNet will do this by establishing a network consisting of policy makers and practitioners (teachers) that will develop and apply „travel well" quality criteria to both existing LRE content as well as that to be selected in future from national repositories. The vision driving the LRE is that a significant percentage of high quality LOs developed in different countries, in different languages and to meet the needs of different curricula can be re-used at European level.

eQualityNet will provide a forum for joint reflection and co-operation related to the exchange and re-use of educational content and allow network members to: (1) better share information and expertise particularly related to „travel well" quality criteria (pedagogical, technical and intellectual property rights (IPR) factors); (2) develop new frameworks (inc-

luding a network of expert teachers) to improve the quality of LOs and metadata in both national repositories and the LRE, including the growing volume of user-generated content and metadata, as well as to improve the multilinguality of LRE content as a result of the translation of metadata, making use, where appropriate, of automatic metadata translation approaches and technologies; (3) enable schools to participate in a Community of Practice related to the use LOs at European level.

Major results will include: the development of „travel well" quality criteria to more easily identify LOs with the potential for cross-border use (this work package is coordinated by Lithuania represented by Centre for IT in Education, in particular by the author of the paper); the practical application by teachers of these criteria to >3,500 LOs in the LRE; 'showcases' of the best of these LOs in a „travel well" section of the LRE portal; where necessary, the enrichment of selected LOs with new or better metadata; a Community of Practice for teachers around these LOs.

Research methodology

Reusability of LOs (or their ability to „travel well" between different contexts and education systems) is considered by the authors 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 quality one.

The main problem here is how to establish a 'proper' set of LOs quality evaluation criteria which should reflect the objective scientific principles of construction a model (criteria tree) for LOs quality evaluation.

If the set of decision alternatives (LOs) is assumed to be predefined, fixed and finite, then the decision problem is to choose the optimal alternative or, maybe, to rank them. But usually the experts (decision makers) have to deal with the problem of optimal decision in the multiple criteria situation where the objectives are often conflicting. In this case, an optimal decision is the one that maximises the expert's utility. These principles have been analysed in multiple criteria decision analysis (MCDA) related research works, e.g., Belton and Stewart (2002).

Evaluation of LOs quality is a typical case where the criteria are conflicting, i.e., LOs could be very qualitative against several criteria, and not qualitative against the other ones, and vice versa. Therefore the authors propose to use MCDA approach for creation of LOs quality evaluation model and method. Expert evaluation is referred here as the multiple criteria evaluation of LOs aimed at selection of the best alternative (i.e., LO) based on score-ranking results.

LOs multiple criteria evaluation method is referred here as the experts' additive utility function represented by formula (1) below including LOs evaluation criteria, their ratings (values) and weights. This method is well-known in the theory of optimisation methods and is named „scalarization method". A possible decision here could be to transform multi-criteria task into one-criterion task obtained by adding all criteria together with their weights. It is valid from the point of view of the optimisation theory, and a special theorem exists for this case.

Therefore here we have the experts' additive utility function:

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

where $f_i(X_j)$ is the rating (i.e., non–fuzzy value) of the criterion i for the each of the examined LOs alternatives X_j. The weights here should be 'normalised' according to the requirement

$$\sum_{i=1}^{m} a_i = 1,\ a_i > 0. \qquad (2)$$

The major is the meaning of the utility function (1) the better LOs meet the quality requirements in comparison with the ideal (100%) quality.

Literature analysis and research results

LOs quality evaluation model

Belton and Stewart (2002) consider that in identifying quality evaluation criteria the following considerations are relevant to all MCDA approaches: (1) value relevance; (2) understandability; (3) measurability; (4) non-redundancy; (5) judgmental independence; (6) balancing completeness and conciseness; (7) operationality; (8) simplicity versus complexity.

