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Evaluation of the Time Needed for e-Learning Course Developing*

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Abstract: *The paper presents an evaluation of the time needed for the development of an e-Learning course as an essential part of e-Learning development costs. Two quantitative methods are proposed: one-factor regression analysis method and modified parametrical modeling method. The parametrical modeling method is extended by introducing of a set of more precise indicators together with their respective weight coefficients. The application of these methods can be used as preliminary planning of the e-Learning course development costs.*

Keywords: *e-Learning, time evaluation for e-Learning course developing, e-Learning course development costs.*

1. Introduction

The term electronic learning or e-Learning is usually applied to learning performed with the use of modern computer and communication technologies for educational data storage, transfer and presentation of the learning content. These technologies are present in all of the educational process stages – course preparation, learning content transfer and assessment of students' knowledge.

One of the advantages of e-Learning is the acceleration of the study process while cutting down expenses. It makes education more accessible and provides the students with the freedom of choosing the place, time and tools of learning. Using the modern multimedia technologies it is possible to present the study material in a

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more attractive, accessible and comprehensive way [1, 2, 7]. The efficiency of learning is higher, thanks to the interactive character of education, the different type of content, and the possibility for a feedback with the professor or students. According to the studies, the increase in efficiency is up to 50%, compared to traditional forms of learning. The electronic content of the study material can be almost effortlessly maintained and updated. The organization and management of large groups of students become easier as e-Learning provides teachers with the opportunities of monitoring the success of students, detecting possible shortcomings and needs for additional training [3]. The specific characteristics of e-Learning allow in some cases, to "bring back to the classroom" those students who drop out of education for different reasons (for example – impossibility of attending classes because of work activities or for physical/psychological reasons, etc.). e-Learning can also be used to achieve higher qualification of the company staff and to provide "life-time learning" [4, 10, 13].

2. Cost of e-Learning

E-Learning requires some initial investments in software and equipment. Nevertheless, in the long turn it saves time and costs. The first step in cost-benefit analysis of e-Learning is to measure all the direct and indirect costs involved in the design, development, delivery, and maintenance of the e-Learning courseware. Generally, the costs for e-Learning can be structured as follows:

- equipment costs – computers, network devices, other technical means;
- software costs – for developing or buying of software tools used for data storage, presentation, updating of the study material, etc.;
- expenses for teachers' training;
- costs for developing of courses and tests;
- communication costs (for example, Internet connection), costs of providing multiple information media (CDs or DVDs), etc.

The estimation of the cost of e-Learning course development could be based on the following steps [6]:

- gathering assumptions and baseline data for life span of course, total number of students, student learning time, reduction in seat time, burdened compensation for instructor, burdened compensation for student;
- determine design and development costs for creating of courseware and training of the trainers;
- determine delivery costs for the number of learning sessions required, instructor costs, student costs, location fees, equipment fees and student materials;
- administration and maintenance costs for tracking, technical support, updates to content and updates to technology.

One important measure for estimating of the e-Learning costs is the time needed for e-Learning course development. It directly affects the payments of the specialists involved in the development process and indirectly – the losses from delay of the learning process. The current paper deals with the problem of

estimating of the time needed for developing e-Learning courses as a significant part of the estimation of overall e-Learning costs.

3. Estimating of the time for developing of an e-Learning course

There are two main prerequisites that should be considered when trying to estimate the time needed for developing of an e-Learning course – used software tools for e-Course development and methods used for evaluation of the time for development.

Developing of an e-Learning course depends to a great extent on the type of the selected software platform. On the other hand, the choice of development platform depends on the course type, the needs of the students and teachers and the skills and knowledge of the administrators involved in the organization of e-Learning [10].

The most popular software products used currently in the implementation of e-Learning can be classified in the following categories:

- Authoring Packages – Mozilla Composer, FrontPage, Dreamweaver, word-processing packages.
- Learning Management Systems (LMS) – the platforms Moodle, Microsoft Class Server, Microsoft Learning Gateway, WebCT, Atutor.
- Content Management Systems (CMS) – **Enterprise CMS**, **Web CMS**, **Component CMS**.
- Learning Content Management Systems (LCMS) – Xyleme, etc.

