

Decision making model for strategic planning of e-learning implementation

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Abstract. *Strategic planning of e-learning implementation includes decision making about the most suitable form of implementing e-learning on different levels. Decision making about e-learning implementation has been covered as consisting of four phases: (1) intelligence, (2) design, (3) choice and (4) implementation. During the Intelligence phase we have precisely identified our central decision problem and have conducted situation analysis. In the Design phase we have developed alternatives and established criteria and subcriteria. The questionnaire about the importance of the advantages and goals of e-learning implementation and about criteria and subcriteria significant for decision making was created. Essential for the survey was use of Croatian e-learning experts that are familiar with higher education (HE) environment. Further, we connected these findings with the results of the factor analysis which was performed on the complete survey. The results of the factor analysis have served as input in the multicriteria decision model (AHP) that we have developed in the Choice phase.*

In this article, firstly we will present and analyze the results of the complete survey. Secondly, the outputs of factor analysis will be stated and compared with the model used in the questionnaire. Finally, the structure of AHP model will be given and qualitative and quantitative evaluation of the model will be indicated.

Keywords. *e-learning, mathematical modelling, decision making, AHP*

1. INTRODUCTION

E-learning is usually defined as a type of learning supported by information and communication technology (ICT) that improves quality of teaching and learning. Implementation of e-learning contributes to the advancement of higher education (HE). E-learning system is a powerful tool for achieving strategic objectives of the university (teaching, research and serving the society) and it contributes to the progress on the institutional level as well as the personal level, including both teaching staff and students [3]. It supports collecting, analyzing and applying information appropriately and comprises different teaching methods, for example information management, creative thinking, critical thinking, problem solving and collaborative learning [1].

Generally speaking, universities in Croatia are currently at the stage of strategic planning and bringing decisions about the implementation of e-learning in the existing academic activities. Strategic planning and decision making about the e-learning implementation is one of the aims of Tempus EQIBELT project [8] coordinated by the University of Zagreb, which provides useful platform for our research.

In our paper we will present the possibility to use mathematical models and statistical techniques in strategic planning and decision making about e-learning.

2. OBJECTIVES AND RESEARCH METHODOLOGY

The overall objectives of the study are:

- to provide basis for decision making for members of EQIBELT project team and university strategy teams in the process of creation of e-learning vision and strategic documents
- to develop the general model for decision making about e-learning implementation in the HE based on theoretical findings and surveys results
- to complete the factor analysis, validate the theoretical model and reduce a large number of variables to a smaller number of factors, i.e. designing the improved theoretical model for modelling purposes
- to develop the AHP and ANP model for decision making about e-learning implementation in HE
- to compare decision models for e-learning implementation in HE based on some other research methods or built on questionnaires including experts from other countries

The specific objectives of this paper are:

- presentation and analysis of the results of questionnaire performed on expert group
- presentation and validation of the theoretical model for decision making about e-learning implementation in HE, by means of factor analysis
- developed structure of AHP model for strategic planning of e-learning implementation

- qualitative analysis of contributions from the questionnaire

We have treated decision making as consisting of four phases: (1) intelligence, (2) design, (3) choice and (4) implementation.

During the Intelligence phase we have precisely identified our central decision problem and have performed situation analysis which has included a review and presentation of key facts and major trends concerning the problem stated.

In the Design phase we have developed a theoretical model for decision making about e-learning implementation and created the questionnaire which was based on this theoretical model (criteria/subcriteria). We have analyzed many relevant sources, but the most important inputs for establishing the criteria/subcriteria and developing the theoretical model were e-learning strategic documents of leading EU universities.

The alternatives in decision making process on e-learning implementation are:

- ICT supported face-to-face learning,
- Blended learning and
- Learning that is entirely online.

In the statistical evaluation of the results we have used factor analysis to validate the theoretical model for decision making about e-learning implementation.

We have connected the results of the complete survey with the factor analysis and these results have served as input in the multicriteria decision model (AHP) that we have developed in the third phase.

The fourth phase of the decision making will be the implementation of e-learning. The action plan and the control system will be included in the fourth phase.

