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PRIORITISATION OF E-LEARNING FORMS BASED ON PAIR-WISE COMPARISONS

Tihomir Hunjak, Nina Begičević
University of Zagreb,Faculty of Organization and Informatics, Varaždin, Croatia
{ tihomir.hunjak, nina.begicevic }@foi.hr

Abstract: *There are different forms of teaching using ICT, and they differ according to the level of technological support, the role and tasks of the participants, the level of students' participation, the physical location of the participants and their interaction.*

Distance learning is the common name for the process of obtaining knowledge and skills with the assistance of ICT and other forms of distance study. E-learning is a special form of such teaching. In terms of the teaching materials' specific qualities, and the recommendation of teaching methods for successful teaching, there are different options for applying e-learning in teaching. E-learning can be used either as an independent form of teaching, or as a support to the already established systems of education, or even as their addition. The problem that is being solved in this paper is the prioritisation of e-learning forms for the specific teaching unit, subject, group of subjects, or the whole teaching programme. All this should be done regarding the context, which is characterised by the quality and innovative teaching, available professionals, equipment, possibility of students' approach to technology, organization of teaching, and rules and regulations.
This problem was solved with the assistance of AHP models developed in the process of group decision making supported by sw TeamEC2000.

Keywords: *e-learning, AHP model, group decision making.*

1. INTRODUCTION

Distance learning is the process of acquiring knowledge and skills in situations when student and mentor are physically dislocated. E -learning is a special form of such teaching. E -learning is a type of learning supported by information communication technology and by fast computer networks.
E-learning and some other different forms of teaching with the assistance of ICT can increase quality of classes and its contents, thus enabling students to solve problems and make individual decisions. Implementation of e-learning can

attenuate the consequences of some occurrences which are very often results of high education expansion: increased class requirements, increased number of students (the percentage of adult, female, and minority learners is increasing [6]), lack of time for scientific research, employment of inexperienced teaching staff, lack of student-professor interaction.

There are different options for applying e-learning in teaching. In terms of the specific qualities of teaching material and the recommendation of teaching methods for successful teaching, e-learning can be used either as an independent form of teaching, or as a support to the already established systems of education – blended - learning model [9, 11].

The problem that is being solved in this paper is the prioritisation of e-learning forms in the context which is characterized by the quality and innovative teaching, available professionals, equipment, possibility of students' access to technology, organization of teaching, and rules and regulations. This problem can be solved using AHP model developed in the process of group decision making supported by software TeamEC2000. The model was tested on the example of Faculty of Organization and Informatics in an anonymous group decision making. Process and results of the conducted group decision making will be described in this paper.

2. THE PROBLEM - *PRIORITISATION OF E-LEARNING FORMS BASED ON PAIR-WISE COMPARISONS*

Informatization has become a part of daily life and communication, it enabled progress in almost all the areas, and it created a unique world global market of information and technology. Application of ICT made a big progress in education. Basic motives for application of technology in class are: improvements of learning quality, students acquire skills of using information technology which they will use in their work and their daily life, expansion of education and training availability, answer to "imperative technologies", cutting down education costs, increasing profitability of investing in education [1].

Implementation of e-learning is only one of the ways of applying modern ICT, which then contributes to the progress of high education.

Analysis of different characteristics, advantages and disadvantages of implementing e-learning was done in frame of SWOT analysis (Table 1). SWOT analysis is a means of system relation analysis of internal advantages (S-Strengths) and weaknesses (W-Weaknesses) and external favourable opportunities (O-Opportunities) and threats (T-Threats) [2]. SWOT analysis was a starting point in creating hierarchy model of the decision problem (objective, criteria, sub-criteria and alternatives).

