Methodology for assessing labor costs of distance learning courses designing through comprehensive assessment of their quality

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Abstract. The aim of the research is to develop a methodology for assessing the labor costs of designing distance learning courses by university teachers based on a comprehensive assessment of the courses' quality. The paper provides and analyses such calculations on the example of courses in theory of algorithms and programming.

Keywords: First Keyword, Second Keyword, Third Keyword.

Introduction

Analyzing and taking into account the process of rapid development and improvement of information and communication technologies, modern university (higher) education is gradually transforming its own existing traditional (face-to-face) forms of education. These forms are being supplemented or replaced by blended and/or distance learning forms. The role of electronic teaching tools (educational resources) and electronic educational materials is constantly growing mainly because they are being actively used by the younger generation of students, which is both a challenge and a reason that higher education certainly is responding to.

In the 21st century, it is obvious that the updating speed of information used in universities for educational purposes requires a continuous change in the content of academic courses, the reviewing of teaching materials and the designing of completely new courses. This fact means a significant increase in the labor costs of the university academic and auxiliary staff to maintain the relevance of the educational process in its form and content. Since the work of designing distance learning courses lies mainly with the university staff, it has resulted in the appearance of an urgent task to evaluate the labor costs of designing new courses and modernizing existing ones while ensuring the proper quality of the educational process.

Transport and Telecommunication Institute (TTI) and European Humanities University (EHU) have accumulated many years of experience in the use of distance learning (DL) in the educational process. The authors of the study have summarized this experience in the assessment of labor costs and the quality of distance learning

courses in the form of a technique that was brought to specific calculations and recommendations.

Currently, for virtually any institution of higher education that uses DL and designs distance learning courses (DC) on their own, there is an acute task of keeping the quality of the developed DCs at a high level, which would allow them to successfully compete with “massive open online courses” (MOOC) or transfer their best developments to well-known platforms for open use. Today, such open online platforms as Coursera, edX, Udacity offer free DCs of high quality. The university rubrics for assessing the quality of designed DCs are not always in an open access. Further, we will present potential rubrics for assessing the quality of a university DC development. The rubrics have become the result of more than 10 year experience accumulated by two higher educational institutions that are in close cooperation. The rubrics are presented on the basis of the qualitative analysis of numerous distance learning courses. This analysis has been carried out by specialists supporting distance learning, its results have been discussed with teachers at conferences, seminars, and continuing education courses in both higher educational institutions. The article also presents a methodology for assessing the teacher’s labor costs for a DC development for undergraduate students in theory of algorithms and programming and related courses.

Criteria for assessing the quality of DC development

Assessing the DL quality is a complex and time-consuming process, which includes:

- a comprehensive analysis of the organizational structure of an educational institution, its technical and information resources;
- assessment of university syllabi, the quality of the developed and used electronic educational resources and course materials;
- analysis of the effectiveness of the teacher/student feedback system and the system for assessing the process of DL;
- determination of the effectiveness of DC didactics and teaching process techniques;
- assessment of the level of literacy of teachers and students in computer technology.

Further, we will consider the quality of DL, related only to the designing of distance learning courses and the development of electronic training resources and materials for them.

By assessment of the DC quality, we mean a system for assessing the course compliance with modern requirements of pedagogical design: a DC strategy, electronic learning resources and materials, pedagogical activities and a student achievement evaluation system.

B. Khan, an authoritative scientist and researcher in the field of DL, notes the need to take into account the following aspects of the institutional direction of DL development: financial assessment; infrastructure assessment; assessment of the cultural readiness of educational institutions [1, p. 24-25].

Considering the issue of quality of a DC development on the basis of infrastructure assessment, one should first agree on:

- a strategy model that is proposed for a DC development;
- an organization form of the learning process in an educational institution where electronic learning materials are created for teaching students in a distance format;
- the type of evaluated DCs;
- the characteristics of teaching methods, depending on areas of knowledge.

Strategy model

Currently, there are two main models for the organization of teachers in DL.