3. QUESTIONNAIRE DESCRIPTION AND RESPONSE

After we had developed the theoretical model for decision making about e-learning implementation, we have created a questionnaire about the importance of the advantages and goals of e-learning implementation and about criteria and subcriteria essential for decision making about the e-learning implementation. The alternatives were not included in the questionnaire, but explanation of each criteria/subcriteria was attached to the questionnaire.

The pilot survey had been conducted at the 1st Policy Workshop on Creating University E-Learning Vision and Strategy, held in March 2006 in Dubrovnik [8], where 33 questionnaires were collected. After the pilot survey, we have carried out the complete survey and collected a total of 90 questionnaires. The participants were: vice-rectors, vice-deans, members of relevant university bodies, members of government bodies responsible for implementation of e-learning methodology and technology, members of EQIBELT project team and university strategy teams, university teachers and student representatives involved or interested in e-learning, coordinators of CARNet reference centres for e-learning, members of the project team for standardization of e-learning material, project

managers of e-learning projects in CARNet [7], tutors in ELA (E-Learning Academy) [7] and e-learning specialists in SRCE [9]. The criteria for the selection were: expertise in e-learning and familiarity with HE environment. In other words, a representative sample of e-learning experts in Croatia was surveyed.

1. THE RESULTS OF THE SURVEY

In this section we present the results of the complete survey on the 90 experts on e-learning in the HE in Croatia and compare them with the pilot survey.

In all questions the discrete scale for validation of importance was from 1 to 5. Figure 1 shows the ratings of advantages of e-learning implementation. In Figure 2 we can find the results of prioritizing of goals of e-learning implementation and Figure 3 ranks importance of criteria. Details about ranking of the proposed subcriteria are given in the Table 1.

The most important advantages of e-learning implementation are *Accessibility of knowledge*, *Flexibility of learning* and *Preparation of students for lifelong learning*. There are slight changes from the pilot survey but the groupings (first three advantages and last three advantages) remain the same.

The highest ranking goals of e-learning are *Improving the quality of educational process and learning outcomes* and *Innovation and modernization of the higher education system*. The goals *Prepare students for lifelong learning* and *Enable better and broader access to education* were also recognized as very important. Let us emphasize that the experts consider again, the improving the education quality as the most important goal of the e-learning implementation. It can be recognized as a sign of awareness that introduction of quality culture in Croatian higher education system is very important.

All proposed criteria were accepted as important, but four of them were ranked above the average mark of four. These criteria are *Organizational readiness of environment*, *Development of human resources*, *Availability of human resources* and *Availability of basic ICT infrastructure*. *Legal and formal readiness of environment* and *Availability of specific ICT infrastructure* are ranked below the average. This last ranking reflects stage of development of e-learning in Croatia, which is generally below the EU level, and therefore the importance of legal framework and appropriate ICT infrastructure is not recognized. Compared to the pilot survey, this complete survey respected more the availability and development of human resources and we found it much more in accordance with EU experiences. In general, the results of the complete survey are very similar to the results of the pilot survey and this fact confirms the consistency of the performed research.

