COMPUTER SCIENCE
ISSN1407-7493 DATORZINĀTNE 2007-30

TECHNOLOGIES OF COMPUTER CONTROL
DATORVADĪBAS TEHNOLOĢIJAS

# EVALUATION OF THE E-LEARNING APPLICATIONS AND SYSTEMS

# ELEKTRONISKO APMĀCĪBAS SISTĒMU KVALITĀTES NOVĒRTĒŠANAS METODES

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***Quality, assessment, evaluation, validation, e-learning, UNITE project***

## 1. Introduction

The project "Unified e-Learning Environment for the School" (UNITE) is a Specific targeted research project (STREP) for the 6th Framework Programme (FP6) of the European Commission. The UNITE consortium aims at developing and establishing a technical platform enhanced with pedagogical guidance for the creation of high-quality e-learning content for secondary school children. The UNITE portal-like platform intends to support the re-use of content material, the exchange of best practices, and the improvement of pedagogic models.

The learning settings are not limited to conventional lessons. UNITE specifically supports forms of learning which are difficult to realize in the classroom and will explore innovative approaches of structuring and delivering content to the learner. Therefore, the pedagogic experts of the consortium are planning to establish a pedagogical framework focusing on mobile learning, exploratory learning and group learning situations. Their input on modes of learning will be transferred into e-learning scenarios which combine the pedagogical recommendations with appropriate technical features provided by the platform.

Constantly while developing the pedagogical and technological concepts, a validation process will be run in 14 secondary schools in 11 countries. In parallel and in close collaboration with the validation in the schools network, the project will carry out an intensive socio-economic evaluation. This will lead to a profound evaluation of the project goals, taking all important aspects into account. Moreover, it will define the basis for the sustainability of the UNITE results after the end of the project.

Division of Applied Systems Software at Riga Technical University (RTU) is a UNITE project partner and main contributor for the design and development of the validation methodology, which key responsibilities in the project include:

- designing the quantitative assessment methodologies for the validations;
- leading the validation activities in Latvia.

This paper aims at reviewing different popular evaluation methodologies and approaches, including the authors' opinion regarding their possible use for the evaluation of e-Learning systems.

## 2. UNITE validation methodology

The objective of the validation is to determine the appropriateness, meaningfulness and usefulness of the UNITE system for the selected e-Learning scenarios by meeting the user requirements and expectations.

Quality assessment of the e-Learning system will be developed and executed on 2 levels:

1. quality assessment of the system:
    a. at the implementation phase,
    b. of the final product,
2. measure efficiency (success \ impact) of the system:
    a. using qualitative evaluation,
    b. using quantitative evaluation.

A most efficient validation dictates that the validation method is a repeatable, systematic procedure to produce validation results. In that way the validation is the main instrument for quality assurance in the project UNITE.

## 3. E-learning evaluation perspectives

A web-based literature survey of e-learning evaluation and assessment reports, articles and other documentation in English, Russian and Latvian revealed that the existing research can be grouped under the following headings:

- ***Particular Product \ System \ Platform Evaluation***, which describes particular educational software and usually is published or commissioned by the software developers.
- ***Performance Evaluation*** or ***Learner Assessment*** is a powerful indicator of the didactic effectiveness of e-learning.
- ***Tools for the evaluation of the e-Learning***, which include
    - data gathering instruments for assessing (e.g. questionnaires, tests, checklists, quizzes with \ without feedback, etc.),
    - recording and analyzing tools (e.g. by duration \ frequency of log-in and log-out, number of accessed pages, hit counters, etc.), which include Web-testing tools (e.g. load and performance test tools, link checkers, HTML validators, security test tools, web-site management tools, usability test tools, navigation & configuration testing, etc.).
- ***Return on Investment*** (***ROI***) assessments, which show cost-effectiveness of the investments in e-Learning.
- ***Benchmarking***, suggests different sets of criteria for quality assuring e-Learning.