In the first model, each teacher prepares distance learning courses mainly on his/her own, seeking advice from IT specialists and pedagogical design specialists. Experts admit that such courses are usually characterized by the simplest pedagogical design, inefficiently managed technological infrastructure, and significant overload of teachers. These distance courses are mediocre from the point of view of electronic pedagogy and are not distinguished by the high quality of electronic educational materials.

The second model is based on a team approach, in which employees with the necessary level of competence in each of the areas of design, development and maintenance of distance learning courses participate in both the development and the teaching of distance learning courses. These are the developers of educational textual content, educational multimedia and video materials, pedagogical designers, and others. The second model is more expensive, but it is also more efficient in terms of the quality and competitiveness of educational services in a distance format [2, p. 55-56].

The experience of the Center for distance learning at EHU has shown that the second model is the most efficient one and it dramatically affects the quality of the developed DCs. This is due to the fact that majority of the university DC teachers deliver courses in humanities and social sciences. That allows them, for example, to well understand and use the Internet technology in teaching, but they do not have a sufficient level of competence for the independent development of high-quality, and sometimes quite complex electronic resources or materials for a DC implementing the requirements of pedagogical design.

Organization form of the educational process

Assessing the DC quality on the rubric's basis, it is necessary to determine the form of organization of the educational process in an educational institution, since at present, in all forms of education, even in traditional ones, students are offered learning electronic materials and various pedagogical activities in a distance format. In this case, we single out the three key independent forms of organization of the educational process: high-residence, low-residence, distance learning. It should be noted that new forms have now begun to be widely applied, for example, the low-residence form,

which seems to be a combination of educational didactic approaches used once for correspondence courses, distance learning and a high-residence form of education with face-to-face classes.

Further, we will apply the criteria for assessing a DC development for the distance learning form as an independent form of organization of the educational process at the university.

One should not ignore the life-long organization forms of the educational process; such forms are actively used in the adult continuing education system. According to one of the authors of the article, the distance learning form for adults is divided into several types: network, case-network, hybrid, distance self-study [2, p. 49-50]. It is clear that the stringent assessment criteria of a developed DC are applicable, first of all, to distance self-study, but in some cases, they can be used for adult network education.

Evaluated type after the DC development

The assessing rubrics for the quality of DCs may also vary depending on the typology of DCs. The type of course is selected depending on the conceptual directions of the design and development of the distance course adopted by the educational institution, as well as on the goals and objectives of the course and the methodological features of its teaching [2].

We will list the classification of the four typologies of courses, which are determined by:

- the form of use in the educational process: full-fledged distance learning courses, hybrid courses, supporting courses [3];
- the nature of communication: asynchronous and synchronous distance learning courses;
- the principle of placement of the main educational material [4];
- type of educational activity [2, p. 53].
- The criteria for assessing the quality of development will be applied to full-fledged distance learning courses.

Teaching methods peculiarities and areas of knowledge

A retrospective analysis of the quality of the DC development shows that the quality of the course largely depends on the peculiarities of methodology applied to various fields of knowledge that students major in. For example, to learn a foreign language, an entire set of educational elements is required to develop not only grammar skills but what is more important to master listening and speaking skills. A DC in social sciences and humanities also have certain peculiarities, although the requirements for them in pedagogical design and didactics are very similar. For example, in social sciences, computer technologies are more actively used for the analysis of statistical data, modeling of social processes, etc. Quite different ones are the criteria for as-

sessing the quality of courses in design, the training materials of which cannot do without high-quality instructional videos and the teacher/student feedback.

As for courses in mathematics and engineering, their structure of the rubrics is similar, but their numerical values K_i should be empirically adapted taking into account the higher labor costs for preparing electronic learning resources, in particular, for organizing the online access to professional software and remote laboratory equipment.

Here are the criteria for evaluating the results of the DC development for

- the second strategic model (work in a group project, teacher + specialists in pedagogical design and IT);
- distance self-study;
- a full-fledged distance course;
- without focus on courses, whose teaching methods can significantly affect the rubrics for evaluating the quality of the development of distance learning courses and the ratio for different criteria.

Further, to calculate the required labor costs, we also use another indicator E - as a dimensionless characteristic of the team and development conditions.