Table 1. SWOT analysis of e-learning

Strengths	**Weaknesses**
▪ Creative teaching [8]; (e-learning is more fun and interesting [12]) ▪ Better visualization and simulation, innovation and multimedia capabilities [1, 11] ▪ Possibility of dynamic interaction [8] (student can get better access to the instructor and immediate feedback [5]; discussion with other students (collaborative learning [5])); ▪ Students are treated more equally [5] ▪ E-learning adapts to the learner's style [5] (students learn independently and at their owe pace) ▪ E-learning integrates training and work [5, 11] ▪ E-learning saves money: travel expenses, facilities and supplies (students take the class from their own offices or homes; classroom supplies are reduced); reduced administrative costs [1, 5, 13] ▪ E-learning saves time (for both teachers and students) [1, 5] ▪ Access to resources [8]; (information are easily accessible [12])	▪ Students need to be well motivated, active, self-conscience and self-organized [8] ▪ Students loss of educational value (students miss the lectures, discussion, questions, assignments, groupwork, and the professor's views and perspectives) [4] ▪ Lack of student participation in interactive online activities (they are afraid of embarrassing themselves in public) [17] ▪ Students fear of losing human contact [5] - (face to face communication); Internet has the potential to isolate students [4] ▪ Misunderstandings [10] and misinterpretation [5] ▪ Financial investments and costs [4] ▪ Technological base and technical requirements for students and teachers [8, 10] ▪ Required re-organization [1, 11] ▪ Problem of authorizing class contents on web [1] ▪ Problem of student identification (when knowledge testing) [1]
Opportunities	**Threats**
▪ Learning anywhere and any time – "just in time – any time" approach [13] ▪ Lifelong learning [6] ▪ Flexible access to learning (e-learning can reach more students over a range of times and locations, possibility of parallel working and studying) [4, 8, 9] ▪ Cutting down education costs [1, 5, 13] ▪ Increased share of high education staff [1] ▪ Answer to technology "imperative" [1]	▪ Problem of acknowledging such education and the acquired diploma from employers [1] ▪ Possibility of increased share of potential employees with easily acquired diplomas, without having the knowledge adequate to their graduated degree [1] ▪ Technology could overcome face to face communication (e-learning can fail in developing required social skills and human contact can be lost [5])

2.1. DESCRIPTION OF ALTERNATIVES

E-learning can be implemented in the specific teaching unit, subject, group of subjects, or in the whole teaching programme (curriculum). It can be used as an independent form of teaching, or as its addition. There are few potential alternatives for applying e-learning in teaching. E-learning can be implemented as a support to the already established systems of education (blended – learning model [9, 11]), it can be partially introduced (only for one subject or group of subjects), or completely independently, as a separate programme with all the advantages this way of learning offers. Problem of choice among the alternatives will be solved with the assistance of AHP model developed in the process of group decision making.
Potential alternatives are described in Table 2.

Table 2. Set of alternatives

Alternatives	Description
No	Unconditional no. Current situation and conditions at faculty, on both university and state level, do not correspond to and do not support implementation of e - learning in high education.
Complementary	Complementary to traditional classroom teaching – hybrid learning. Selected courses would enable integration of e–learning, traditional classroom teaching and multimedia, so called blended – learning model.
Partly	Only for some courses. Selected courses where e-learning brings advantages (new visualization and simulation possibilities) would be only conducted on distance, leaving out traditional class option.
In whole	Unconditional for all the courses. The entire faculty curriculum and all the courses would be included into e-learning programme. This would enable students to acquire a diploma without being physically present at the faculty.

2.2. CRITERIA AND SUB-CRITERIA DESCRIPTION

The hierarchy tree of the decision model (objective, criteria, sub-criteria and alternatives) was created in several stages. In the first stage different sources were studied [1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 16, 17, 18], and SWOT analysis and first draft of the model were done. In the second stage e-mail brainstorming among high education employees was conducted. They created the second model version by updating the first draft. The final model version was created based on additional information gathered from e-learning experts. Figure 2 shows the hierarchy model of the decision problem.

In the continuation of the text, criteria and sub-criteria applied in the model are being briefly described.