- ***Pedagogical experiments*** or ***Comparisons with traditional learning***, which usually are organized for a particular goals \ objectives in the specific context (e.g. institution, in the frame of the project, research, study, etc.).
- ***Case Studies*** of the particular courses, programs, trainings, etc., which also are usually limited to the specific subject area.
- ***Quality Management approaches***, which include official approaches like TQM (Total Quality Management), EFQM excellence model, standards (ISO 9000), Audit procedures, etc.

## 4. Quality assessment models

Measuring the effectiveness of e-Learning is an important issue in the development and use of any e-Learning system or strategy, which not only shows the value of their use, but also allows improving in the future.

The today most popular and used quality assessment models and this paper authors' comments regarding an opportunity to use them for e-Learning system evaluation are given below (Table 1).

**Table 1. Quality assessment models overview.**

| Name | Comments for usage in quality assessment of the e-Learning applications and systems |
|---|---|
| 1. *Kirkpatrick's Four Levels of Evaluation* model (classical quality assessment model) | Kirkpatrick's 4-levels of evaluation model allows getting fast and illustrative quality assessment of the e-learning activities [1]. Although Kirkpatrick's model has a lot of benefits, such its relative ease and convenience to use, it suffers from the big amount of subjectivity and doesn't offer any quantitative measures for the evaluation. As the practice shows the last level (evaluation of the business impact of the training program) is the most difficult to implement in the real situation and usually due to this reason it is being ignored. |
| 2. *ROI* (Return on Investment) | Return on investment model is directed at the financial part of the evaluation [2]. ROI is a very popular metric because of its versatility and simplicity in comparison with other more complex financial evaluation tools such as Net Present Value (NPV) and Real Options. However the actual ROI measurement procedure is quite time and efforts consuming, because it is difficult to isolate the effects of specific training or programs and provide accurate estimates.<br>Costs are only part of the e-Learning equation. The primary advantage comes from increasing the top line, i.e. enabling organizations to do things they couldn't do with traditional training. Moreover, it is important to count only incremental costs, because some of the resources are already available for other purposes, for instance, PCs, LANs, Internet etc. The money already spent on these resources shouldn't be toted up as an expense of e-Learning. |
| 3. *Bloom's Taxonomy* | Bloom's taxonomy allows looking in more details at instructional activities and could help to choose the learning strategy in the future, referring to "*Assessment is not an end in itself but a vehicle for educational improvement*" [3].<br>After considering what should be taught within a course, it is important to decide to which extend and under which circumstances the competencies should be mastered by the students. So, learning objectives can be defined following the Bloom's taxonomy. This model can be also used to choose the |

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| | type of the assessment questions in testing procedures. |
| 4. *Benchmarking* | There are different tools available for benchmarking e-Learning, so this fact could be seen as an advantage in using this methodology [4,6 – 12].<br>In comparing the different approaches to benchmarking it is concluded that:<br>• Benchmarking is a tried and tested process that can significantly enable organizational learning and enhance organizational performance.<br>• There are numerous approaches to benchmarking and the commonsense approach draws appropriately from a mix of these.<br>• Benchmarking is not simply about performance measures. At its most effective it becomes a core business strategy.<br>• A process orientation is required in the organisation to ensure benchmarking is effective.<br>• The EFQM Excellence Model® provides a very effective route into benchmarking. It encourages benchmarking against measures of performance but also stimulates the search for good practice [5].<br>• Benchmarking can provide a valuable tool for individual and team development. |
| 5. *Quality audits* | The principles of Quality Audit are based on the style of quality standards used in several formal national and international standards such as the ISO-900x international quality standards (for instance, ISO 10011-1:1990 Quality Standard) [13, 14]. These standards do not in themselves create quality. Quality audits – or expert third-party reviews – can help to determine what's working and what's not in the e-Learning system. |
| 6. Methodology, which takes into consideration *students learning styles* | All the people learn and process information in different ways, that's why it's important to build courses and programs that address multiple learning styles. Assessing the impact of the e-Learning on learners with different learning styles could give an answer how to improve e-Learning system to reach the greater number of students. As the analysis results show usually the best improvement scores have the "visual" learners, which is easy to understand taking into consideration characteristics of the majority of e-Learning systems available today [15,16]. |
| 7. *Pedagogical experiment* | The major aim is to evaluate didactic effectiveness of the use of a "new" teaching mean in comparison with traditional methods which are applied now at schools.<br>Organization of the experiment:<br>• Two "equal" groups are formed taking into account several factors and conditions (existing level of skills, lessons, time etc.);<br>• One of the groups will use in learning process "new" tool/system, another one will be taught by traditional methods;<br>• Several characteristics of both groups will be compared, for instance, level practical skills, and final/intermediate marks.<br>Processing & estimation of the results:<br>• Wilcoxon and Student's statistics criteria are applied to compare groups' results and to estimate didactic effectiveness of the use of new tool/system;<br>• Additionally variance and correlation analysis is used to investigate an influence of different factors to the effectiveness of teaching process using new tool/system.<br>Outcome:<br>• Estimation of a didactic effectiveness of the use of CBLS;<br>• Recommendations how better to apply new tool/system.<br>This approach was suggested by RTU to use in the UNITE project for the |

