

Flexible Model for Organizing Blended and Distance Learning

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Abstract. The proposed flexible model for the organization of mixed and distance learning involves the creation of an individual learning path for student testing before starting training. Based on the learning outcomes, the student is credited to the learning path. The learning path consists of mandatory and optional modules for training, optional modules can be skipped by passing the test successfully. The training model is represented using the ontological model, and the decision-making rules for the model are logical rules.

Keywords: Blended learning · Distance learning · E-learning · Ontological model · Artificial intelligence · Digital literacy · Lifelong learning

1 Introduction

The main goal of this research is to create a flexible model of blended and distance learning, which will allow students and teachers to work more efficiently and effectively organize educational activities. The research also aims to increase interest in intelligent learning systems, blended, distance and e-learning among teachers. The model will be considered on the example of the organization of advanced training courses as lifelong learning for teachers. The course is devoted to the formation of digital skills of university professors, which is supposed to be organized before the start of the new school year. In the context of the COVID-19 pandemic, the universities of the world switched to distance learning, including traditional universities that taught face-to-face. In such circumstances, many teachers felt a lack of digital skills and it was decided to organize long practice-oriented courses for teachers. However, in the context of a large university with a large number of teachers and a wide range of educational programs, which is inherent in classical universities, the level of digital skills of teachers is completely different. However, a survey conducted among teachers showed that teachers of engineering programs want to improve their digital skills, not to mention teachers of humanities. Since the resources of the training Center are limited, and each teacher requires an individual learning path, it became clear there was a need for organization of courses that would help teachers to improve their skills, and it was decided to develop a flexible model for organizing blended and distance learning. This model is applicable both for blended learning and for distance learning and contains online lectures, online tests, as well as practical exercises, which, depending on the type of organization of the lesson, can take place either face-to-face or online. The flexibility

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of the model is provided with enrollment in this course. Each student passes an entrance test, which determines their level of digital skills. The levels are conditionally divided into four: beginner, elementary, intermediate, advanced. In case of determining the advanced level, digital skills training is not carried out and the applicant can be enrolled in another advanced course. The rest of the tested applicants, depending on the level of skills, are credited to one of three trajectories, which are also quite flexible. If the applicants have any skills at the entrance to the module inside the trajectory, they can skip it by passing the test and immediately get to the next module.

Modern researches in the field of blended, distance, e-learning show that students use technology in various ways, adapting communication tools in accordance with their individual needs [1]. Availability and flexibility of digital resources created the prerequisites for the further development of accessibility and flexibility of education [2].

Thus, the 21st century students tend to exhibit the following characteristics [3]:

1) They prefer multimedia environments, are constantly connected with their peers and most of the time via the Internet,
2) They require several consecutive stimuli (to avoid boredom),
3) They are impatient, and need constant feedback during the assignment completion,
4) They are social and pragmatic,
5) They focus on team spirit,
6) They adapt training to individual needs.

In order to develop a high-quality course that meets modern expectations, it was decided to develop a course for teachers with recorded online lectures on the necessary theoretical knowledge. To support the mastery of practical skills, video instructions have been prepared for working with various services. All instructions are written in the form of text documents for students who prefer a text format, packages of case studies, traditional tasks, questions and tests are developed. The instructors of this course have been given great freedom in creating tasks, so the tasks are prepared in a creative and varied way. Thus, criteria 1) and 2) are satisfied. Constant feedback is provided by the instructor conducting the lesson during the lesson, online and offline. As a necessary part of the course a chat and a forum for participants of the same trajectory is organized. Thus, criterion 3) is satisfied. Some tasks involve the fulfillment of team tasks, therefore, for the performance of such tasks, pedagogical scenarios have been developed for organizing the performance of these tasks in a team, both online and in class, in this way criteria 4) and 5) are satisfied. The flexibility of this model is laid down in the name and the moment of enrolling in the course, and until the end, the student can adapt it to the individual needs, thus, criteria 6) is fulfilled. Given all of the above, a flexible model for organizing blended and distance learning meets these requirements.

2 Related Works

E-learning systems actively use models and methods of artificial intelligence [4–7]. The effectiveness of such training are noted in the articles devoted to the study of the use of blended and distance learning using artificial intelligence.

