Electronic Educational Systems as a Knowledge Management Mechanism: Approaches to Assessment of Effectiveness

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ABSTRACT
The paper considers the issues of assessing the effectiveness of electronic educational systems of universities. Based on the analysis of existing approaches, methods and indicators for assessing efficiency, the authors propose a comprehensive methodological approach applying both the analysis of indicators of commercial efficiency of the university and taking into account the quality of teaching using the electronic educational system from the standpoint of usefulness for students. Practical application of the methodological approach developed by the authors makes it possible to improve the quality of university management and more effectively build a development strategy, choosing the most modern and most effective training systems, while maximizing profit and other indicators of commercial efficiency. In addition, the conditions that complicate the use of the complex management methodology developed by the authors are analyzed and auxiliary methods are proposed to assess the effectiveness of the use of teaching aids and the effectiveness of the electronic educational system in teaching a certain discipline.

Keywords: *education, information technology, electronic educational system, electronic information and educational environment, learning efficiency, commercial efficiency, knowledge assessment, usefulness.*

1. INTRODUCTION

Nowadays, the scope of application of computer technology in education is constantly expanding. The use of modern information technologies is becoming environment for functioning of educational process leading to formation of new educational technologies as a result of, for example, combination of distance learning and pedagogical testing based on educational standards.

There is also a tendency towards the formation of a single structured educational information space, as a certain information environment which a person enters from the moment he begins his education in elementary school, and which accompanies him throughout his life in educational, professional and other activities.

In the context of this trend, there have been developed many large and small training information systems, their technologies currently used in universities within the framework of electronic information and educational environments (EIEE).

The intensification of the use of e-learning and distance learning technologies is due to the following properties:

- allow you to reduce costs of organizing the educational process;
- provide an opportunity to study from anywhere in the world at a convenient time;
- can be used in emergency situations (for example, in the case of the COVID-19 pandemic).

However, not all e-learning systems are equivalent. They have different functionality, visibility, complexity, inertia, etc. As a result, the quality of education in them is different. Thus, the comparative analysis and evaluation of the effectiveness of electronic educational systems becomes relevant.

The purpose of this work is to analyze methods for evaluating the effectiveness of information systems and to choose the most appropriate method for evaluating the effectiveness of electronic educational systems.

2. MATERIALS AND METHODS

The problem of evaluating the effectiveness of information systems has been well studied [6]. So, in the following works [2, 3, 5, 7, 8, 11, 12] there are analyzed such methods as the functional point method, boiler method, total cost of ownership, consumer index, economic value added, source of economic value, Average industry results, return on investment, model of cumulative economic effect, Gartner measurement, functional cost analysis and others to determine efficiency and possibility of use in specific situations. These methods are aimed at identifying ultimately the economic effect achieved through the introduction or use of an information system.

However, in relation to educational information systems, the use of these methods is not entirely justified, since the quality of education is not taken into account – effectiveness of the information system from the point of view of students.

Evaluation of the effectiveness of training is often based on the Kirkpatrick model, proposed back in 1959 and used very effectively. [1, 4, 9, 10] However, neither this model nor its improved modification [10] take into account the effect of using an educational information system by an educational institution.

Of the greatest interest for training organizations, in our opinion, are educational information systems that provide a high level of quality of training with a simultaneous increase in economic effect. We believe that effectiveness of educational information systems should be considered with the help of a comprehensive indicator including both the quality of training and economic efficiency.

3. RESULTS AND DISCUSSION

To assess the effectiveness of university educational information systems, the authors propose to apply the "comprehensive index of usefulness of the electronic information and educational environment" (CIU EIEE), which includes, on the one hand, indicators of the "usefulness of EIEE for students" (according to the improved Kirkpatrick model), and, on the other hand, indicators of economic efficiency of using the system for the university.

The improved methodology for evaluating the effectiveness of training [10] includes the following indicators:

1. Assessment of listeners' reaction by analyzing answer sheets or questionnaires.
2. Assessment of knowledge and skills through professional testing or exams.
3. Assessment of behavior after training through subjective assessment during, for example, a coaching-style interview or brainstorming on the problems of the team.
4. Checking the proficiency of the acquired skills by training other employees.
5. Assessment of practical skills by performing a typical task.
6. Evaluation of the impact of the training program - measurement of the target indicator, for improving of which the training was conducted (improvement of quality, increase in staff productivity, increase in sales, etc.)

It is proposed to evaluate the reaction of listeners using the following index:

$$I_{lr} = \frac{Q_s}{n} \quad (1),$$

where Qs is the number of trainees who are satisfied with the learning outcomes;

n is the number of all trainees who have completed the program.