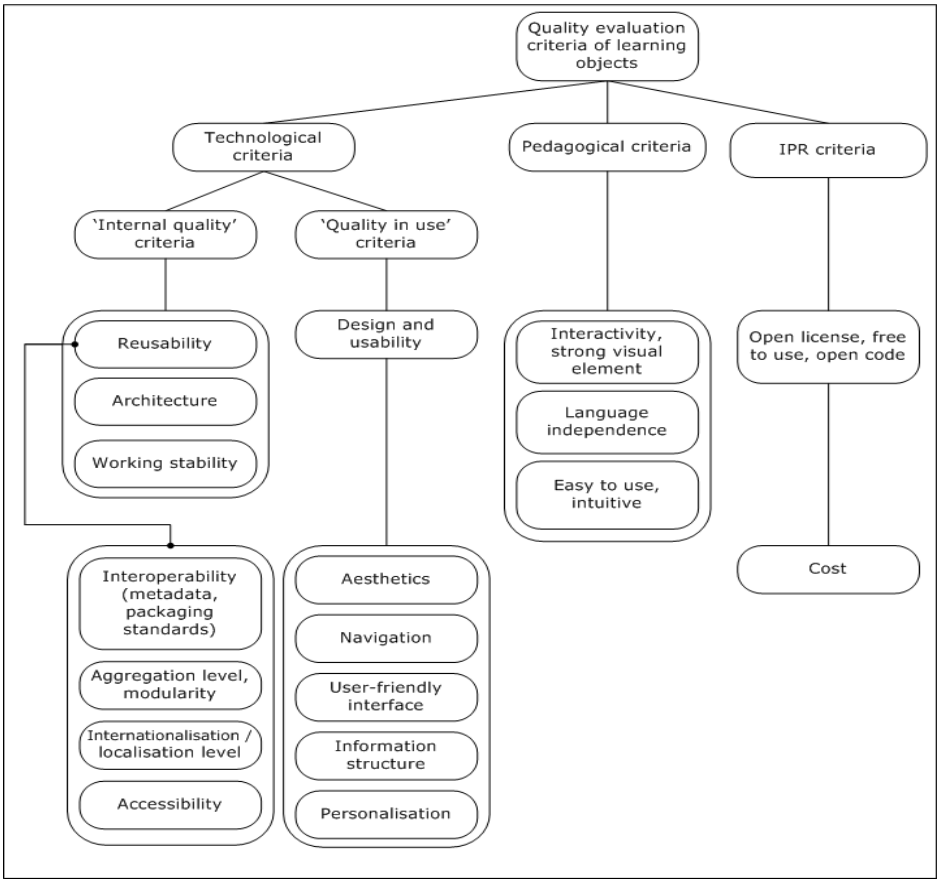
Kurilovas and Dagiene (2009a, 2009b, 2009c) have applied these considerations in their cycle of papers on technological evaluation of learning software and thus have identified a number of LOs technological quality evaluation criteria presented in the technological part of the LOs quality evaluation model presented in Fig. 1 below.

On the other hand, European Schoolnet while implementing a number of pan-European LRE related projects (CELEBRATE, CALIBRATE, MELT, INSPIRE, etc.) has identified some pedagogical „travel well" criteria: (1) language independence or low language dependence (easily translatable) or multilinguality; (2) strong visual structure (animations, images and short videos are travelling best); (3) no large semantic density (easy to include in any curriculum).

The authors propose to construct the LOs quality evaluation criteria tree (model) based on MCDA considerations presented above by using technological LOs quality evaluation criteria developed by Kurilovas and Dagiene (2009a, 2009b, 2009c) together with pedagogical criteria developed by European Schoolnet, and IPR criteria.

This proposed LOs quality evaluation criteria tree (model) is presented in Fig. 1.

Figure 1. LOs quality evaluation model (criteria tree)



LOs quality evaluation method

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, Ounaies *et al.* (2009) have proposed to use fuzzy group decision making theory to obtain final assessment measures. Linguistic variables conversion into non-fuzzy values of the evaluation criteria is as follows: 'excellent'=*0.850*; 'good'=*0.675*; 'fair'=*0.500*; 'poor'=*0.325*; 'bad'=*0.150* (Ounaies *et al.*, 2009).

