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Research paper

A Mathematical Blended Learning Model for University Students

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Abstract

The article aims to develop a model for assessing the quality of blended learning for university students. Different viewpoints on blended learning and the quality of learning are summarized and systematized. A model and method for assessing the quality of blended learning are presented. Approaches are developed for obtaining estimates of the quality of learning based on a priori and a posteriori assessment methods.

Keywords: *blended learning, quality of learning, quality of blended learning, mathematical model, optimization task.*

1. Introduction

The main objectives of higher education are the continuous improvement of educational content and quality training. The introduction of the blended learning model in the educational process is a flexible tool in this regard.

There are different definitions of the term "blended learning". Imported to Russia from abroad, this term is interpreted as a formal or nonformal educational program that combines online digital media and traditional classroom learning [1]. To ensure a comprehensive learning experience for every student at every stage of his or her education program, the following conditions for education need to be satisfied: e-learning, learning management, learning environment management and learning time management [2].

Thus, blended learning at university combines traditional and distance learning [3].

2. A Methodology for Blended Learning Management

As a rule, blended learning comprises the following stages: motivational, distance learning of theoretical subject matter, classes, in-class interactive and practical activities based on the syllabus, labs, independent work on assignments, distance verification of finished assignments, online testing and follow-up activities. The educational process has to be organized in such a way as to reflect the latest Russian and international trends in education. What follows is a review of some of the above-mentioned blended learning stages. [4]

In any education model, the question arises as to how to motivate learners. According to researchers, the most effective motivational tools in blended learning are the following ones:

– make a motivational introduction (video screening or any other presentation), explaining why knowledge of this or that content is important;
– establish well-defined educational goals for students;
– provide students with interesting materials containing videos, charts or animation;
– provide students with concise instructions on how to accomplish typical, reproductive assignments;
– give students additional learning content that they will need to accomplish productive and reconstructive assignments;
– provide students with individual or independent productive and reproductive assignments;
– provide students with additional learning content that they will need to accomplish creative assignments;
– provide students with individual or independent creative assignments;
– provide students with concise information on what the points will be given for and their number in case of assignment completion;
– use e-mails, a forum or an "Ask Your Teacher" chat for students to overcome difficulties that may arise in completing their assignments;
– give students the opportunity to assess each other's work in a forum or chat;
– make use of pretesting based, for instance, on the topic of an independent assignment;
– give bonus points for assignments completed on time.

In working on increasing student motivation, the teacher develops students' interest in and responsible attitude towards learning, discipline, aspiration to achieve good results and to feel successful; the teacher should also increase their cognitive activity and independence. Different motivational techniques and tools can be used to boost student motivation, including the use of educational and information technologies motivating students to learn. Using

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the latest information and communication technologies makes it possible to improve considerably the students' independent work.
Distance learning brings about marked changes to the students' independent work in terms of organization and management. Independent distance learning is an effective way of organizing student learning that improves their reception of education content (for example, via Moodle), their cognitive independence and activity, their motivation to learn, their communication skills, their self-organization and self-discipline, their ability to respond to professional challenge and their student-teacher cooperation skills.
In pedagogical practice, any learning technology includes mandatory reflection, the aim of which is for students to mention, detect and reflect on the main components of learning activities. Teacher-guided student reflection is an integral part of the active learning process.
Experience shows that developing student reflection is a relatively complicated process for teachers that requires time, efforts and certain capacities. This process is, however, worth it because it makes the students' self-awareness process more purposeful and cognitive.
Having examined some organizational aspects of blended learning, let us get back to our definition of the term "blended learning". We define it as a learning system that integrates traditional organizational methods and learning techniques with online learning based on the latest information and communication technologies and, thus, has positive impact on the effectiveness and quality of learning. Let us dwell on the quality of learning.
The quality of higher education includes quantitative and qualitative indicators of university graduates' learning outcomes. Each discipline is making its own contribution to the general notion of "quality of learning". If properly implemented, internal mechanisms for ensuring the quality of the learning process bring about better governance, educational work and teaching techniques for detecting gaps in students' knowledge. The education management system can be effective only if ensures internal mechanisms of teaching and learning quality.
In our view, the quality of blended learning is a comprehensive indicator that includes the following:
– qualitative and quantitative knowledge and skills' indicators of students enrolled in specific educational program;
– qualitative and quantitative education management indicators (quality of learning materials and delivery strategies, practical tasks and delivery strategies, independent and individual assignments ad delivery strategies, quality of testing, etc.).
Research objective is to develop a mathematical blended learning model for university students.