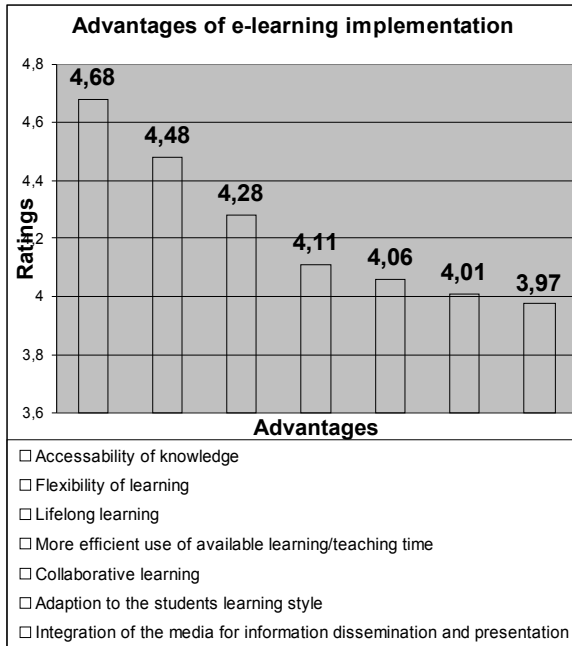


Figure 1. Advantages of e-learning implementation

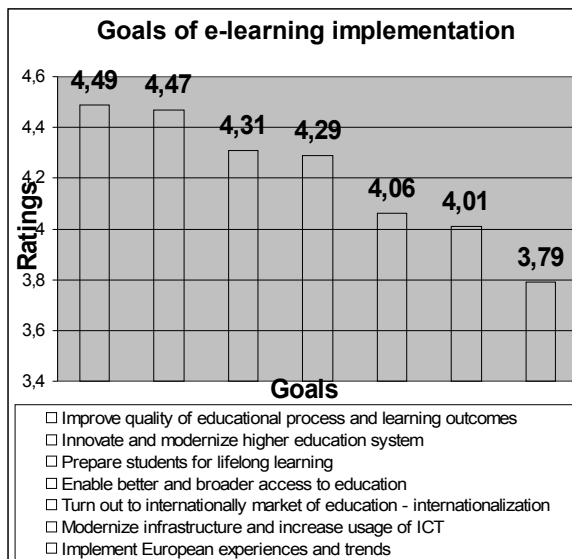


Figure 2. Goals of e-learning implementation

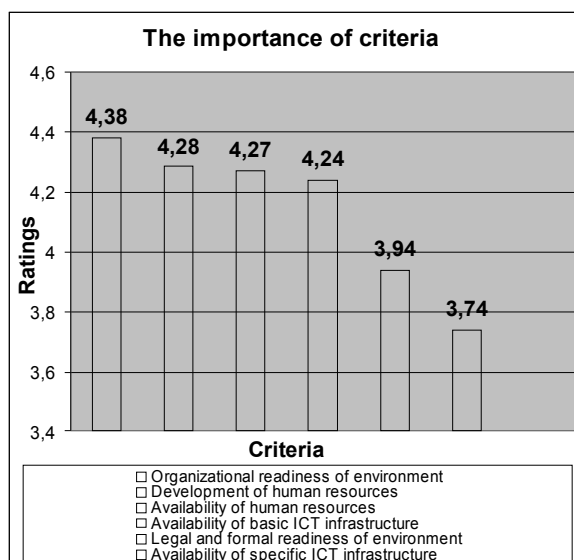


Figure 3. The importance of criteria

Table 1. The importance of subcriteria

ORGANIZATIONAL READINESS OF ENVIRONMENT	
Faculty strategy for development	4,54
Organizational readiness of universities/faculties for e-learning implementation	4,42
University framework for development	4,34
Financial readiness of universities/faculties for e-learning implementation	4,21
AVAILABILITY OF BASIC ICT INFRASTRUCTURE	
Network infrastructure	4,50
Teachers and students equipped with computers	4,43
Classrooms equipped for e-learning	4,17
Integral information system of universities/faculties	3,86
DEVELOPMENT OF HUMAN RESOURCES	
Continuous training of academic staff	4,63
Continuous training of support staff	4,17
Training of students for use of e-learning	4,04
LEGAL AND FORMAL READINESS OF ENVIRONMENT	
Evaluation and quality control at universities/faculties	4,20
System and criteria for academic staff promotion	4,04
Standardization of digital educational materials	4,03
Protecting intellectual property rights on state and academic level	3,49

AVAILABILITY OF HUMAN RESOURCES	
Specialized e-learning centres at universities	4,56
Availability of technical support staff for e-learning	4,36
Availability of support staff for graphical design, animation and video	4,09
Availability of support staff for methodology of e-learning	4,08
AVAILABILITY OF SPECIFIC ICT INFRASTRUCTURE	
Virtual learning environment	4,31
Managed learning environment	4,06
Library management system	3,97
Production of video and audio materials	3,61
Network videoconferencing system	3,60
Exam management system	3,57
Video and audio streaming	3,49
Systems for simulation and virtual environment	3,32

4.1. Additional contributions from the experts

In the questionnaire we asked the participants to add additional advantages and goals that were not listed. Here we point out some of their contributions.

Additional advantages of e-learning implementation at universities: possibility of student self evaluation; interactive evaluation of knowledge; constructive approach in acquisition of knowledge; building learning communities (networks of learners); enable student initiative and creativity; transparency of student assessment; enable efficient teaching for more students; better planning in advance “covers” possible mentor’s inadequacies; wider accessibility of education to students with disabilities and underrepresented groups; better documented process of learning and assessment process; new emphasis on methodology and pedagogy etc.