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| | qualitative evaluation of the effectiveness of the e-Learning system. |
| 8. *Expert evaluation* | Expert evaluation is a complex of logical and mathematical procedures aimed at information acquisition from domain area experts, its analysis and generalization in order of optimal decision-making.<br>One of the expert evaluation methods is a "Delphi technique", which strengths are its combination of qualitative (written) and quantitative (numerical) data and its ability to form a consensus of expert opinion. Limitations are time involved for mailing and receiving replies and lack of stimulation from face-to-face contact.<br>Benefits of the method include inexpensiveness, since it generally does not involve travel to face-to-face meetings. |

Different models can be used for quality assessment of the e-Learning systems; each of them has its own benefits and drawbacks. The selection of the appropriate model obviously should be done in accordance with objectives and goals of the evaluation, considering the pros and cons of each method in the particular context.

## 5. Quality approaches

The issue of quality in e-Learning is widely discussed among all levels of the involved parties. With reference to the latest study on the "Quality in e-Learning" in Europe, widely accepted idea is that "*the main problem is not finding a quality approach per se, but rather choosing the right one from among the huge number of quality strategies available*" [17].

If we mean by "*quality approaches*" any methods, policies, procedures, rules, criteria, tools, checklists or any other verification instruments or measures that have the purpose of enhancing the quality of e-Learning products or services, different quality approaches available can be classified by authors for the purposes of the UNITE systems' validation (Table 2).

**Table 2. Quality approaches.**

| | | **Quality approaches** | **Comments** |
|---|---|---|---|
| **Approaches for the Quality Assessment of the e-Learning system** | **at the Implementation Phase** | Software Verification approaches:<br>• Static:<br>  o Consistency techniques,<br>  o Measurement techniques,<br>• Dynamic:<br>  o White-box (structural) testing,<br>  o black-box (functional) testing,<br>  o Random testing. | Software testing may be viewed as a sub-field of software quality assurance.<br><br>*Verification* is the process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase [18]. |

