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DETERMINING THE EFFICIENCY OF ONLINE LEARNING MODELS

Abstract: The study proposes a method for objectively determining the efficiency of online learning based on quantitative data generated by users while studying at online courses. Classifications of online learning models are researched and the efficiency of 4 common models in Ukraine is evaluated.

Keywords: efficiency of online learning, massive open online course, expert evaluation method, self-paced learning, motivational technique, blended learning format.

Introduction

Trends in the educational process in 2020 have finally confirmed that the future development of educational technologies is possible with the intensive use of online learning. With the spread of coronavirus infection, the world is on the verge of transition to the use of online technology in all spheres, and educational institutions that have developed online learning before, were competitive and ready for further action.

In spring of 2020, online education has experienced the greatest peak of interest in the history of its existence and continues to increase the number of active participants both from educational institutions and from potential students, course participants. Increasing demand for online education, especially in the context of the coronavirus pandemic in 2020 [1], creates the preconditions for its further development. This requires the improvement and development of assessment processes automation, personalization of materials submission and increase students’ motivation.

Modern education market challenges and the demand for further online learning processes automation development leads to the need for constant analysis and improvement of existing online learning models, their classification to identify the most effective ones and further modernize the other [2-5].

Problem statement

To determine the efficiency of different models of online learning we need to use a number of criteria and methods of objective rating of models against these criteria.

This method will further select the best model or several ones during the educational process organization. Because of the coronavirus pandemic, the right approach to the educational process organization will increase efficiency and provide the necessary level of knowledge of potential students.

Thus, there is a **necessity** *to determine the efficiency of online learning models by applying our own method based on selected criteria.*

Analysis of the online learning models classification approaches

Researchers of online education in their works classify models of online learning using their own criteria.

In particular, L. Harasim [6] proposed an analysis of online learning models made according to three modes of educational material delivery to the student: **adjunct mode** – uses the network to improve traditional face-to-face learning; **mixed mode** – uses the network as an important part of a traditional or distance course; **totally online mode** – relies on the network as the main carrier of delivery of educational material for the whole course or even the program.

The study by A. Doering and G. Veletsianos [7] identified the following models of integration of online courses into the classical educational process: curriculum-based, activities-based, standards-based and media-based. The **curriculum-based integration model** focuses on teaching exclusively in accordance with the curriculum, a slight deviation from the objectives of the curriculum, achieving the goals of the curriculum and student collaboration live and online. The **activity-based integration model** focuses on the use of curriculum topics, student-centered activities, as well as live and online student collaboration. The **standards-based integration model** focuses on compliance with national standards, adapting the curriculum to compliance with standards, activities focused on students and teacher, and students live and online collaboration. The **media-based integration model** focuses on the use of media materials, entertainment and student motivation.

Within the educational institutions of the Middle East, A. Mirza and M. Al-Abdulkareem [8] distinguish the following models of implementation of online learning technologies: virtual model, hybrid model and the traditional university model. The **virtual model** involves the opening of specialized online universities, where learning takes place entirely through the Internet. The **hybrid model** involves the presence of real institutions, where students come to register, to take exams and, if necessary, to meet with teachers. The **traditional university model** involves LMS (Learning management system) usage to support the learning process within the traditional university course.

Depending on a number of factors, such as the availability of resources, target audience and pedagogical requirements, M. Weller [9] identifies five models of building mass courses: a model with low support, a model with a hierarchical support structure, expert plus part-time support model, automatic generation of personalized courses model, pre-supported community model. The **low-support model** provides high-quality teaching materials available online and virtually no student-teacher communication. The **model with a hierarchical support structure** assumes that students have specialized teaching materials that are available in whole or in part online, and partial support by teaching assistants. In turn, the course team is responsible for the support of the assistants. The **expert plus part-time support model** includes having an expert, usually a lecturer, who provides training materials and whose opinion is particularly important, but whose time is very expensive. Therefore, this model has certain features of the previous one and involves direct communication of students with teaching assistants, who, in turn, may have access to an expert to solve particularly complex issues. The automatic generation of personalized courses model involves the actual creation of a course "on the fly", using the approach of "learning objects". These objects are contained in a database and are compiled on the basis of user profiles based on diagnostic tests, students' preferences, current learning needs, and so on. M. Weller notes that this approach is not yet sufficiently researched, scientific and practical work in this direction is quite rare. The **pre-supported community model** is based on the presence of a large number of course participants. This allows you to transfer many functions of the teacher to them. Students are invited to respond to the work of colleagues, have a dialogue and support each other.