We propose to carry out the assessment of knowledge and skills in the same way:

$$I_{ks} = \frac{Q_p}{n} \quad (2)$$

where Qp is the number of trainees who have successfully passed the test.

We propose to evaluate the behavior after training as follows:

$$I_b = \frac{\sum_{i=1}^{n} \frac{r_i}{b}}{n} \quad (3)$$

where ri is the subjective assessment given to the

i-trainee based on the test results in points;

b – the maximum number of points in the selected rating system.

The authors believe that the verification of the proficiency of the acquired skills by training other employees can be carried out by testing the trained employees through the same test tasks that were used to assess the knowledge and skills of the trainees who passed the program:

$$I_{ss} = \frac{Q_{ps}}{Q_{ts}} \quad (4)$$

where Qps is the number of employees who have successfully passed the test;

Qts – the number of all employees trained by those who passed the initial program.

Assessment of practical skills by doing a typical task is proposed to be carried out in the following way:

$$I_{tt} = \frac{\sum_{i=1}^{n} \frac{m_i}{100}}{n} \quad (5)$$

where mi is the percentage of completion of a typical task by the i-trainee.

We propose to evaluate the impact of the training program on the basis of the percentage of plan implementation of the target indicator for which training was conducted:

$$I_t = \frac{\sum_{i=1}^{n} \Delta V_{fi}}{\Delta V_p} \quad (6)$$

where ΔVf is the actual change in the target indicator of the i-trainee;

ΔVp – the planned change in the target indicator.

The last 3 indicators (verification of proficiency in acquired skills, assessment of practical skills and assessment of the impact of the training program) should be used not with students, but with employees of organizations or industrial enterprises, for example, as part of the implementation of professional development programs.

Thus, we propose to do final assessment of usefulness of EIEE for trainees according to the formula:

$$I_S = I_{lr} \cdot I_{ks} \cdot I_b \cdot I_{ss} \cdot I_{tt} \cdot I_t \quad (7)$$

As indicators of the effectiveness of EIEE of university, we suggest using the following, (which, in our opinion, are the most important):

1. An increase (or decrease) in profits when using EIEE due to an increase (or decrease) in tuition fees.
2. Reducing the costs of supporting the educational process through electronic document management and reducing overhead costs (electricity, heat in classrooms, etc.).
3. Growing number of trainees. Due to the use of EIEE, the influence of the territorial remoteness of the trainees is reduced, so theoretically a larger number of trainees can be attracted.
4. Growing productivity due to EIEE. Thanks to the improved processes of delivery, verification, issuance of works, grading, etc., more works can be checked per unit of time. Similarly, more students can be trained per unit of time.

It is also important to separate and take into account both the cost of EIEE and the annual costs of its operation and maintenance (including the complexity of creating training materials). There are relatively inexpensive systems with high operating costs and vice versa.

Thus, effectiveness of EIEE for the university can be estimated by calculating the following index

$$I_U = \frac{\Delta P \cdot \Delta Q + \Delta C_{sp} \cdot t + \Delta E}{C_{sw} + C_{so} \cdot t} \quad (8)$$

where ΔP is changed annual profit when using EIEE due to changes in tuition fees;

ΔCsp – changed annual costs for the maintenance of the educational process

t – the estimated life of the EIEE;

Csw – cost of buying (designing) EIEE

Cso – annual costs for the operation and maintenance of EIEE (including annual costs for developing training materials);

ΔE – changed productivity due to the use of EIEE, expressed in cost units;

ΔQ – changed number of trainees when using EIEE.

The complex index of usefulness of the electronic information and educational environment can be calculated with the formula:

$$I_E = I_S \cdot I_U \quad (9)$$

This methodological approach seems to be more adequate when assessing effectiveness of EIEE, as such, as it takes into account both economic efficiency of its application and effectiveness of training (usefulness for students). Since there may be a case when, according to formula (9), a decrease in the effectiveness of training in EIEE can be compensated by an increase in economic efficiency, and vice versa, and also taking into account that it is important for the training organization to use at least break-even systems when choosing EIEE, it is proposed to use IU and IE indicators together.

It seems reasonable to calculate these indicators for each alternative EIEE and choose the break-even system with the highest value of the complex utility index (IE max, IU >1). This choice is due to the assumption that systems that ensure low learning efficiency will eventually cease to be in demand with students, which, in turn, will lead to a decrease in the number of trainees and profits.