The Authoring Packages provide opportunities of learning content developing. The Learning Management Systems satisfy the needs of the educational institutions and the Content Management Systems are efficient in the cases when several teachers work on the course development and they use the same study materials in different courses. The Learning Management Systems are a combination of different types of software solutions.

The methods used for the evaluation of the time needed for the development of an e-Learning course are generalized in [5]. They can be classified as *expert* and *statistical-mathematical methods* (Fig. 1) depending on the type of evaluation.

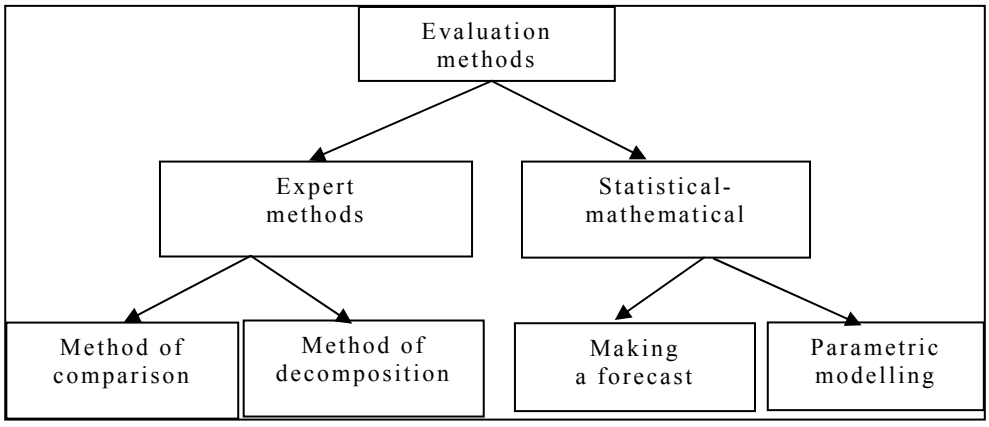

Fig. 1. Methods of evaluation of the time needed for the development of an e-Learning course

3.1. Expert methods

The evaluation of the time needed for the development of an e-Learning course is based on experience, intuition, and knowledge about the process. The time evaluation forecasts are made on the basis of expert opinions, opinions from organizations financing the education courses, as well as technological studies. The "*expert interview*" method is used extensively – the expert information report or more precisely – the time evaluation forecast, is made on the basis of independent assessments by different experts who know well the development process. This method results in correct evaluation when larger numbers of experts are included. It is also important to include surveys of opinions of the future consumers – students who will attend such courses. Questionnaires are used to gather this type of information.

Technological forecasting is gaining wider recognition during the last few years. It is used to evaluate the costs and needs related to a specific e-Learning course. The method also includes study of experts' opinions related to the technological points of emphasis during course development.

Another widely used expert method is "*the method of comparison*". A specific course is selected to be used as a reference and the time of development of different courses is evaluated on the basis of comparison with that reference course. This method explores processes, results and specific indicators comparing them to similar processes, results and indicators, selected as a reference basis. In that way, it is possible to account for the differences with respect to the reference and to explore the reasons and factors which are the sources of these differences. The method of comparison is appropriate for similar courses and when there is no enough information on the course content and duration.

The evaluation of an e-Learning course development time of can be done using the "*method of decomposition*". The decomposition is carried out "from top to bottom" or "from general to detailed characteristics". The course is broken down to several elements, which are then separated into sub-elements until the decomposition reaches the stage of "black boxes" – these are the elements which cannot be decomposed any more. The elements subject to successive decomposition are: functions, goals, tasks, problems, and data. They are described using the so called *supplementary tables*, which are structured depending on the subject of analysis. The tables are used to draw *hierarchical diagrams* (Fig. 2), when the following conditions must be satisfied:

- presence of a tree-like structure;
- for each element, there is a preceding one, except for the root element;
- all end elements with no follow-ups must be specified.