The study proposed by P. Hill [10] classifies the models both in terms of the technique of delivery of educational material and in terms of approaches to the design of the course. He singles out the following models: ad hoc courses and programs, fully online programs, school as a service, educational partnerships, competency-based education, blended learning and "flipped classroom", as well as massive open online courses.

The problem that was investigated by A.W. (Tony) Bates [11], touches on the classification of models of massive open online courses as xMOOCs and cMOOCs. xMOOCs is the common name for courses developed by Coursera, Udacity and edX. They are based on the use of specialized software platforms based on cloud technologies. Therefore, according to this classification, all online courses that use the Open edX platform can be considered xMOOCs. In turn, cMOOCs are based on the use of social networks and other means of content exchange, such as software that aggregates posts from various sources on a certain hashtag, and so on.

Eeven wider classification of massive open online courses (**BOOCs, DOCCs, LOOC, MOORs, SPOCs, SMOCs**) is given by Amit Chauhan in the article "Massive Open Online Courses (MOOCS): Emerging Trends in Assessment and Accreditation" [12].

After the analysis, it should be noted that the existing approaches to the classification of online learning models have room for further research. In general, the tendency to comprehensively study online learning is rather young, so in this scientific field there is sufficient potential for deeper research of the problem. The proposed classifications laid the groundwork for analyzing the efficiency of online education models in general. Further research, in our opinion, should be directed towards the study of existing models and their improvement within the objectives of learning and learning outcomes.

The analysis of classification criteria study makes it possible to determine the necessary boundaries of the research of the online learning process to assess its efficiency. We proposed to use the method of expert evaluations to determine the criteria of efficiency and further create and implement our own model of online learning.

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Criteria for the online learning process efficiency

To determine the criteria that affect the efficiency of online learning models, one of the varieties of expert evaluation method was used, namely – *pairwise comparison*. A group of 10 experts from the Prometheus massive open online course platform was asked to rank 7 performance criteria:

- **percentage of students who received a certificate (K1)** allows to superficially rate the efficiency of the educational process, but does not provide information on whether the course meets all the methodological components, and the educational process itself is properly constructed; for example, this indicator can be high both in case of conformity of a course to all norms and as a result of this high students performance, as well as in case of incorrect construction of a course that simplifies the process of tests passing or performance of other tasks.
- **the percentage of students who passed the tests with maximum score (K2)** allows to rate the complexity of the presentation of materials and test problems;
- **the percentage of students who continued their studies at the course (K3)** usually [13], the number of people dropping out at the beginning or in the middle of the course is quite high; this indicator allows to determine that the course is properly structured, the educational process is not complicated, and the necessary motivational factors are used to continue learning;
- **percentage of students who chose another similar course after course completion (K4)** allows to rate the quality of the material and the availability of incentives to continue learning;
- **the percentage of students who passed the test with the first attempt (K5)** – the high value of the indicator allows to talk about the correctness of materials submission and tests construction;
- **the percentage of students who passed the test after watching the corresponding video (K6)** – low value of the indicator allows to speak about incorrect tests construction, their unrepresentativeness, and also about poor-quality representation of material in video;
- **the percentage of students who took part in the offline groups of the course, if any (K7)** allows to rate the degree of students’ involvement.

Experts were asked to compare the above criteria in pairs in order to determine the most important (significant) in each pair. The experts filled in the table of pairwise comparisons as follows: if the criterion i (in a row) was more significant than the criterion j (in the column), then they wrote 1 in the cell ij, 0 otherwise. The cells of the table’s main diagonal were crossed out. The summarized ranks of all experts are given in the final table 1.

In order to check the consistency of experts' opinions, the concordance coefficient W was calculated according to formula (1) [14]:

$$W = \frac{Q}{Q_{max}}, \tag{1}$$

where $$Q = \sum_{i=1,j=1}^{K} a_{ij}^2 - NE \cdot \sum_{i=1,j=1}^{K} a_{ij} + C_{NE}^2 \cdot C_K^2, \tag{2}$$

Table 1

The final table of ranking the proposed criteria for the online learning efficiency

	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	∑	**Weight**
K1	-	7	5	4	5	8	10	39	**0,186**
K2	3	-	3	4	2	3	1	16	0,076
K3	5	7	-	7	4	4	9	36	**0,171**
K4	6	6	3	-	3	4	6	28	0,133
K5	5	8	6	7	-	5	7	38	**0,181**
K6	2	7	6	6	5	-	8	34	**0,161**
K7	0	9	1	4	3	2	-	19	0,090
∑	21	44	24	32	22	26	41	210	1

$$Q_{max} = \frac{NE \cdot (NE-1) \cdot K \cdot (K-1)}{4}, \quad (3)$$

where a_{ij} – numbers in c ells above or below the diagonal of the final ranking table, C – binomial coefficient, NE – number of experts, K – number of criteria.