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. For example, for the most simple (general) case, when all LOs evaluation criteria are of equal im-

portance (i.e., we pay no especial attention to LOs reusability criteria), the experts could consider the equal weights $a_i = 0.125$ agreeably to the normalisation requirement (2).

But if we pay especial attention to LOs reusability criteria, we can, e.g., consider the increased weights for the 1st and 6th LOs quality evaluation criteria (see Fig. 1 above and Table 1 below), because these criteria deal with LOs reusability mostly. In this case these increased weights could be, e.g., twice bigger in comparison with other ones – *0.2*, and all other criteria weights according to normalisation requirement (2) should be equal *0.1*.

Lithuanian Physics expert teacher (the co-author of the paper) has applied the presented evaluation model and method in eQNet project (see Table 1 below). A number of qualitative reusable Physics LOs have been identified in Lithuanian LOs repositories and evaluated against the model and method presented above. There are several examples of these LOs presented in Table 1: (1) LO_1: Light diffraction (available online at http://mkp.emokykla.lt/imo/lt/mo/330/); (2) LO_2: Photo effect (available online at http://mkp.emokykla.lt/imo/lt/mo/367/); and (3) LO_3: Isobar process (available online at http://mkp.emokykla.lt/imo/lt/mo/395/).

Table 1. Experimental evaluation results of Physics LOs „travel well" quality

LOs evaluation criteria	LO_1q	LO_2q	LO_3q	LO_1twq	LO_2twq	LO_3twq
Technological criteria:						
1. Technological reusability	0.850	0.850	0.850	*0.1700*	*0.1700*	*0.1700*
2. Design and usability	0.850	0.850	0.850	0.0850	0.0850	0.0850
3. Working stability	0.850	0.850	0.850	0.0850	0.0850	0.0850
4. Architecture	0.675	0.675	0.675	0.0675	0.0675	0.0675
Pedagogical criteria:						
5. Interactivity level	0.500	0.500	0.500	0.0500	0.0500	0.0500
6. Language independence	0.850	0.675	0.500	*0.1700*	*0.1350*	*0.1000*
7. Ease of use, intuitiveness	0.850	0.850	0.850	0.0850	0.0850	0.0850
IPR criteria:						
8. Open licence, cost	0.850	0.850	0.850	0.850	0.850	0.850
Evaluation results:	***0.7844***	***0.7625***	***0.7406***	***0.7975***	***0.7625***	***0.7275***

These results mean that LO_1 meets 78.44% quality (q) in comparison with the ideal, LO_2 – 76.25%, and LO_3 – 74.06%. They also mean that LO_1 meets 79.75% „travel well" quality (twq) in comparison with the ideal, LO_2 – 76.25%, and LO_3 – 72.75%. Therefore, LO_1 is the best alternative (among the evaluated) both from general quality and „travel well" quality points of view.

Conclusion and recommendations

The case study presented in the paper shows that MCDA approach-based LOs evaluation model presented in Fig. 1 and method represented by formula (1) are applicable in real life situations when schools have to decide on purchase of learning software such as

LOs for their education needs. The proposed model and method are quite objective, exact and simply to use for choosing the qualitative LOs in the market. On the other hand, the proposed model and method for evaluation of „travel well" quality of LOs is applicable for the aims of eQNet project in order to select „travel well" LOs from LRE to use them in other education contexts and countries.

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CHEMIJOS MOKYMAS BENDROJO LAVINIMO MOKYKLOJE: KAI KURIE AKTUALŪS KLAUSIMAI

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Įvadas

Chemija – vienas pagrindinių gamtamokslinio ugdymo komponentų. Nuo 1990 metų Lietuvos bendrojo lavinimo mokykloje chemijos mokymas iš esmės pakito. Akivaizdu, kad mokyklinio ugdymo procese chemijos mokymas sudaro mokslinių žinių turinio pa-