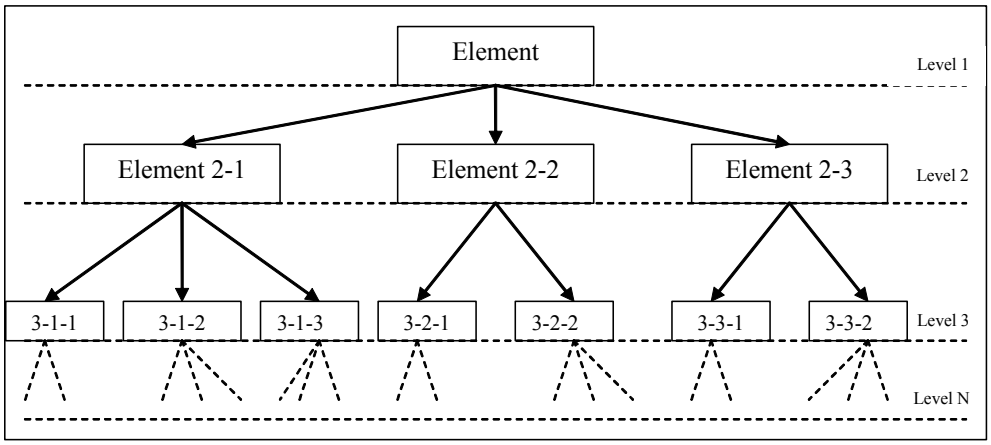

Fig. 2. Hierarchical diagram with a tree-like structure

The method consists in breaking down of the main course goals into tasks and subtasks and evaluating each of them separately. The application of the decomposition method can be illustrated by example of preparing a course in "Physics". The development process is decomposed to execution of the following main tasks and subtasks:

- preparation
  – defining of the course purpose, scope and content,
  – gathering of the necessary study materials,
  – determining the final number of computer screens;
- developing the course
  – distributing the tasks among the project participants,
  – transforming materials into electronic form;
- implementation of the e-Learning course
  – course testing,
  – implementation of the final product (installation on the client server);

The total time of developing of a specific course topic is a sum of the times needed to perform the respective tasks and subtasks. Insufficient precision and labor costs are the shortcomings of the decomposition method. If one task is omitted or evaluated incorrectly it will result in significant error in the evaluation of the overall time needed for the development of the course. Another shortcoming is that the economy of time when some of the tasks are performed simultaneously is not accounted for.

3.2. Statistical and mathematical methods

These methods pertain to the so called *quantitative methods*. They use statistical data from courses that have been already developed in order to evaluate the time needed for future e-Learning courses preparation together with appropriate statistical and mathematical evaluation methods.

These methods are based on the assumption that the time needed for the development of an e-Learning course generally corresponds to the trends and time

requirements from a past period [8]. Once the trend and the average change with respect to the past periods are determined, the choice of the most appropriate model comes – a mathematical formula which would describe the process.

The *statistical methods* use the respective statistical relations in order to determine the relation between the course development time and some course parameters – for example, number of pages at the e-Learning course.

The modeling methods are used to specify some indicators influencing the needed time for the development of an e-Learning course. These indicators should be quantifiable. The most frequently used indicators are those specified in the studies of R u s s e l l [9]: *experience of the project operator, complexity of the project, external factors*. K a p p [5] includes as an additional indicator the *degree of interactivity* of the course and determines using the *parametrical modeling* methods the time needed for the development of an e-Learning course. In the same study, the author introduces two additional correction coefficients for the indicator *experience of the project operator*, namely – *a weight coefficient* and a *learning experience coefficient*, while only one *correction coefficient* is proposed for each one of the other indicators. Finally, the time needed for the development of an e-Learning course is calculated as the product of the estimated time multiplied by the correction coefficients.

In the current paper two modifications of the statistical and mathematical methods for e-Learning course development time evaluation are proposed based on the authors teaching and course development experience.