The values of this coefficient are in the range from 0 to 1, the better the consistency, the greater W is.

The following value of the coefficient of consistency was obtained for the conducted survey of experts:

$$W = \frac{534}{945} = 0{,}565. \quad (4)$$

The statistical significance of the coefficient W was estimated using the Pearson test (5):

$$\chi^2 = \frac{4}{NE-2}\left(Q - 0{,}5 \cdot C_{NE}^2 \cdot C_K^2 \cdot \frac{NE-3}{NE-2}\right). \quad (5)$$

The number of degrees of freedom NU for this criterion is determined by the formula (6):

$$NU = C_K^2 \cdot \frac{NE(NE-1)}{(NE-2)^2}. \quad (6)$$

For the conducted survey $\chi^2 = 60{,}28$, $NU = 29{,}53$. From the distribution tables χ^2 for $NU = 30$ and $\alpha = 0{,}05$ $\chi^2_{табл} = 43{,}8$. Thus, the coefficient of agreement of experts' opinions W was considered significant.

Determining the efficiency of existing online learning models

The efficiency of learning processes for a particular course is calculated by the formula (7):

$$E_K = \sum_{i=1}^{7} C_i \cdot w_i, \quad (7)$$

where E_K – efficiency of learning processes for a particular course; C_i – the value of the i-th criterion for the course; w_i – weighting factor of the i-th criterion.

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By substituting the weights of the criteria obtained by pairwise ranking by experts in this formula, we obtain (8):

$$E_K = 0{,}186K_1 + 0{,}076K_2 + 0{,}171K_3 + 0{,}133K_4 + 0{,}181K_5 + 0{,}161K_6 + 0{,}090K_7, \quad (8)$$

where $K_1 \dots K_7$ – values for the relevant criteria from the table (1).

The most commonly used within the massive open online courses platform Prometheus models are:

- Self-paced (the student masters the course independently on his own);
- with teacher’s support (the teacher consults the student, helps to master the course);
- blended format (course with offline part);
- with motivational elements (different levels of certification, use of a course for certification trainig, etc.).

The value of the efficiency of the learning process was calculated by formula (7) for 97 different courses on the Prometheus platform used in different learning models. The total efficiency of each of the 4 models was determined by the arithmetic mean of the efficiency of the courses used in a particular model. The results are shown in table 2.

Table 2

The efficiency of online learning models

Online learning model	**Number of courses**	**Calculated efficiency**
Self-paced	97	**42,233**
With teacher’s support	24	**43,601**
Blended format	24	**44,088**
With motivational elements	38	**44,799**

The value of the calculated efficiency depending on the model used is shown in Figure 1.

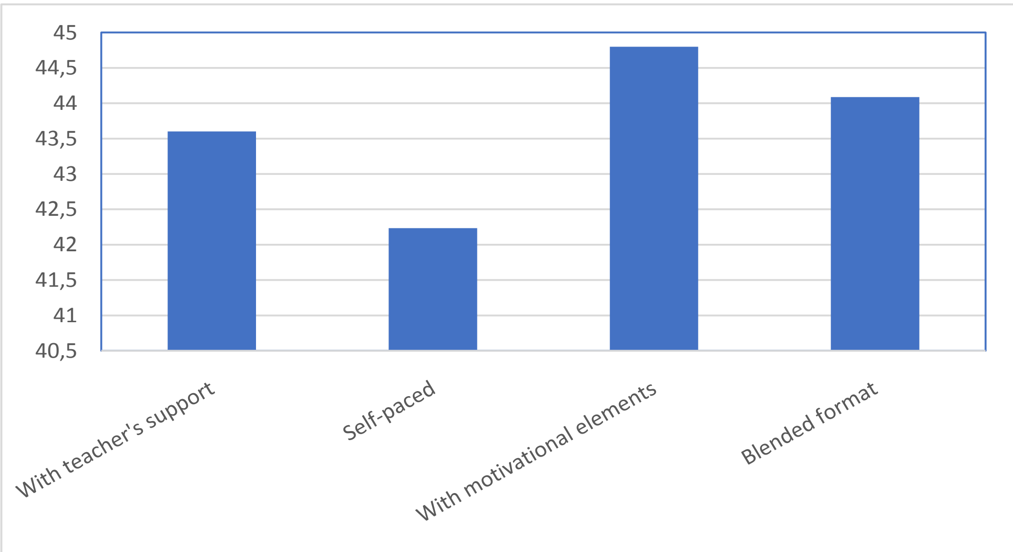

Figure 1. The calculated efficiency of online learning depending on the model used