We present Table 1, which contains the procedure for calculating the coefficient K - standard labor costs in man-weeks for 1 ECTS, the value of which depends on the weight of the criteria for assessing the quality of a developed DC. The value of the coefficient K (for our example in man-weeks) is the sum of the values K_i of the coefficients for each group of criteria, i.e.

$$K = \sum_{i=1}^{3} K_i + \sum_{i=4}^{9} K_i + \sum_{i=10}^{15} K_i + \sum_{i=16}^{20} K_i, \text{ where } K \leq 1 \quad (1)$$

The ratios of standard labor costs in man-weeks for 1 ECTS, depending on the criteria for assessing the quality of a developed DC, are presented in Table 1.

Table 1. Standard labor costs ratios.

Name of the group criteria	Criteria for quality assessment of a developed DC	Maximum sum of weight criteria in a group	Standard labor costs ratio Ki
1. Course strategy	Course summary	0.25 (max 0.25)	0.05
	Course syllabus designed in accordance with the requirements of the university		0.15
	Simple and clear statement of the goals, objectives and expected results of the course		0.05

Name of the group criteria	Criteria for quality assessment of a developed DC	Maximum sum of weight criteria in a group	Standard labor costs ratio Ki
2. Compliance with the didactic principles of a DC: apprehensibility, accessibility, interactivity	Simple and clear statement of the goals, objectives and expected results of the course	0.11 (max 0.15)	0.05
	Clear structure of the course as a whole and its individual modules		0.01
	Clear definition of course certification policy		0.01
	Correspondence of the number of working weeks to the number of credits		0.01
	Clear and detailed instructions and recommendations for working with each module/topic of the course		0.04
	Clear instructions or recommendations for completing (final) tests/course activities and an exam		0.05
3. E-learning resources (materials)	Interactive teaching alerts and teacher/student feedbacks	0.15 (max 0.3)	0.03
	Teacher's copyright materials in the course		0.1
	Attribution of authorship for all study materials		0.02
	Additional electronic training materials		0.02
	Web links to the resources that are freely available on the Internet		0.02
	Learning materials with modern multimedia technologies (multimedia presentations, videos, computer models, mindmaps, etc.)		0.1
	Compliance of electronic educational materials with recommendations for their design		0.04
4. Learning didactic resources and activities	Correspondence of the number of tests/ tasks per one credit according to the requirements of the university	0.15 (max 0.3)	0.02

Name of the group criteria	Criteria for quality assessment of a developed DC	Maximum sum of weight criteria in a group	Standard labor costs ratio Ki
	Variety of didactic resources created using the DL system: instructional glossaries, instructional Wikis, interactive lectures, educational forums, computer tests, and other educational tools imbedded in DL system		0.1
	Tasks/activities for students' self-study in accordance with the requirement of the university		0.1
	Activities aimed at collaborative learning		0.03
	Modern DL pedagogical technologies and methods		0.05

The value of each ratio was determined by the teachers themselves at seminars and continuing education courses. The presented ratios can be supplemented or changed depending on the groups of academic courses. Accordingly, each university, taking into account its features and financial, technological capabilities, can perform this work of calculating the sum of the ratios independently based on surveys of teachers or questionnaires.

The results of the quality evaluation of developed DCs must necessarily be the basis for calculating the ratio of labor costs for their design, since everything that is developed for DCs should maximally reflect the quality of development.

In order to take into account, the characteristics of a developers team for the labor costs Qj, it is proposed to use Table 2, through which we can calculate the product of the values of the characteristics to assess the level of qualification and the readiness of the group (team) for development. The product of all characteristic values in quantitative terms is indicated by the letter Q (it should be in the range 1.01-1.26). The idea of using just such constant limits was borrowed from the COCOMO model [5]. In the absence of any j-th characteristic for the development team, the value Qj = 1.

For a qualitative assessment of the qualification level and readiness of specialists in a group, it is necessary to proceed from its possible composition: teacher-author of the course, manager for coordination of work, instructor in pedagogical design, specialist in the development of educational video materials, specialist in the creation of educational animated materials, if animation is present in an updated version of the course [2, p. 73] (Table 1).