Additional goals of e-learning implementation at universities: reduction of costs of learning and better accessibility of education and training; contribution to competitiveness of national economical players; better transparency of information on faculty and university level; increase the efficiency of studying and decrease the student drop out etc.

2. RESULTS OF THE FACTOR ANALYSIS

Factor analysis is a generic term for a family of mathematical and statistical techniques that can simultaneously manage over a hundred variables, compensate for random error and invalidity, and disentangle complex interrelationships into their major and distinct regularities [6].

We have used factor analysis to validate the theoretical model (Table 2), to reduce a large number of variables to a smaller number of factors for modelling purposes (AHP modelling), to specify the strength of the relationship between each factor and each variable and to determine which sets of items should be grouped together in the theoretical model. The complete results of the performed factor

analysis are presented in the paper “Validation of theoretical model for decision making about e-learning implementation” submitted to JIOS [4].

The extraction method which was used in the factor analysis was Principal Component Analysis [2] and the rotation method was the orthogonal Varimax rotation [2] with Kaiser normalization. The number of factors was specified, $m=5$ (5 factors were recognized in the theoretical model). The factor analysis was performed with the support of the statistical program SPSS [2].

We set the lower boundary for projection of variable variance on the factor on 0.519 and noticed that 6 variables did not correlate above 0.519 with the principal components of the original correlation matrix and therefore we excluded them from the model. Moreover, 5 out of the above mentioned 6 variables relates almost equally to two or three factors. Finally, the new theoretical model was reduced to 21 variables [4]. Experts did not agree upon importance of *Protecting intellectual property rights* and *Standardization of digital educational materials* and in our opinion it shows that in general the present state of e-learning implementation in HE in Croatia is at a rather early stage. Furthermore, the variables *Training of students for use of e-learning*, *Integral information system of universities/faculties*, *Virtual learning environment* and *Organizational readiness of universities/faculties for e-learning implementation* were excluded because of the redundancy with other variables in the theoretical model.

The factor analysis results have also confirmed 5 factors of the theoretical model for decision making about e-learning implementation (Table 2).

The factor analysis performed does not only confirm the major findings of prior data acquisition and analysis, but it also refines and better restructures our first theoretical model. We assume that there are two reasons for correspondence between the two models. Firstly, the fact that the qualitative analysis in the first part of research was thoroughly made on a considerable sample of strategic documents on e-learning implementation and, secondly, the use of experts in the survey. The latter was essential for this highly specific area which requires both familiarity with e-learning and expertise in the HE environment.

Table 2. The results of the factor analysis (*Rotated Component Matrix*)

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	F 1	F 2	F 3	F 4	F 5
F1 - HUMAN RESOURCES					
Availability of support staff for methodology of e-learning	,883	3,415E-02	5,202E-02	-1,120E-02	-4,832E-02
Availability of technical support staff for e-learning	,835	6,881E-02	,119	2,543E-02	,103
Availability of support staff for graphical design, animation and video	,761	,118	9,200E-02	,105	1,353E-02
Continuous training of support staff	,709	,146	,164	,196	,106
Specialized e-learning centres at universities	,652	-1,242E-03	,176	,206	4,064E-02
Continuous training of academic staff	,610	,175	,139	,238	,156
F 2 - SPECIFIC ICT INFRASTRUCTURE FOR E-LEARNING					
Video and audio streaming	-,196	,840	9,800E-02	-1,927E-03	,108
Network videoconferencing system	-5,610E-02	,806	,176	,204	,154
Systems for simulation and virtual environment	,265	,784	-9,944E-02	9,253E-02	,153
Production of video and audio materials	,214	,769	9,195E-02	-9,597E-03	-4,100E-02
Exam management system	,160	,609	,254	,136	-,101
Library management system	,242	,603	,179	9,750E-02	-,276
F 3 - BASIC ICT INFRASTRUCTURE FOR E-LEARNING					
Network infrastructure	,163	,193	,778	,107	3,312E-02
Teachers and students equipped with computers	,266	,105	,720	-6,693E-02	-1,287E-02
Classrooms equipped for e-learning	-3,167E-02	,183	,625	2,887E-02	,564
Managed learning environment	,268	,233	,528	,417	-,240
F 4 - STRATEGIC READINESS FOR E-LEARNING IMPLEMENTATION					
Faculty strategy for development	,191	3,302E-02	5,800E-02	,792	,154
University framework for development	9,796E-02	,282	-,100	,662	-3,168E-02
Financial readiness of universities/faculties for e-learning implementation	,194	-3,291E-02	,397	,558	7,218E-02
F 5 - LEGAL AND FORMAL READINESS FOR E-LEARNING IMPLEMENTATION					
System and criteria for academic staff promotion	,123	-9,182E-02	-4,377E-03	2,484E-02	,807
Evaluation and quality control at universities/faculties	,340	,251	6,778E-03	,289	,512