3.2.1. Regression analysis method for e-Course development time estimation

The main idea of the regression analysis method is the use of the classic formula of one-factor regression analysis [11]

(1) $$y = \alpha + \beta x + \varepsilon,$$

where y is the dependent variable, α is a constant coefficient, β is the independent variable (a coefficient of the variable x) and ε is a coefficient of the influence of different external factors (noise coefficient). Using sample data in Table 1 for the development of five e-Learning courses [12], the coefficients α and β and the time forecast time y can be determined. At this stage the coefficient ε, showing the presence of accidental "noise" will be assumed to be zero.

Table 1. Sample data

Course No	1	2	3	4	5
Number of computer screens	360	240	300	420	320
Time of course development (min)	7200	5280	6905	7560	6080

The main goal is to explore the relation between the number of e-Course computer screens and the course development time in order to determine the forecast time needed for the development of such course using a certain number of e-Course screens. The *independent variable,* which is considered to be the factor influencing the result, is marked by *x,* and the *dependent variable*, considered as a result, is marked by *y* – it is actually the time for the development of an e-Learning

course. The following algorithm is proposed on the example of an e-Course with 800 course screens:

Step 1. Mathematical average values for x and y are calculated using the data in Table 2 as

$$x_{\text{av}} = \frac{\sum_{i=1}^{5} x_i}{5} = \frac{1640}{5} = 328 \text{ e-Course computer screens,} \tag{2}$$

$$y_{\text{av}} = \frac{\sum_{i=1}^{5} y_i}{5} = \frac{33025}{5} = 6605 \text{ min.} \tag{3}$$

Step 2. The values of x_{av} and y_{av} are used to calculate the coefficients α and β using the smallest-squares method [11] as shown in Table 2.

Table 2. Data for calculating of regression coefficients

No	x_i	y_i	$x_i - x_{\text{av}}$	$y_i - y_{\text{av}}$	$(x_i - x_{\text{av}})^2$	$(x_i - x_{av})(y_i - y_{\text{av}})$
1	240	5 280	–88	–1 325	7 744	116 600
2	300	6 905	–28	300	784	–8 400
3	320	6 080	–8	–525	64	4 200
4	360	7 200	32	595	1 024	19 040
5	420	7 560	92	955	8 464	87 860
Σ	1 640	33 025			18 080	219 300
Σ/5	328	6 605				

Step 3. Calculation of the coefficients α and β:

$$\beta = \frac{\sum_i (x_i - x_{\text{av}})(y_i - y_{\text{av}})}{\sum_i (x_i - x_{\text{av}})^2} = \frac{219\,300}{18\,080} = 12.12, \tag{4}$$

$$\alpha = y_{\text{av}} - \beta\, x_{\text{av}} = 6605 - (12.12 \times 328) = 2629.64. \tag{5}$$

Step 4. e-Course development time calculation – forecast time needed for the development of an e-Course using 800 computer screens is

$$y_{\text{for}} = \alpha + \beta\, x_{\text{for}} = 2629.64 + (12.12 \times 800) = 12\,325.64 \text{ min.} \tag{6}$$

End. The result for the e-Course development forecast time, if 800 computer screens are to be considered, is equal to 12 325 min, or 205.4 hours, or 17.12 days.

Using statistical data on the time needed for the development of an e-Learning course and a comparison with the forecast time calculated using the discussed method, the average value of the "noise" coefficient ε can be determined and used, if such "noise" really exists.

3.2.2. Modified parameter modeling method for e-Course development time estimation

The parameter modeling method uses indicators proposed by K a p p [5] and R u s s e l l [9] and their respective correction coefficients. In the current paper their

values are assumed to be discrete and between 0 and 1 following some heuristically derived assumptions for the process of e-Learning course development:

- *Operator experience* (*t*) – if the operator has more than 5 years experience, the assigned value $t = 0$ and if it is less than 1, $t = 1$.
- *Complexity of the course and number of participants* (*l*) – this indicator takes into account the complexity of the e-Learning course, as well as the additional time losses related to administrative issues and communication between the participants. It is assumed that if more people work on the course, the higher is the level of complexity – when the project team consists of 1 person, the complexity level is low – $l = 0$, and for teams consisting of 10 or more people, it is assumed that the complexity is high and $l = 1$.
- *External factors* (*m*) – they have no direct link with the work on the course, but still influence the time of its development – for example, the time of checking the e-mail, phone conversations, days-off taken by the staff, etc. It is accepted that if these factors have weak impact, $m = 0$, and if the impact is stronger, $m = 1$.
- *Degree of interactivity* (*n*) – in the simplest cases there is no interactivity – students cannot influence the information on the e-Course computer screen. Introducing interactivity makes the time needed for the course creation longer. When there is a high degree of interactivity (audio and video communication with the teacher in real time), the time for the development of an e-Learning course can increase up to three times compared to the time for the development of a course without interactivity. If there is no interactivity $n = 0$, while in case of full interactivity $n = 1$.

K a p p [5] introduced a weight coefficient for the indicator *operator experience* (*t*). To create a more flexible model and to have higher precision in the evaluation of the time needed for the development of an e-Learning course, additional weight coefficients of the indicators *project complexity* (*l*), *external factors* (*m*) and *degree of interactivity* (*n*) are introduced in the current paper.

The values of the used indicators *t, l, m, n* and the corresponding weight coefficients k_t, k_l, k_m, and k_n (defined on the basis of empirical data and practical experience) are shown in Table 3.

Table 3. Indicators and weight coefficients

Indicator	Operator experience *t* (years)	Complexity of the course and number of participants *l*	External factors *m*	Degree of interactivity *n*
Min	(> 5 years) $t = 0$	(1 – 10 people) $l = 0$	(weak) $m = 0$	(absent) $n = 0$
Max	(≤ 1 year) $t = 1$	(more than 10 people) $l = 1$	(strong) $m = 1$	(full) $n = 1$
Weight	$k_t = 0.4$	$k_l = 1$	$k_m = 0.4$	$k_n = 3$

The methodology proposed by K a p p [5] for determining the time needed for the development of an e-Learning course is modified by the introduction of the additional weight coefficients, as shown here:

(7) $$y = x + x \times (k_t \times t + k_l \times l + k_m \times m + k_n \times n),$$

where y is the corrected time for development of the e-Course, x is the time before correction determined by using one of the above mentioned methods.

3.3. Quantitative example

Let us assume that the development of a specific e-Course, where 30 computer screens are to be used, takes 100 hours in case of minimum values of the indicators in Table 3 ($t = 0$, $l = 0$, $m = 0$, $n = 0$), while the operator's experience is maximal, then $x = y = 100$ hours. Let us assume again that an e-Learning course with 30 computer screens is to be developed with moderate project complexity, moderate impact of the external factors, as well as moderate degree of interactivity, i.e. $L = 0.5$, $m = 0.5$ and $n = 0.5$. If the operator's experience is the same as in the reference case ($t = 0$), the corrected time for developing this course will be calculated as

(8) $$y = 100 + 100 \times (0.4 \times 0 + 1 \times 0.5 + 0.4 \times 0.5 + 3 \times 0.5) \text{ hours.}$$

The proposed modified parametric modeling method provides the opportunity of defining more adequately the time necessary for the development of an e-Learning course. It should be pointed out that the used indicators and the corresponding weight coefficients are a result of empirically based assumptions and a higher degree of precision can be achieved by the statistically specifying of the used indicators and variation of their coefficients values.

4. Conclusion

The present study is concentrated on the problem of the preliminary evaluation of the time needed for the development of an e-Learning course as an essential part of e-Learning development costs. Two quantitative methods for that are proposed – the one-factor regression analysis method and modified parametrical modeling method. These methods have already been used in theory and practice for different types of analysis, but their interpretation in the present article is focused to e-Learning course time development evaluation. The parametrical modeling method is extended by introducing of a set of more precise indicators together with their respective weight coefficients. The application of these methods would allow preliminary planning of the e-Learning course development costs.

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