Criterion **Classes and class contents** includes sub-criteria: *Quality*, *Multimedia and innovativeness* and *Interaction and communication*. Quality of classes and class contents is a very important sub-criterion which implies satisfaction of the students with quality of all class segments: knowledge transfer, professor credibility, possibility of searching, analysing, interpreting information and availability and acquisition of content. Reuse and management of learning content is one of today's challenges in e-learning. Standards in e-learning aim to enable the reuse of technology-based learning content across multiple environments and products [16]. For academic institutions and virtual universities, the primary focus is on the internal reuse of the learning content. There are many advantages to standardise e-learning, but there are as yet only specifications for standards and no actual standards [16].

Internet and multimedia software significantly enrich educative communication. It is important to estimate if and when they bring new visualization and simulation possibilities which cannot be found in a traditional classroom.

Interaction and communication is different in e-learning than in classroom teaching. Interaction between students and professors in the classroom is direct – face-to-face, which has, of course, a huge advantage, however there a trend of increased number of students has been noticed, and it results in so-called mass lecturing. E-learning enables "individual" attention of professor toward student, a student gets better access to the instructor and immediate feedback.

Criterion **Technology** includes sub-criteria *Software system* and *Administrative procedures*. Software system requires higher complexity and security in implementation of e-learning than it is the case in traditional classes. Every lecturer who teaches his/her class exclusively on the web must have at his/her disposal a back-up system which can take over the work in case the server breaks down, or needs servicing.

Administrative procedures relate to the system (either traditional education or e-learning) and desk. By implementing e-learning it is necessary to introduce new administrative and academic enrolment procedures, financing, and organization and realization of classes.

Criterion **Teacher training** includes sub-criteria *Knowledge of tools* and *Pedagogical aspects*. Holding technology-aided classes requires a high degree of staff' skills and requires a level of competence for lecturing and technical problems. Such training should be an integral part of education and curriculum. Lecturers should have support of both technical and pedagogical staff.

Sub-criterion Pedagogical aspects refer to pedagogical approach in traditional classes and in e-learning. It is a question weather pedagogical aspect in education

will be lost by implementing e-learning, or the problem of mass lecturing will be solved.

Criterion **Organization of education** includes criteria: *Technical and educational support, Staff availability* and *Profitability of investments*. Technical and educational support (help services, help desks) is a necessary part of every educational institution. If e-learning is a part of an educational institution, and some or all courses have the possibility for online lecturing, it is essential to have technical and educational service which then offers necessary education and help in using, and also designs multimedia elements and specific software.

Staff availability is one of the occurring problems, both in traditional class and in e-learning. Classroom learning is becoming more and more mass lecturing, with too big number of students, and too little number of professors. In e-learning it is important to put in a lot of effort for ensuring online support to students. This is done through tutors-teachers, persons who also monitor student's work and help him/her with possible work problems.

Investment profitability refers to investments into technology and staff, as well as change of infrastructure. Introduction of technology, continuous staff training, and infrastructure change are as important in traditional class as they are in e-learning. The mentioned changes will in short-term lead to increase of expenses: technology is constantly changing, software is being updated, and costs of constant staff training are high. But in long term, profitability of investment in high education can be improved by technology in several ways: enable the institution to reach to a higher number of different students; decrease and cancel some of the teacher performed activities, which could be better performed using technology (in that way teachers have extra time for the more productive activities); increase learning quality, either by training students to achieve better results and learn new skills, or by training them to reach the existing goals quicker and easier [1].

Criterion **Regulations and university support** includes sub-criteria: *University policy* and *Education and diploma acknowledgement*. University policy follows European and world trends, and through CARNet (Croatian Academic and Research Network) [18] it is trying to give support to institutions in carrying out organizational changes due to implementation of e-learning.

Education and diploma acknowledgement is a very important sub-criterion in deciding the level of e-learning implementation into high education. Acknowledgement of e-learning education and its diploma has not been yet legally settled in Croatia.