These data show that the efficiency of online learning increases with the involvement of additional motivational elements in the educational process [13,15], but all the proposed models have a mediocre level of efficiency. Accordingly, none of the existing models is efficient enough, requires refinement and use of new elements.

Conclusions

Approaches to the classification of online learning models were analyzed, in particular, the classifications considered by M. Weller and L. Harasim, which allowed to establish boundaries for further research.

Our own method was proposed to determine the efficiency of online learning models based on quantitative criteria, the list and weights of which were obtained by the method of expert evaluations.

The proposed method was tested on quantitative data of the 4 most common models used at online learning platform Prometheus – self-paced, with teacher’s support, with blended learning format and with motivational elements. Numerical values for the evaluation criteria were obtained by analyzing the students’ online courses completion data. The results of the study showed that the efficiency of existing models has the potential to be increased. This will allow further research to propose our own model, which should be based on a combination of elements to increase motivation and will be aimed at maximizing the efficiency of online learning.

REFERENCES

1. Rindlisbacher C. The 100 Most Popular Courses During the Pandemic // Class Central. 2020. URL: https://www.classcentral.com/report/coronavirus-most-popular-courses/ (дата звернення: 07.09.2020).

2. Пархоменко А. В. Перспективи розвитку систем дистанційної освіти у вищій школі. IX Міжнародна науково-технічна конференція студентів і аспірантів «Друкарство молоде». Київ, 2009. С.110-112.

3. Пархоменко А. В. Місце дистанційної освіти у вищій школі. VIII Міжнародна науково-технічна конференція студентів і аспірантів «Друкарство молоде». Київ, 2008. С.121-122.

4. Parkhomenko A. The Future of Modern Distance Education Systems. Innovations in Science and Technology. Kyiv, 2009. С.193-194.

5. Сегол Р. И., Пархоменко А. В. Использование МООС в учебном процессе. Проблемы современного образования в техническом вузе: материалы V Междунар. науч.-метод. конф. / ГГТУ им. П. О. Сухого. Гомель, 2017. С.143-145.

6. Harasim L. Shift happens. Online education as a new paradigm in learning. Internet and Higher Education 3, 2000. P. 41-61

7. Doering A., Veletsianos G. Hybrid Online Education: Identifying Integration

Models Using Adventure Learning. Journal of Research on Technology in Education 2008 41:1, P. 23-41

8. Mirza A., Al-Abdulkareem M. Models of e-learning adopted in the Middle East. Applied Computing and Informatics, Vol. 9, 2011. P. 83–93

9. Weller M., Models Of Large-Scale E-Learning. JALN, Vol. 8, Issue 4, December 2004. P. 83-92

10. Hill P. Online Educational Delivery Models: A Descriptive View // Educause review. 2012. URL: https://er.educause.edu/-/media/files/article-downloads/erm1263.pdf (дата звернення: 07.09.2020).

11. Bates A.W. (T.). Teaching in a Digital Age v.2 // 2019. URL: https://pressbooks.bccampus.ca/teachinginadigitalagev2/ (дата звернення: 07.09.2020).

12. Chauhan A. Massive Open Online Courses (MOOCS): Emerging Trends in Assessment and Accreditation. Digital Education Review, Number 25, June 2014. P. 7-18

13. Parkhomenko A., Segol R., Lisovichenko O. Comprehensive analysis of the students’ motivation connection to the massive open online courses completion rate. Адаптивні системи автоматичного управління. Київ : «Політехніка», 2019. № 34 (2019), С. 73-80.

14. Кендэл М. Ранговые корреляции. Москва : Статистика, 1975. 215 с.

15. Пархоменко А. В., Сегол Р. І., Лісовиченко О. І. Вивчення мотивації слухачів онлайн-курсів. Адаптивні системи автоматичного управління. Київ : «Політехніка», 2018. № 1 (32). С. 137-145.