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| | | Formative evaluation procedures:<br>• Critical commenting,<br>• Developmental testing,<br>• Revising,<br>• Reviews (of literature, learners, learning context, existing solutions, etc.),<br>• Walk-through,<br>• Storyboards with potential users & experts,<br>• Observations, video-taping, user-tracking, interviews with users & experts,<br>• Peer review. | Formative evaluation is a method of judging the worth of a program while the program activities are forming or happening. |
| | | • Benchmarking<br>o Quality assurance guidelines,<br>o Quality evaluation criteria,<br>o Quality marks,<br>o Best Practices. | QAA guidelines, "Consumers guide to e-Learning" recommendations, "Quality on the Line", NEA 2000 benchmarks, WCET and best practices, BAOL Quality marks, etc. |
| | | • Expert evaluation | |
| | | • Bloom's Taxonomy | |
| | | • Quality standards | ISO 9000 |
| | | • Quality assurance frameworks | |
| | **of the Final Product** | Software validation approaches:<br>• Formal methods,<br>• Fault injections:<br>o Hardware,<br>o Software,<br>• Dependability analysis:<br>o Hazard analysis,<br>o Risk analysis. | *Validation* is the process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements [18]. |
| | | • Usability testing | |
| | | • Expert evaluation | |
| | | • Evaluation of the learning content | |
| | | • Benchmarking<br>o Quality assurance guidelines,<br>o Quality evaluation criteria,<br>o Quality marks,<br>o Best Practices, | |
| | | Summative evaluation procedures:<br>• Feedback from users (questionnaires, interviews, pre and post tests, etc.),<br>• Revising,<br>• Expert / Peer review. | Summative evaluation provides information on the product's efficacy (it's ability to do what it was designed to do). Summative evaluation is typically quantitative, using numeric scores or letter grades to assess learner achievement. |

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| **Approaches for measuring efficiency (impact) of the system** | • Expert evaluation ("Delphi" technique),<br>• Kirkpatrick's Four Levels of Evaluation,<br>• ROI (Return on Investment) or any other method estimating financial output,<br>• Pedagogical experiments (comparing with traditional learning cases, use of control & testing groups),<br>• Benchmarking<br>  o Quality assurance guidelines,<br>  o Quality evaluation criteria,<br>  o Quality marks,<br>  o Best Practices,<br>• Learners performance testing<br>  o Taxonomy of learning levels,<br>  o Before and after Testing,<br>  o Multiple-choice questions,<br>  o Assignment tasks,<br>• Feedback from learners and users:<br>  o Interviews (oral guided, written, telephone, etc.),<br>  o Questionnaires,<br>  o Lists of criteria (checklists),<br>  o Concept-mapping exercise,<br>  o BLOGs,<br>• Observations,<br>• Case Studies, | Qualitative and quantitative criteria are to be used to measure efficiency of the e-Learning system. |
| | • WATTS (web-assessment techniques and tools), such as e-mails, discussion groups, forms for comments, quizzes, feedback, tracking use (log-in \ log-out pages, hit counters, duration, statistics) etc.,<br>• Methodologies, which take into consideration students' learning styles,<br>• Knowledge surveys,<br>• Examination / Certification,<br>• Self-assessment techniques,<br>• Collaborative assessment techniques:<br>  o Critique,<br>  o Brainstorm,<br>  o Discussions, forums,<br>• Quality audits,<br>• Quality management activities<br>  o Total Quality Management (TQM),<br>  o Continuous Quality Improvement (CQI). | |

## 6. Conclusions

The development of e-Learning products and the provision of e-learning opportunities is one of the most rapidly expanding areas of education and training. E-Learning is also one of the areas that attract the most research and development funding. If this investment is to be maximized, it is our challenge to generate robust models for the systematic evaluation of e-learning and produce tools which are flexible in use but consistent in results.

Measuring the quality of the e-Learning systems should be done with the use of multiple-method evaluation strategy that considers both qualitative and quantitative criteria. Qualitative and quantitative criteria suggested to be taken into consideration to evaluate the quality of the UNITE system could be executed through a Delphi method, which:

- allows to measure the quality, using both qualitative and quantitative criteria;

- provides a formal method for quality validation of the UNITE system;
- allows to foresee and suggest the directions for improvement of the system;
- could be used for comparing the quality of current UNITE version with the previous version, or even different e-learning systems.

Authors of this paper analyzed different quality evaluation methods for the purposes of the e-learning systems' assessment. The table 2 shows overall recommendations regarding the methods to use:

- at the e-learning systems' implementation stage;
- for final product assessment;
- for measuring efficiency of the system (i.e. the impact on learners).

The overall conclusion is that the evaluation of e-learning is fundamentally the same as the evaluation of any other learning but with particular groups of variables playing a more prominent role and the impact of others differs significantly from their impact in traditional learning.