The article [8] describes the implementation and experience of blended learning in the intellectual learning environment @KU-UZEM. The blended learning model is implemented as a combination of face-to-face learning and e-learning. The intellectual learning environment diagnoses the level of students' knowledge, and also gives feedback and tips to help them in understanding the subject of the course, overcome their mistakes and consolidate the concepts studied. ITest provides an assessment environment in which students can take tests that have been prepared according to their level of study. In [9], the blended learning is achieved through a Learning Management System (LMS) using distance learning technology. LMS consists of course materials supported by flash animation, student records, user roles, and grading systems such as surveys and tests that comply with SCORM standards, and the learning process has been supported by an intelligent program. The article [10] identifies system requirements for an intelligent, mobile blended learning environment (m-Learning). Here, the theories of ontology modeling are developed. A context-sensitive adaptation mechanism, using explicit and implicit knowledge of the student profile model, is proposed. It is shown that the context in which the training takes place is represented by a set of functions that contextually depend on the training modeled as an ontology with multiple relations. The implemented prototype is a partially contextual system for representing m-Learning data. It is concluded that the m-learning environment is useful for the results of the program, mainly for students who study according to the gateogical model. Further work is being carried out to cover the m-Learning requirements that are better suited for students using the model of pedagogical education. Representation ontologies describe a conceptual model, which is the basis of the knowledge representation formalism. Ontology is successfully used in modeling systems for various types of knowledge. For example, ontological models for representing knowledge are proposed in articles [11–16]. The use of ontologies for modeling knowledge in specific areas is a key aspect for integrating information from different sources, for supporting collaboration in virtual communities, for improving the search for information, and, more generally, it is important to justify the existing knowledge. In the field of e-learning, ontologies can be used to model educational areas, as well as to create, organize and update specific learning resources. One of the main problems in modeling educational areas is the lack of experience in the field of knowledge engineering by e-learning participants. The paper [17] presents a comprehensive approach to ontology lifecycle management, used to determine personalized e-learning experience. The development of systems capable of drawing logical conclusions from the knowledge base is developing rapidly around the world. The extraction of existing and the generation of new knowledge and statements from the existing knowledge base is carried out using specialized mechanisms designed for reasoning and logical conclusions [18–23]. In the article [24], the authors propose implementing an Intelligent system for assessing the formation of professional competencies of students based on fuzzy models and logical conclusions from the knowledge base for distance learning systems. В [25] предложена модель и метод оценки компетенций студентов e-learning system. In [25], the authors propose a model and method for assessing students' competencies in the e-learning system.

3 Entrance Testing for Students

Entrance testing for students is carried out in order to determine their level of digital skills. Entrance testing is carried out by a multiple choice test with a single correct answer. The test contains 50% of questions of difficulty level A, 30% of difficulty level B and 20% of questions of difficulty C. The test tasks are developed in accordance with the following requirements for difficulty levels.

Test tasks of difficulty level A:

"identification" of some object or verification of "knowledge-familiarity";

choosing one answer from many knowing just one concept;

open type task aimed at revealing knowledge of the definition of a monosyllabic basic term.

Test tasks of difficulty level B:

it is aimed at the application of previously acquired knowledge in typical situations (that is, in those situations with which the subject is familiar) or to check the "knowledge of copy reproduction". Test tasks of this level of difficulty should include test tasks aimed at thinking related to statements of a conjunctive or disjunctive form or test tasks with several concepts for choosing a subset of the correct options from a given set of conclusions. In some cases, test tasks for compliance and order can be assigned to test tasks of this level of difficulty.

Test tasks of difficulty level C:

it is aimed at the application of acquired knowledge and skills in non-standard conditions (that is, in conditions previously unfamiliar to the subject) or to test "knowledge of skills and application". Test tasks of this level of difficulty include tasks that cause conclusions formulated in the form of statements of an implicative type. Such tasks require the use of reasoning in the form of deductive, inductive inference and analogy, and in order to obtain the final answer, some sequence of conclusions (several concepts) is required.

The percentage of test items, points and its difficulty are presented in Table 1.