The use of the proposed methodological approach to the assessment of EIEE may be complicated by the following conditions:

1. Different teaching methods can be used for the same discipline. The influence of teaching methodology can distort the final result of evaluating the effectiveness of the training system.
2. The initial level of training of students in different systems may be different.
3. Different EIEEs have different sets of training tools with different effectiveness. Also, some teaching tools show their effectiveness when teaching some disciplines, but not when teaching others. The correctness of the choice of a training tool for a particular discipline or type of lesson also influences the final assessment of the effectiveness of the entire EIEE.

Thus, for the most accurate identification of the effectiveness of various EIEEs, we consider it possible to conduct test training with subsequent assessment of EIEE using IU and IE indicators according to the methodology

described above. To ensure a "clean experiment", it is desirable to fulfill the following conditions

- training should be conducted according to the same teaching method by the same teacher (group of teachers);
- training in various EIEE should be conducted in the same list of disciplines, respectively, and the assessment of EIEE should be conducted in these disciplines;
- participants of test training should be selected from approximately the same social environment and have similar characteristics (age, level of education, qualifications, experience, social status, etc.).

Even if these conditions cannot be met, according to the proposed methodology, it is possible to compare various EIEE in general, regardless of the specifics of the disciplines offered by the training organization. However, compliance with these conditions, firstly, will show the possibility of using EIEE for training in certain fields (specialties), and, secondly, allow us to evaluate the effectiveness of teaching methods and training tools within the framework of EIEE.

Let's say we have evaluated two EIEEs using the methodology proposed above. Then, to evaluate the teaching methods, we can conduct several test trainings within the framework of one EIEE in one discipline (group of disciplines) using the same training tools, but different teaching methods. Then the ratio of the complex utility indices obtained by applying each of the methods to the utility index of the second EIEE (let's call this indicator the index of the teaching methodology - IEM) will show the effectiveness of one method relative to the other:

$$IEM_n = \frac{I_{E1n}}{I_{E2}} \quad (10)$$

where IE1n - the complex index of utility of the first EIEE, obtained by applying method n;

IE2 - the complex index of utility of the first EIEE.

Similarly, we can evaluate the effectiveness of a training tool using in test training the same methodology, but different training tools:

$$IET_n = \frac{I_{E1m}}{I_{E2}} \quad (11)$$

where IE1m - the complex index of utility of the first EIEE, obtained by applying teaching tool m;
IE2 - the complex index of utility of the first EIEE;
IETn – training tool index.

As well as:

$$IED_l = \frac{I_{E1l}}{I_{E2}} \quad (12)$$

where IE1l - the complex index of utility of the first EIEE when teaching discipline l;
IE2 - the complex index of utility of the first EIEE;
IEDl – discipline index.

4. CONCLUSION

Thus, the methodology proposed in this paper provides a more comprehensive and effective assessment of the usefulness of EIEE for the university, since it takes into account both indicators of commercial efficiency and effectiveness of training. This approach will allow the university to build a development strategy more effectively, choosing the most modern and effective training systems and maximizing profits at the same time.

In relation to university management, it is useful to consider the following possible situations:

1. IE max, when IU >1. This is the best option for a university in the context of a long-term perspective. EIEE makes a profit, even if not the maximum, but it has the highest ratio of usefulness for students and for the university.
2. IE >1, when IU max. It is also quite an attractive option for a university. EIEE is the most profitable with an acceptable and fairly stable indicator of the ratio of usefulness for students and for the university. However, in the future, such an EIEE may lose relevance in comparison with more efficient systems (with the so-called utility ratio for students and for the university).
3. IE <1, when IU max. This is not a desirable option for the university, despite the high profitability indicator. It is obvious that such an EIEE will have a low learning potential and its relevance from the point of view of the trainees will be lost.
4. IE >1, or IE max when IU <1. It is also an undesirable option for the university, despite the high value of the ratio of usefulness for students and for the university. In this case, the profit does not cover the costs of EIEE. As a result, the university suffers losses. You can use this option only if you are confident in the relevance of this EIEE in the future (which requires additional analysis) and a carefully constructed business strategy that guarantees additional profit by finding additional areas of use of EIEE.

When working on the paper, auxiliary methods were formulated that allow us to evaluate the effectiveness of teaching methods (the index of educational methods – IEM), teaching tools (the index of educational tools – ITT) and the effectiveness of EIEE in teaching a certain discipline (the index of discipline - IED), by the values of which we can make a choice of specific methods and teaching tools when compiling training programs and implementing them within the framework of the selected EIEE.

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