## Acknowledgement

The presented research is supported by the project UNITE "Unified eLearning Environment for the School" under EC IST FP6 Program.

This work has been partly supported by the European Social Fund within the National Programme "Support for the carrying out doctoral study programm's and post-doctoral researchers" project "Support for the development of doctoral studies at Riga Technical University".

## References

1. Kirkpatrick D.L. "*Evaluating Training Programs: The Four Levels"* // San Francisco, CA: Berrett-Koehler, 1994.
2. Phillips Jack J. "*Return on Investment in Training and Performance Improvement Programs: A Step-by-Step Manual for Calculating the Financial Return (Improving Human Performance". //* Gulf Publishing, Houston, Texas, 1997.
3. Forehand M. "*Bloom's taxonomy: Original and revised*" // In: M. Orey (Ed.), Emerging perspectives on learning, teaching, and technology, 2005. *http://www.coe.uga.edu/epltt/bloom.htm*
4. Bacsich P. "*Evaluating Impact of e-Learning: Benchmarking*" // In: Proceedings of the eLearning Conference, Brussels, May 2005.
5. Europen Foundation for Quality in eLearning. // *http://www.qualityfoundation.org*
6. *P.Bacsich's "Pick & Mix" system* // Described in: *http://www.alt.ac.uk/altc2005/timetable/files/527/Benchmark_overview.doc*.
7. *The NLN ILT self-assessment tool* // Available at: *http://www.nln.ac.uk/*
8. Marshall S., Mitchell G. *"The "e-Learning Maturity Model" work done for the New Zealand tertiary sector" //* Sector Report, Victoria University of Wellington, Wellington, New Zealand, 2005.
9. *The 24 US IHEP "Quality on the Line" benchmarks //* Described on pages 25 and 26 of *http://www.ihep.org/Pubs/PDF/Quality.pdf*.
10. McKinnon K.R., Walker S.H., Davis D. "*The Australian HE benchmarks most relevant to e-learning"* // The university-wide framework "Benchmarking in Australian Universities", Australia, 2000, *http://science.uniserve.edu.au/courses/benchmarking/benchmarking_manual.pdf*.
11. *The US APQC/SHEEO e-learning benchmarks in "Supporting Faculty Use of Technology in Teaching"* // American Productivity & Quality Center (APQC), Dec 1999, see the section

"STUDY KEY FINDINGS" in: http://www.researchandmarkets.com/reportinfo.asp?report_id=42890
12. CEHE (Consortium for Excellence in Higher Education) team. *"Benchmarking Methods and Experiences"* // Centre for Integral Excellence Sheffield Hallam University, UK, 2003. http://excellence.shu.ac.uk/publications/Final%20Publications/Benchmarking%20Methods%20and%20Experiences.pdf
13. *"ISO 10011-1 1990 Audit Standard in Plain English"* // Guidelines for planning and performing quality audits. Available at: http://praxiom.com/iso-10011-1.htm
14. Wallace S. *"Quality Audit"* // The ePMbook, 2004. Available at: http://www.epmbook.com/qualityaudit.htm
15. De Lemos J.C., Pelin A., Quiroz J. "*The relationship between learning styles and the computer-based instruction system Precalc" //* http://archives.math.utk.edu/ICTCM/EP-8/C17/pdf/paper.pdf
16. Graf S. "*Learning Styles and Cognitive Traits – their Relationship and its Benefits in Computer-Based Educational Systems"* // http://wit.tuwien.ac.at/people/graf/slides/RelationshipLSCT.pdf
17. Ehlers U.-D. et. al. *"Quality in e-Learning". Use and dissemination of quality approaches in European e-learning*. // A study by the European Quality Observatory. Cedefop Panorama series, Luxembourg: Office for Official Publications of the European Communities, 2005.
18. *Standard Glossary of Software Engineering Terminology* // http://standards.ieee.org/
19. *The Encyclopedia on Educational Technology* // http://coe.sdsu.edu/eet/