Table 1. Digital skills levels

Test difficulty level	Percentage of questions in one test	Range of points	Digital Skill levels
A	25%	0–30	Beginner
A	25%	31–60	Elementary
B	30%	61–95	Intermediate
C	20%	96–120	Advanced

A formalization and a method for calculating the assessment of knowledge on the advanced training course are proposed. They have been considered in [24]. Here, the response in a natural language is evaluated compared to the reference answer from the knowledge base, and, in this case, a simple multiple choice test with a single correct answer is evaluated. In the considered case, the assessment model presented in [24] is simplified and looks as follows:

Let P be a finite and non-empty set representing a knowledge base of a given discipline; Q – a finite and non-empty set representing a base of test questions on a given discipline; S – a finite set representing a knowledge base of student answers to the test questions in a given discipline. Then it is possible to define the following rules for decision making:

If the set of student's answers an empty set, i.e. $S = \emptyset$, it is believed that there is not a single answer to test questions;

If the set of student's answers to the test questions is not an empty set, but is not contained in the knowledge base of a given discipline, i.e., $S \neq \emptyset \ \& \ S \not\subset P$, then it is believed that a student does not know the material for a given discipline;

If the set of student's answers to the test questions is not an empty set, but completely coincides with the set of correct answers, i.e., $S \neq \emptyset \ \& \ S = T$, then it is believed that a student fully knows the material which is foreseen in the standard answers;

If the set of student's answers to the test questions is not an empty set, but is strictly contained in the set of correct answers, i.e. $S \neq \emptyset \ \& \ S \subset T$, then it is believed that a student partially knows the material foreseen in the correct answers;

Теперь, с учетом выше определенных правил для принятия решений можно определить оценку ответов студента на тестовые вопросы в виде следующего нечеткого бинарного отношения: Now, taking into account the above specific rules for decision making, it is possible to determine the assessment of student's answers to the test questions in the form of the following fuzzy binary relationship

$$'\text{Assesment}' \rightleftarrows S \subseteq T = \{ < s, t > \mid \ s \in S, t \in T, \ \mu_{S \subseteq T}(< s, t >) \},$$

Where $\mu_{S \subseteq T} : S \times T \rightarrow]0, 1[$ – membership function for fuzzy relations.

To calculate the elements of a fuzzy relation $S \subseteq T$, it is necessary to specify the elements of sets S *and* T that represent the set of individuals of the class, the set of properties of the class and the set of semantic arcs incident to the class.

Now we present the method of assessing the level of knowledge proposed in [21].

Let $Q = \{q_1, q_2, \ldots, q_n\}$ be a set of test questions, $S = \{s_1, s_2, \ldots, s_n\}$ – a set of student's answers to test questions, $T = \{t_1, t_2, \ldots, t_n\}$ – a set of correct answers – $q_1, q_2, \ldots, q_n$, respectively. Then the fuzzy binary relation $S \subseteq T$ can be represented using Table 2, in which the elements of the set S serve as row names, and the elements of the set T serve as column names. At the intersection of a row S_k and a column t_l, there is a placed element $\mu_{S \subseteq T}(< s_k, t_l)$, k = 1, 2,…, n; l = 1, 2, …, n.

Table 2. Definition of a fuzzy binary relation $S \subseteq T$.

	t_1	t_2	..	t_n
s_1	$\mu_{S\subseteq T}(<s_1,t_1>)$	$\mu_{S\subseteq T}(<s_1,t_2>)$	..	$\mu_{S\subseteq T}(<s_1,t_n>)$
s_2	$\mu_{S\subseteq T}(<s_2,t_1>)$	$\mu_{S\subseteq T}(<s_2,t_2>)$	..	$\mu_{S\subseteq T}(<s_2,t_n>)$
...	...	...	..	...
s_n	$\mu_{S\subseteq T}(<s_n,t_1>)$	$\mu_{S\subseteq T}(<s_n,t_2>)$	..	$\mu_{S\subseteq T}(<s_n,t_n>)$

The total score corresponding to Table 2 is calculated by the next formula:

$$\mu_{S\subseteq T}(<s,t>) = \frac{\sum_{k}^{n}\sum_{l}^{n}\mu_{S\subseteq T}(<s_k,t_l>)}{n*n} \quad (1)$$

In the general case, Table 2 can be multidimensional, in which the elements can again be tables, i.e. it can have several levels of hierarchy. For each table, regardless of its hierarchy level, the overall score will be calculated using a formula similar to formula (1). In this case, the overall score of the low-level table will be considered the value of the table element of the nearest upper level.

Thus, we have developed a method for assessing knowledge in a given subject area based on a fuzzy relationship between the sets of student's answers to test questions and the sets of correct answers.