Criterion **Authorization** represents legal accordance on copyright. All teachers must be acquainted and in accordance with the copyright law. Institutions must, together with teacher, reach clear agreements on ownership of materials created in class. When putting new materials on web, institutions should hire experts for copyright and intellectual property.

Criterion **Immediate student interest** includes criteria: *Activity, motivation and self-discipline*, *Technological base and technical pre-requisites*, and *Availability and adjustability*. Activity, motivation and self-discipline of an individual are crucial motivation factors for a successful class. E-learning can guarantee success only with very motivated students, since students who learn only by Internet tend to quit their studies more often.

Technological base and technical pre-requisites of students are an essential pre-condition for practical work using different technologies. Students should have the basic technical conditions (hardware and software) in order to become a part of a long-distance educational system. They must be trained for work using information technology.

Availability and adjustability of education, as well as the lifelong learning trend, offer a possibility for learning to become an important part of man's life. E-learning is an ideal solution for educational system users because it allows independent time management and physical dislocation.

3. THE AHP APPROACH TO THE PROBLEM

The Analytic Hierarchy Process (AHP) (Saaty, 1980) is a powerful and flexible decision making process which helps people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered [3]. AHP method is implemented in program tool Expert Choice, in versions for individual and group decision making. This method has been applied in fields of management, governing, allocation and distribution for bringing strategy decisions of high importance and responsibility and for bringing tactical decisions of lower importance. 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 (sub-criteria). Complex decision problem solving which this method uses is based on the problem decomposition into a hierarchy structure which consists of the goal, the criteria, sub-criteria and the alternatives [7] (Figure 1).

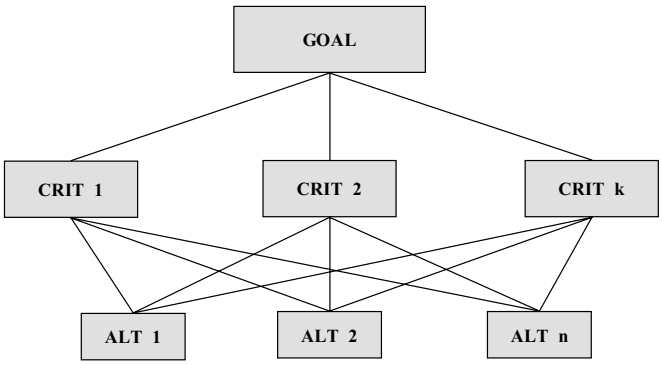

Figure 1. Basic AHP model with goal, criteria and alternatives

The method application can be explained in four steps:

(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 sub-criteria 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 all possible pairs of the elements of this level, starting with the top of the hierarchy and working its way to the lowest level. A pair-wise comparison in EC is the process of comparing the relative importance, preference or likelihood of two elements with respect to another element (the goal) in the level above. There are three pair-wise comparison assessment modes: verbal judgments, graphical judgments and numerical judgments. The decision maker's preferences are expressed by numeric values on 1-3-5-7-9 scale - Intensity of Importance Scale (Table 3) [14].

(3) (On the basis of the pair-wise comparisons, relative significance (weights) of elements of the hierarchy structure are calculated (calculation of relative priorities for each decision making element through a number of numerical calculations), which 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 very high.

(4) Results are priorities of the alternatives (priority list of alternatives) and hierarchy tree with objective's 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.

Table 3. Intensity of Importance Scale [14]

Intensity of importance	Definition	Explanation
1[a]	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

4. IMPLEMENTATION IN A REAL CASE - *FACULTY OF ORGANIZATION AND INFORMATICS*

Expert Choice software based on the Analytic Hierarchy Process (AHP) helps groups to structure decision into objectives and alternatives, prioritise using pair-wise comparisons, and justify decisions using graphical reports and sensitivity analyses. The criteria are presented in a hierarchical structure, decision makers are able to drill down to their level of expertise, and apply judgments to the objectives considered important for achieving their goals [3].
We were using TeamEC2000, specially designed for those who are making group decisions.