***T.Rikure, L.Novickis. Elektronisko apmācības sistēmu kvalitātes novērtēšanas metodes***

*Elektronisko apmācību lietojumu un sistēmu izstrādes nozare pašlaik ļoti ātri attīstās un paplašinās. Viens no svarīgākiem aspektiem elektronisko apmācību sistēmu izstrādē ir noteikt vai izstrādātās sistēmas kvalitāte atbilst pedagoģiski pamatotai un finansiāli rentablai sistēmai. Rakstā ir apskatītas vairākās kvalitātes novērtēšanas metodoloģijas un pieejas, kuru realizēšanai tiek izmantoti kvalitatīvie un kvantitatīvie kritēriji. Ir doti autoru komentāri šo pieeju iespējamai lietošanai e-apmācības sistēmu kvalitātes novērtēšanai.*

*Kvalitātes novērtēšanas metodoloģijas un pieejas ir apskatītas UNITE projekta ietvaros, kas ir Eiropas Komisijas 6.ietvarprogrammas „STREP" tipa projekts. UNITE projekta ietvaros ir plānots izstrādāt un ieviest tehnoloģisko platformu, kas tiks papildināta ar pedagoģisko saturu ar nolūku veidot un izstrādāt augstas kvalitātes e-apmācības saturu vidusskolas skolnieku apmācībai. Lietišķo datorsistēmu programmatūras (LDP) profesoru grupa ir UNITE projekta partneris, kurš ir iesaistīts kvalitātes novērtēšanas metodoloģijas izstrādes un ieviešanas posmos, un kura galvenie pienākumi iekļauj: 1) kvantitatīvās validācijas metodoloģijas izstrāde; 2) validācijas aktivitāšu vadība Latvijas vidusskolās.*

***Rikure T., Novitsky L. Evaluation of the e-Learning applications and systems***

*The development of e-Learning products and the provision of e-Learning opportunities is one of the most rapidly expanding areas of education and training. An important aspect in implementation of e-Learning systems is to determine whether the system and courseware are pedagogically sound and cost effective. Different evaluation methodologies and approaches using qualitative and quantitative criteria are discussed in the paper, including their possible use for the evaluation of e-Learning systems.*

*Quality evaluation approaches are discussed in the frame of UNITE project, which is a Specific targeted research project (STREP) for the 6th Framework Programme (FP6) of the European Commission. The UNITE consortium aims at developing and establishing a technical platform enhanced with pedagogical guidance for the creation of high-quality e-learning content for secondary school children. The UNITE portal-like platform intends to support the re-use of content material, the exchange of best practices, and the improvement of pedagogic models. Division of Applied Systems Software at Riga Technical University (RTU) is a UNITE project partner and main contributor for the design and development of the validation methodology, which key responsibilities in the project include: 1)designing the quantitative assessment methodologies for the validations; 2)leading the validation activities in Latvia.*

***Рикуре Т., Новицкий Л. Оценка качества систем электронного обучения***

*Разработка систем электронного обучения на данный момент является одной из самых быстро развивающихся областей обучения и образования. Важным аспектом во внедрении систем электронного обучения является возможность определить педагогическую ценность обучающей*

*программы, а также ее финансовую рентабельность. В данной статье рассмотрены, по мнению авторов, наиболее подходящие и заслуживающие внимания методики оценки качества, а также даны рекомендации по их использованию применентельно кк элекронным обучающим системам .*

*Методики оценки качества систем электронного обучения рассматриваются в рамках проекта 6-ой рамочной программы Европейской Комиссии UNITE. Целью проекта UNITE является создание и внедрение технологической платформы с использованием педагогического модуля для создания обучающего материала (контента) высокого качества для школьников средних школ. Профессорская группа «Lietišķo datorsistēmu programmatūras» (LDP) является партнером в данном проекте. Основными задачами профессорской группы являются: 1) разработка количественной методологии оценки качества системы электронного обучения, 2) управление процессом оценки качества в школах Латвии.*