Now we will translate the calculated grade into the grade using the value of the grade relationship in determining the level of the testee:

$$'\text{Assesment}' = \begin{cases} \text{beginner, if } 0 \le \mu_{S\subseteq T}(<s,t>) \le 0.25 \\ \text{elementary, if } 0.26 \le \mu_{S\subseteq T}(<s,t>) \le 0.5 \\ \text{intermediate, if } 0.51 \le \mu_{S\subseteq T}(<s,t>) \le 0.79 \\ \text{advanced, if } 0.8 \le \mu_{S\subseteq T}(<s,t>) \le 1 \end{cases}$$

After determining the initial level of the student as beginner, elementary, intermediate or advanced, within the framework of the considered course, enrollment for the corresponding learning trajectory is made. Test takers with the advanced level fall into the reserve for admission to courses requiring high professional skills.

4 Ontological Model of a Lifelong Learning Course

The term "ontology" (the word "ontology" comes from the Greek "ontos" - existing and "logos" - concept, teaching, reason), proposed by R. Goklenius, appeared in 1613. At present, the methods of knowledge engineering, the young science of the extraction, structuring, presentation and processing of knowledge are becoming more and more popular. One of such conceptual shifts aimed at further intellectualization of user interaction systems was the emergence of ontologies. Since ontologies were the answer of science to the urgent needs of their time, their appearance also occurred in several

areas of knowledge at once. Accordingly, in each of them the resources of the ontological type were formed according to their own rules specific to the field of knowledge. The ontological model is built in Protégé tool [27]. It was developed at Stanford University in collaboration with the University of Manchester. The Protégé tool is a Java program that is freely distributed and designed to develop (design, modify, view) ontological structures of various subject areas. The program allows you to design ontologies, expanding the hierarchical structure of abstract and concrete classes and slots. Having formed the ontological structure, the ontology editor allows you to generate forms for obtaining knowledge for defining instances of classes and subclasses. The ontology editor Protégé supports the use of the OWL language, and also allows the generation of HTML documents that display the structure of ontologies. The use of a frame model of knowledge representation allows Protégé to be adapted for editing domain models, which are presented not only in the OWL language, but also in other formats. A comparative analysis of ontology editors by eight key criteria showed Protégé's excellence. Ontological structures can be developed and used in solving many diverse problems, also for multi-user sharing.

The ontology defines a set of representative primitives in the context of computer and information sciences with which we can model a field of knowledge or a discourse. The representative primitives are usually classes (or sets), attributes (or properties), and relationships (or relationships between members within a class). The definitions for representative primitives include information about their meaning and limitations of their logically concerted application.

This formalism determines the "O" ontology as triple (V, R, K), where V – is a set of classes for the subject field, R – is a set of relationships between the classes, and K – is a set of attributes within the field [13].

The ontological model consists of modules for advanced training and tests (Fig. 1).