3. A Mathematical Blended Learning Model for University Students

Psychological and pedagogical research has various blended learning models. Our model focuses on assessing the quality of this learning method. The assessment of the quality of blended learning pursues the objectives listed below. Let us consider the following assumptions:
1. Blended learning of a discipline combines the traditional and distance learning methods (n methods, $i = 1 \div n$ or i = 1 ÷ 2).
2. Every discipline consists of M topics, in line with the curriculum.
3. Every topic is to be completed before a specific deadline: T:
$T = T_1 + T_2 + ... + T_M$.
4. In any learning method, every topic comprises or may comprise the following organizational components (l components, $l = 1 \div K$): 1) motivating students to learn, 2) studying the theoretical work, 3) giving or doing practical assignments, 4) lab work,
5) working on an individual assignment, 6) independent work, 7) topic-based quiz, 8) knowledge assessment, 9) final examination, and 10) student reflection.
5. In studying any topic j ($j = 1 \div M$), every organizational component l ($l = 1 \div K$) can be provided with a specific utility function of blended learning of a discipline, which is not subject to direct measuring. It can be assessed using expert ranked estimates (R_{ij}^l) of a j topic, in the i learning method, in terms of impact of the organizational component l on the quality of learning. Ranks are determined using the rank correlation method and ranged from the maximum one (K) to the minimum one (1) depending on the *utility* of blended learning of a specific discipline, given the j topic and the i learning method.
6. To perform the selection procedure, a propositional variable x_{ij} equal to 1 is specified, if the teacher uses the i learning method when teaching a j topic, and equal to 0 otherwise, i.e. $x_{ij} = \in \{0,1\}$.
Taking into consideration the above assumptions, the problem of assessing the quality of blended learning is formulated as follows.
Let's assume that:
n is the number of blended learning methods,
M is the number of discipline-related topics,
T_j is the time allotted for the study of the j topic,
K is the number of organizational components in presenting the j topic,
R_{ij}^l is the ranks attributed by experts to the j topic in the i learning method in terms of impact of the organizational component l on the quality of learning.
For every organizational component l, it is necessary to choose the i learning method for every j topic so that the sum of ranks reflects the combined effect on the quality of blended learning of a discipline:

$$\sum_{i=1}^{n}\sum_{j=1}^{M}\sum_{l=1}^{K} R_{ij}^{l} x_{ij} \to \max \quad (1)$$

under the following limitations:
time allotted to the study of a discipline is

$$\sum_{j=1}^{M} T_j \le T, \quad (2)$$

the need to study all topics is

$$\sum_{i=1}^{n} x_{ij} = 1, \ (j = 1, M), \quad (3)$$

a choice of at least one learning method for each topic is

$$\sum_{j=1}^{M} x_{ij} = 1, \ (i = 1, n), \quad (4)$$

integrity of propositional variables is

$$x_{ij} = \in \{0,1\}. \quad (5)$$

4. A Method for Assessing the Quality of Blended Learning

The problem-solving stages (1)-(5) can be grouped into the following units: 1) assessing the effectiveness (utility) of blended learning by the teacher; 2) assessing the effectiveness (utility) of blended learning by the student; 3) making a comprehensive expert assessment of the effectiveness (utility) of blended learning; 4) choosing the education management type in blended learning.
Let us examine the above units. The general aspects of blended learning and the quality of learning have been examined, the notion of "quality of blended learning" has been explained and a

model for the quality of blended learning has been presented above. Research effort will now focus on the establishing R_{ij}^{l} ranks.

The quality of students' knowledge and skills is understood as sound, deep and consistent knowledge as well as its practical application [5].

The teacher's assessment of students' knowledge and skills is a significant component of the integral indicator of the quality of learning.

The teacher's assessment of how effective blended learning is, or the teacher's approach is, also includes his assessment of learning management.

Among the qualitative indicators of learning management when studying a specific discipline are the following ones: student satisfaction with the discipline-focused learning process; course structure, accessible and clear learning materials; logical coherence of learning materials; comprehensive learning materials on independent laboratory and practical assignments (tasks); the teacher's establishment of clear criteria for assessing accomplished laboratory and practical assignments (tasks); conformity of tests to learning materials; students' satisfaction with their teachers' learning material presentation; and student guidance on learning materials. Other teachers of the department attend their colleagues' classes and assess the above-mentioned criteria, which we call an *a priori* assessment.

In our view, the assessment of learning management is to be done not only by teacher, but also by other active participants in the learning process, i.e. by students.

We believe it appropriate to take into consideration the students' views on the teacher's organization of the learning process in this or that discipline. This will allow the teacher to improve his professional skills. We define the students' views on their teacher's learning management as a source of a posteriori information or the so-called "student approach". Students assess both their own learning indicators and the above qualitative indicators of learning management in this or that discipline.

What follows is an examination of the *a posteriori* assessment of the learning process. We use the learning process indicators (LPI) and the students' experience in assessing their personal capabilities to detect the most informative indicators in terms of further improvement of the LPI. The following stages are suggested to deal with this key task: framing of survey questions; student survey and statistical data collection; data processing and ranking of LPI factors; analysis of data obtained. The assessment adopts the rank correlation method and the concordance correlation coefficient is used to check opinion consistency.

This approach broadens the teachers' experience in LPI management. The students' involvement in LPI assessment allows the teacher to improve his pedagogical work and detect the so-called weak spots. A posteriori assessment develops the students' skills in accurately assessing both their teachers' and their own performance.

Both approaches to assessing the effectiveness (utility) of blended learning – the teacher approach and the student approach – result in a generalized expert assessment and allow the teacher to improve the learning process as a whole. This stage shapes R_{ij}^{l} ranks (see (1)-(5) tasks in choosing the blended learning method).

Given that (1)-(4) expressions are linear forms, the developed mathematical model is an integer programming model that is solved using MS Excel's Solver.

5. Conclusion

Our study has attained all of its objectives. The main conclusions are as follows:

– views on blended learning have been summarized and systematized;

– views on the quality of learning have been summarized and systematized;

– assessment of the quality of blended learning has been done, a model for assessing the quality of blended learning and a method for meeting the identified objective have been presented;

– methods have been developed to facilitate the assessment of the quality of learning, based on the a priori and a posteriori assessment techniques;

– assessment has been given of the effectiveness of blended learning in terms of impact on the quality of learning.

In our viewpoint, blended learning allows to combine modern teaching approaches and information and communication technologies with a view to provide effective and quality education for all students.

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