Table 2. Characteristics for assessing the skill level of a group of DC developers**.**

Name of the characteristic groups	Characteristics of the development team	Qj
Language proficiency	Language of instruction in the course	0.95

Name of the characteristic groups	Characteristics of the development team	Qj
	English	0.9
	DC design language	0.95
DL pedagogy and pedagogical design	Skills in DL didactics	0.95
	Expertise in methods and ways of organizing communications in DL and intercultural environment	0.9
	Expertise in the requirements of pedagogical design	0.9
Mastery of the course material	Experience in conducting research in the subject area of the course	0.8
	Copyright publications to be used in the course	0.95
	Professional (by education)	0.95
	According to sources of literature (self-education)	0.95
	General vision (short courses)	0.95
	Experience in teaching the course	0.8
Team communication	Experience in collaborative development of similar courses	0.9
Experience in ICT and media technologies for the development of ELR and materials (electronic learning resources)	Development of multimedia presentations	0.95
	Scripting and filming learning media materials	0.95
	Designing and creating learning animations	0.9
	Using video conferencing in distance learning	0.9
	Using online educational tools, such as a Google application	0.7
	Experience in creating educational computer models for DL	0.9
Number of developers	More than 4	1.05
Quality of development management	Full-fledged project	0.9
	Resource allocation development plan	0.95
	Task for development only	0.95
Staff turnover	With a turnover rate of more than 25%	1.1

The value of Q_j in the Table 2 may also be greater than 1 - they are the subject of expert evaluations based on the experience gained in developing distance learning courses.

At the same time, assessing the level of readiness of the group for the DC development, we can present general requirements for all members of the group or orient these requirements depending on the professional qualities for each specialist.

Labor costs calculation for the DC development

The study uses the structure of the COCOMO II model [5] and proposes an approach to assessing efforts in designing a distance course based on the size and complexity of the developmental course. The approach is based on the similarity of software development processes (SE) and distance learning courses.

We can consider this distance learning course as a specialized software development project that will result in the creation of online digital educational materials in accordance with specific requirements. The distance course is measured in credit points (ECTS).

By analogy with the COCOMO model, the basic formula was first used, which involves calculating the first rough estimate of the labor costs involved in developing a distance course only on the basis of knowledge of the course volume in ECTS credit points (the main driver of development costs). As practice has shown, a preliminary calculation using the basic formula allows to correctly evaluate and adjust (adapt) the ratios shown in Tables 1 and 2 for their further use in practical calculations in a particular organization.

In this case, the basic calculation formula for labor costs (in man-weeks) has the following form:

$$\text{Labor costs} = M \times (NC)^{E1}, \tag{2}$$

where M and E1 are selected from Table 3, NC - DL course size in credits.

Table 3. The table of ratios for the basic formula (labor cost).

NC (DL course size in ECTS)	M (man-weeks/ECTS)	E1
1-2	2.5	1.01
3-6	3.0	1.10
7-10	3.5	1.26

As the next step we can use the basic calculation formula for schedule (in weeks) estimation (similar to COCOMO recommendations). The result will be the following:

$$\text{Schedule} = N \times (\text{Labor cost})^{E2}, \tag{3}$$

where N and E2 are selected from Table 3.

Table 4. The table of ratios for the basic formula (schedule).

DL course size (ECTS)	N (weeks/labor cost)	E2
1-2	2.5	0.38
3-6	2.5	0.35
7-10	2.5	0.32

The next step in increasing the accuracy of calculating the required labor costs was the use of other existing drivers of cost and labor, which are associated with ensuring

the quality of the developed distance course. For this, a list of drivers was used, which we displayed above in Tables 1 and 2.

In this case, the general formula for calculating labor costs is modified and takes the following form:

$$\text{Labor costs} = \text{NC} \ \text{x} \sum_{i=1}^{n} K_i \ \text{x} \ NC^{(1.01 + 0.24\, x \prod_{j=1}^{m} Q_j)}, \quad (4)$$

that is, in accordance with the formula (2) M= NC x $\sum_{i=1}^{n} K_i$, E1=$(1.01 + 0.24 * \prod_{j=1}^{m} Q_j)$

here for K_i i varies from 1 to n (n is the number of ratios from Table 1), and for Qj, j varies from 1 to m (m is the number of characteristics from Table 2). Constants 1.01 and 0.24 are borrowed from COCOMO model [5].