Many decisions are too complex so single decision-maker cannot meaningfully synthesize all relevant information and make informed decisions. A group can generate a higher number of ideas and usually know more than an individual does [15]. A group is more ready to bring riskier decisions, since risk is shared among all group members. Group decision making has also certain disadvantages: it slows down decision making process, there are frequent conflicts between group members, and there is possibility of imposing opinion from the side of an authoritative member.

In choosing the most suitable form of implementing e-learning with TeamEC2000 software, advantages of group decision making surpass its disadvantages. Decision making problem is very complex, and this makes it more suitable for group solving. In order to solve the problem it is important that decision makers be competent, that is that they have the needed knowledge and experience of decision making problem. It is also important that the group has more knowledge and experience than an individual. Decision making aided by TeamEC2000 software also eliminates disadvantages of group decision making: it speeds up the process of making a decision, it prevents imposing opinion of an authoritative member, because every decision maker brings in his/her own judgment, and contributes to decrease of conflicts (possible conflicts are only in discussion).

TeamEC2000 accepts judgments from multiple stakeholders using wireless keypads or EC Decision Portal for same time, same place or remote decision making, synthesize judgments from multiple stakeholders and enjoy the peace of mind of knowing that calculations are correct (inconsistency ratio < 0,10), track each team member's judgments, and weight team members and evaluate outcomes based on team member demographics [3].

Using the wireless electronic keypads, decision makers can brainstorm and answer questionnaires, make judgments about the objectives or sub-objectives and alternatives of a decision problem and then the results can be structured into a decision hierarchy. The keypad version keeps the decision makers focused on the problem, while contributing to more efficient use of meeting time.

In our case of "How to choose the most suitable form of implementing e-learning?" on Faculty of Organization and Informatics we were using TeamEC2000 with wireless electronic keypads for 5 decision makers (Participants) and top down structuring with numerical judgments mode. All Participants are employees of the Faculty of Organization and Informatics, and they all posses specific knowledge which makes them competent to assess and to give judgments in the process of group decision making on the most suitable form of e-learning implementation. One Participant has Ph. D. in Information Science, and one of Participants has MA. in Economic Science and three Participants are B. Sc. in Informatics, at the moment they are students of Postgraduate Study. During their studies and training, they were one or more times included in lectures where e-learning was used as a support to the already established traditional classroom teaching. All Participants are "traditional classroom teaching" lecturers on Faculty of Organization and Informatics, and two Participants are involved in creating courses that integrated e–learning and traditional classroom teaching. Two Participants are working on a CARNet project in domain of e-learning. One of the Participants is expert in programming and has experience in developing necessary infrastructure for implementation of e-learning courses. All Participants were

attendants of CARNet' s workshop "Developing courses with help of WebCT tool".

Group decision making was lead and supervised by Facilitator, who was the only one with the access to the central computer. Facilitator's role is to create and modify model's structure and enter or edit Information documents. Facilitator enters participants and demographic information about each participant and optional passwords.

4.2. RESULTS OF GROUP DECISION MAKING

Results of every participant's decision making and results of group decision making were gained by conducting a group decision making. Results of group decision making in TeamEC2000: hierarchy tree with objective's relative significance and priorities of the alternatives, gained by judgment synthesis of participants included in decision making process, are shown in Figure 2.

Criterion *Class and class contents* has the highest relative significance – 0.266, which makes it the most important for reaching the goal. Alternative *Complementary* has the highest priority of 0.400, which means the recommendation is to apply blended-learning model, i.e. to the integrated e-learning and traditional classroom lectures, as the most convenient option for implementing e-learning at Faculty of Organization and Informatics.