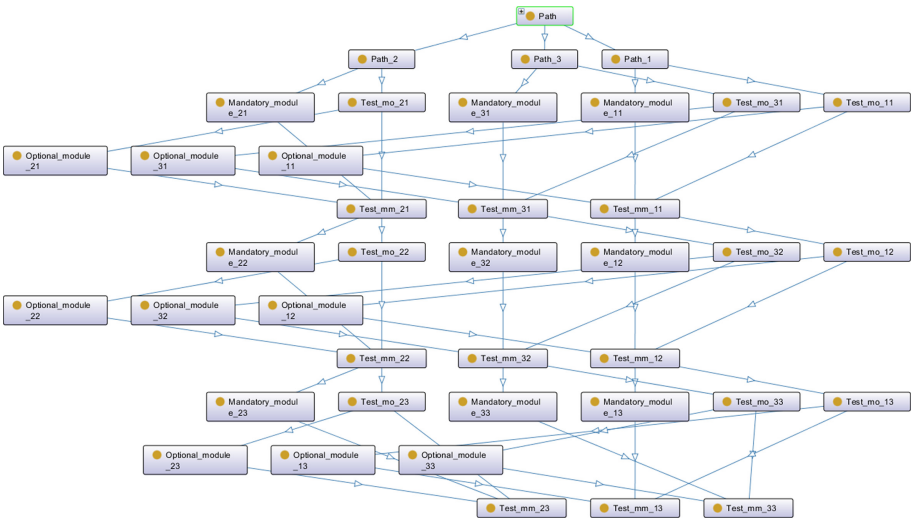

Fig. 1. Ontological model of a lifelong learning course

Each of the modules includes the mandatory modules, completion of which ends with the test and the optional modules, which begin with taking the test and, if the test is passed, it can be skipped. The described ontological model should minimize the inevitable repetitions that arise during the study of the course and provide students and their teachers with the opportunity to create individualized educational trajectories. Both mandatory and optional modules can be implemented both in a blended learning model and in a distance model. In the mixed model, it is assumed that practical classes are held face-to-face, and lectures can be held either online, offline, or face-to-face in a flipped classroom model. In the distance learning model, all classes are held in a remote format.

A possible variant of trajectory 1 in a bracketed formal record, in the case when the student successfully passed the tests for the optional module and does not study them, may look like this:

Path_1:

((((Mandatory_module_11)Test_mm_11) Test_mo_11) Mandatory_module_12) (Test_mm_12) Test_mo_12) (Mandatory_module_13(Test_mm_13) Test_mo_13))

Students are enrolled on Path_1 from among beginner students. The main software products related to computer literacy of teachers are products of Microsoft, therefore, although the teaching is carried out by university employees, the content of the Microsoft course is taken as the basis [27]. The course starts with the required module 11 "Work with Computers" and optional module 11 "Interract with a computer", the mandatory module 12 "Use a computer", optional module 12 "Access information online", the required module 13 "Communicate online", optional module 13 "Participate safely and responsibly online."

The ontological model of the advanced training course allows organizing flexible training in both mixed and distance formats.

An advanced training course should ensure the achievement of the planned learning outcomes. Its development should meet the following principles:

- use of a video lecture or MOOC mechanism;
- the use of didactic materials developed in accordance with the developed university procedure;
- result-centeredness of the course;
- automatic control of the planned results for mastering the competencies (planning and development of assessment tools for the course, providing control of the abilities to apply knowledge in practice at the set deadlines);
- automatic management of the entire educational process based on the selected structured course content (all educational material should be divided into small, easy-to-learn finished fragments, ending with automatic control and assessment of the level of formation of the planned learning outcomes);
- transparency of the criteria for assessing learning outcomes in points established in accordance with the complexity of their formation;
- increasing motivation for learning through the use of various techniques;
- joint training through network technologies of communication and counseling by the students themselves in the process of studying the course;

– the availability of electronic courses for anyone by means of basic Internet technologies, including mobile devices.

Thus, the Flexible model for organizing blended and distance learning based on ontology as the structural basis of the knowledge base allows us to implement the principles of mass variable learning and are able to provide individual educational trajectories.

5 Conclusion

In this paper, a flexible model for organizing blended and distance learning was proposed. The content of the course is presented in the form of an ontological model, which allows creating links between the course modules and test tasks. Based on the entrance testing, the student is enrolled in the learning trajectory. The training path consists of mandatory and additional modules for training, additional modules may be skipped if the test is passed successfully. The training model is represented using the ontological model, and the decision making rules for the model are the logical rules. The advanced training courses based on the ontological model using video lectures increase the efficiency of the learning process due to the growth of students' motivation and the possibility of parallel training of students with significantly different starting capabilities.

6 Further Work

Further work prospects, in our opinion, lie in creating a larger number of courses, based on entrance testing and individualization of the learning path with an improved system for assessing the level of mastering material, which will be based on semantic search, optimal ontology visualization and interactive dialogue.

In the future, it is planned to use the technology of formation and assessment of competencies, which can be used to form the assessment of competence of any EP. The technology is described in article [24]. In developing the technology for assessing competencies, the following points were taken into account: disciplines are the main links in educational activity, and it is the levels of students' mastery of the disciplines that are being evaluated. It is obvious that, evaluating the level of knowledge in the disciplines, in the end, you can correctly establish the level of competencies. In such conditions, it is more convenient to adapt the already accumulated experience and use adapted diagnostic methods within the framework of the competency-based approach. Within the framework of the methodological aspects of the automated competency assessment, a knowledge base will be developed on test questions of various types and difficulty levels. In addition, in technical aspects, researchers will continue to develop software that implements all stages of the semantic analysis of texts based on ontological technologies and natural language processing. The research results can be used to create intelligent distance learning systems and to assess competencies in a natural language.

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