3. AHP BASED MODEL FOR DECISION MAKING ON E-LEARNING IMPLEMENTATION

AHP is one of the most widely exploited decision making methods in cases when the decision (the selection of given alternatives and their prioritising) is based on several criteria/subcriteria.

The method application can be explained in four steps [5]:

1. The hierarchy model of the decision problem is developed in such a way that the goal is positioned at the top, with criteria and subcriteria on lower levels, and finally alternatives at the bottom of the model.
2. After the hierarchy has been determined, the decision makers begin the procedure of prioritising in order to determine the relative importance of elements on each level. On each hierarchy structure level, the pair-wise comparisons should be done by comparing all possible pairs of the elements of this level, starting with the top of the hierarchy and working this way to the lowest level.
3. On the basis of the pair-wise comparisons, relative significance (weights) of elements of the hierarchy structure is calculated. Finally, these results are eventually synthesised into an overall priority list of alternatives. Decision maker is allowed to change preferences and to test the results if the inconsistency level is considered high.
4. Results are priorities of the alternatives in the form of priority list of alternatives and hierarchy tree with objectives' relative significance. The sensitivity analysis is also carried out. Sensitivity analysis is used to determine the sensitivity of the alternatives to changes in the objectives' priorities.

In the Choice phase, we have developed AHP based model for decision making on e-learning implementation based on the reduced and restructured theoretical model (21 variables).

We have built the AHP model in TeamEC2000 software which is specially designed for making group decisions. The hierarchy tree (criteria and subcriteria) and alternatives for our problem are shown in Figure 4.

The evaluation of the established AHP model will be carried out in two ways. First approach is based on the qualitative analysis of similarity of the obtained results with implementation strategies of comparable European universities. The problem in this analysis is that the Croatian universities did not define their benchmark universities. Benchmark universities are a group of universities which we would like to compare ourselves to. These comparable universities have to be identified on the university level as a result of serious institutional research and therefore this can not be obtained as the output of some individual research.

The second one is quantitative one in which as a sample, the group of the vice-deans/deans of faculties, schools and departments and the members of university bodies responsible for teaching,

quality improvement or university development, will be used. These professionals have a responsibility to initiate and implement strategic decisions about the most suitable option for e-learning implementation at Departments/Faculties/Universities in Croatia.

The results of the group decision making incorporates knowledge of all stakeholders in the process of group decision making and will conclude with the recommendation for applying the most suitable option for implementing e-learning. This evaluation will be reported on in another paper.