The Sensitivity Analysis is also carried out. Sensitivity Analysis offers a stable solution, but it also enables change of input figures and observing consequences on priorities of the alternatives. Sensitivity Analysis is used to investigate the sensitivity of the alternatives to changes in the priorities of the objectives.

There are five types of Sensitivity Analyses: Dynamic Sensitivity, Performance Sensitivity, Gradient Sensitivity, Head to head and 2 D plot. Analyses can be performed from the Goal node or from the current node in the hierarchy such as an objective.

Dynamic Sensitivity Analysis from the Goal node is presented in Figure 3. Dynamic Sensitivity Analysis is used to dynamically change the priorities of the objectives to determine how these changes affect the priorities of the alternative choices. If a decision maker or a moderator think an objective might be more or less important than originally indicated, they can drag that objective's bar to the right or left to increase or decrease the objective's importance and see the impact on alternatives.

Figure 2: Results of group decision making in TeamEC2000

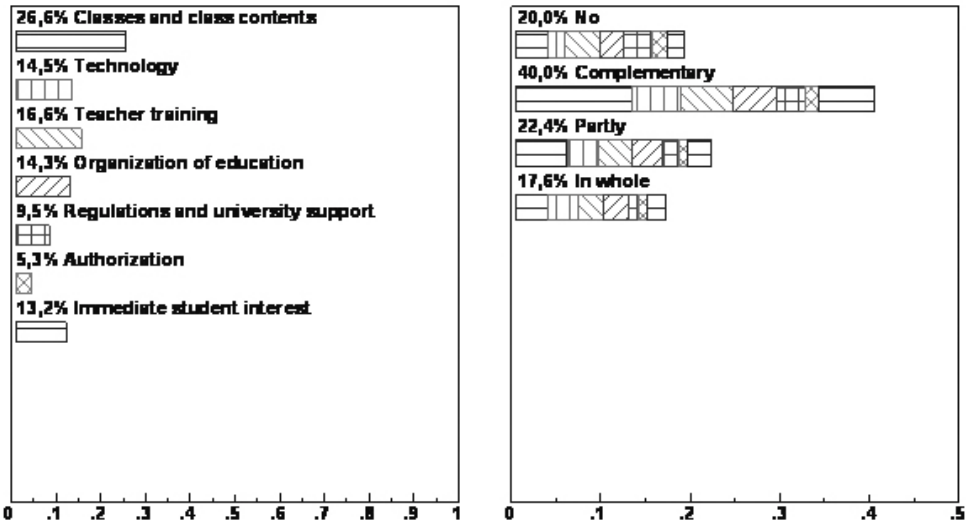

Figure 3: Dynamic Sensitivity Analysis from the Goal node

5. CONCLUSION

This paper shows that the problem of prioritisation of e-learning forms can be solved with the help of multi-criteria modelling. Based on problem analysis, it has been determined that in order to solve the problem, the most suitable form would be group decision making aided by suitable tools. Model for decision making on the most suitable form of implementing e-learning was created using program tool TeamEC2000. The problem of choosing among alternatives was solved with the assistance of AHP model developed in the process of group decision making.
Model was tested at Faculty of Organization and Informatics in an anonymous group decision making, and its result was a recommendation to apply the blended – learning model as the most suitable option for implementing e-learning at Faculty of Organization and Informatics.

We managed to consider all the important criteria and sub-criteria for problem solving in the process of decision making. While conducting the Sensitivity Analysis, we concluded to what level the priorities of alternatives are sensitive to changes of input figures which cannot be unambiguously determined. Results of decision making included knowledge of all the stakeholders in process of group decision making.

Such model for decision making enables multi-criteria analysis, it increases and systemizes knowledge on the problem, it strongly motivates decision makers, and it speeds up and makes cheaper the process of decision making.

The gained results are recommendations for more coherent and more qualitative solution to e-learning implementation problem, and they are an indication of need for systematic e-learning usage in our educational institutions.

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