Our recommendations for evaluating labor costs can be used for the following situations:

- making investment or other financial decisions related to the development of a distance course;
- setting budgets and project schedules as the basis for planning and control;
- selection of specialists with necessary qualifications in a group of developers;
- making decisions or agreeing on trade-offs between software costs, schedule, functionality, and performance or quality metrics.

The considered approach to the assessment of labor costs during the development of a distance course was experimentally implemented as part of the educational resources development for the portal of assessing competencies in software engineering [6].

The numerical values Q*j* given in the tables were checked by the authors only for the indicated group of courses. For other groups of courses, their empirical refinement is required, the algorithm of which is of independent scientific interest and is not considered in this paper. We only note that this algorithm is based on expert evaluation of the labor costs of the process of a distance course developing.

As an example, consider the calculation of labor costs for the distance course “Modern Information Technologies” (MIT, 3 ECTS credits), which is mandatory and is studied at all educational programs at EHU.

The course is intended to systematize students' knowledge and skills in the field of using computer technologies for processing text and graphic information, technology for working with spreadsheets and Internet technologies.

Filling out tables with coefficients of normative labor costs was carried out by specialists in the field of pedagogical design of EHU University for the course of MIT.

Using the first basic calculation formula for labor costs (in man-weeks) for ECTS=3 and date from the Table 3 (course size 3-6 ECTS, M=3, NC=3 and E=1.1) we will have the following result

$$\text{Labor costs} = 3.0 \text{ x } 3^{1.1} = 10 \text{ (man*weeks)} \quad (5)$$

Schedule calculation (duration in weeks) can be done using data from Table 4 for the same DL course size 3-6 ECTS with already calculated Labor cost = 6,7. The schedule duration result will be the following:

$$\text{Schedule} = 2.5 \text{ x } 10^{0.35} = 5.6 \text{ (weeks)} \quad (6)$$

As the final result for using the basic formulas, we can assume that for the development of 3 ECTS distance learning course we need a nominal 5.6-week development for two full-time employees (10 / 5.6 = 1.8).

The second calculation is performed using a general formula that allows you to take into account the quality criteria of the developed distance course. In other words, we will calculate the values of M and E1 based on the data from Tables 1 and 2 but not take them from Tables 3 and 4.

For a calculation example, we will choose from Table 1 the maximum number of course quality criteria - all values from all groups of criteria. In this case, the value of M = 3.5.

We also proceed with the calculation of the exponent value E2. To do this, we multiply the values of all the criteria from Table 2, except for one Staff turnover, that is, suppose that we have all the desirable characteristics of the development team, and the composition of the team will not change during development. Then the exponent for the formula for calculating labor costs E1 will be determined by the formula:

$$\text{E1}=(1.01 + 0.24\, x \prod_{j=1}^{m} Q_j)) \quad (7)$$

where j is from 1 to 27.

For the data taken from table 2 we have:

$$\text{E1} = 1.01 + 0.24 \text{ x } ^{0.006} = 1.011 \quad (8)$$

In this case (for the course MIT), the adjusted value of the projected labor cost will be:

$$\text{M= NC x} \sum_{i=1}^{n} K_i = 3 \text{ x } 0.78 = 2.34$$

$$\text{Labor costs} = 2.34 \text{ x } 3^{1.011} = 7.1 \text{ (man*weeks)}$$

In turn, the assessment of the duration of the development of the course will differ:

$$\text{Schedule} = 2.5 \text{ x } 7.1^{0.35} = 4.9 \text{ (weeks)}$$

As can be easily seen from the calculation example, the required quality indicators of the developed course can noticeably affect the development time.

Conclusion

This study offers a methodology for calculating the labor costs of DL courses development for a group of courses in theory of algorithms and programming. The authors formulate the rubrics and criteria for the DL course quality assessment as well as the characteristics of the team of developers, which are taken into account in the calculation of labor costs.

The authors propose to expand the study to other groups of courses that are likely to require a conversion of the ratios proposed for use in the developed methodology. In broad terms, the given formula, as the authors consider, may be of a universal character for calculating the labor costs of any DL courses development.

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