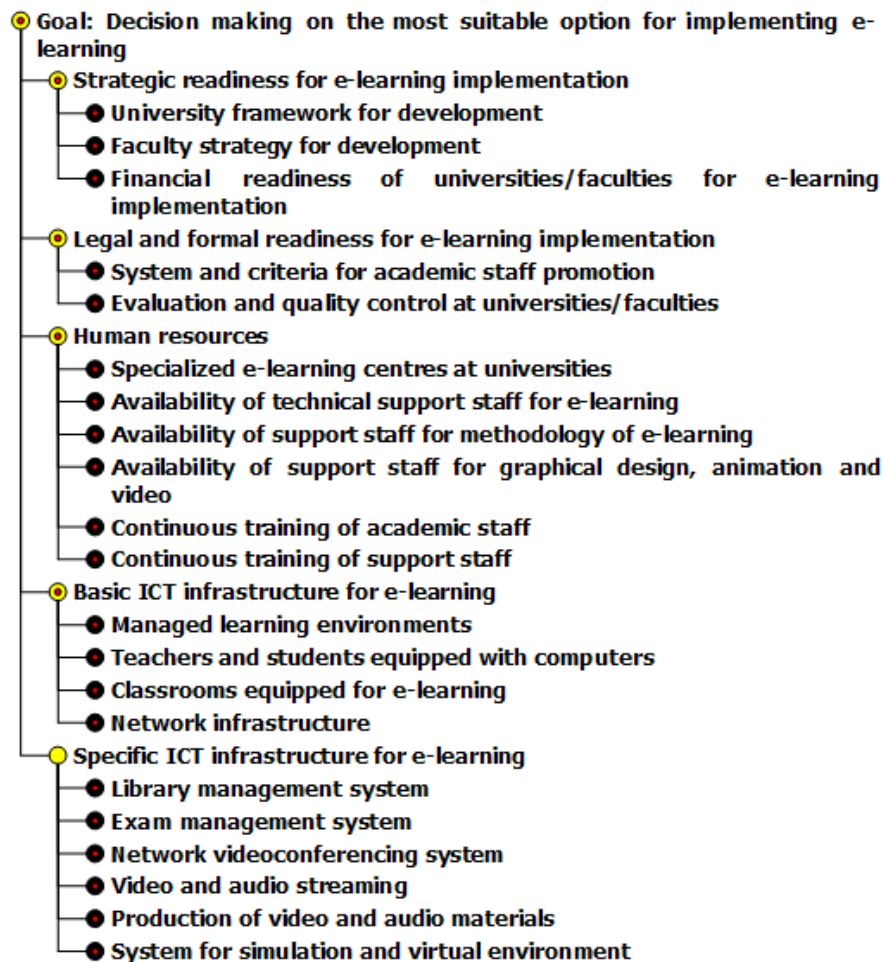


Figure 4. AHP based model for decision making on e-learning implementation

7. CONCLUSION

The results of the survey performed on group of experts on e-learning in HE were used as input for mathematical modelling. This modelling contributes significantly to institutional planning, management and quality development for online distance education and e-learning.

Organizational readiness, that includes university framework and faculty strategy for development, as well as Financial readiness, were recognized as the most influential criteria for e-learning

implementation. Furthermore, the Human resources criterion, that covers continuous training of academic staff, support staff and students, was also highly ranked.

Survey participants ranked the Basic ICT infrastructure much higher than Specific ICT infrastructure and this, among other, reveals the fact that Croatian universities still starve for basic ICT infrastructure.

Legal and formal readiness in the AHP model was reduced to just two subcriteria (Academic staff promotion and Quality control), since the Standardization of e-learning materials and Intellectual property rights were not uniformly recognized as significant or insignificant in the factor analysis.

9. REFERENCES

- [1]T. Bates. Strategy and Visions of e-learning in Higher Education, Zagreb, Croatia, 2005.,
URL: <http://eqibelt.srce.hr/lectures/bates.html>, 10.03.2006.
- [2]N. Brace, R. Kemp, R. Snelgar. SPSS for Psychologists: A guide to data analysis using SPSS for windows. New York, N.Y: Palgrave, 2000.
- [3]B. Divjak, N. Begičević. Imaginative acquisition of knowledge - strategic planning of e-learning. ITI 2006, Cavtat, Croatia, 2006.
- [4]B. Divjak, N. Begičević. Validation of theoretical model for decision making about e-learning implementation. Submitted to Journal of Information and Organizational Sciences, Faculty of Organization and Informatics Varaždin, University of Zagreb
- [5]T. Hunjak, N. Begičević. How to choose the most suitable form of implementing e – learning?. IIS 2005, Varaždin, Croatia, 2005.
- [6]R.J. Rummel. Understanding Factor Analysis. The Journal of Conflict Resolution, 1967.,
URL: <http://www.hawaii.edu/powerkills/>, 20.04.2006.
- [7]*** Croatian Academic and Research Network. <<http://www.carnet.hr/>>, 12.03.2005.
- [8]*** Education Quality Improvement by E-Learning Technology. <<http://eqibelt.srce.hr/>>,
16.01.2006.
- [9]*** Sveučilište u Zagrebu, Sveučilišni računski centar. <<http://www.srce.hr/>>, 10.01.2006.