Journal of Social Studies Education Research
Sosyal Bilgiler Eğitimi Araştırmaları Dergisi
www.jsser.org
2018:9(2),47-64

Organizing Blended Learning for Students on the Basis of Learning Roadmaps

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Abstract

The relevance of the problem of organizing blended learning for students is related to the sharpening contradiction between the high potential of this educational technology and the poor methodological elaboration of its use in actual learning practice. With regard to this, the paper is aimed at providing grounds for the methodological system of blended learning for students with learning roadmaps and bringing it to life. The leading idea of the methodological system consists in creating a special subject information environment that enables each student to design their own roadmaps for mastering certain subjects that fulfill the principles of blended learning. Theoretical justification of using the learning roadmaps in teaching the students has been given and blended learning in conditions of subject information environment has been performed in practice. It is shown that the students' blended learning model based on the course learning roadmap promotes the successful acquisition of IT subjects. The suggested method of organizing the students' blended learning is of interest for the contemporary theory of learning as well as for teachers implementing the elements of e-learning in their educational process.

Keywords: *blended learning, learning roadmap, self-regulated learning, subject information environment.*

Introduction

At present, the quality of educational process at higher education institutions is associated with the transition to innovation methods and means of learning in conditions of e-learning (Guri-Rosenblit & Gros, 2011)**.** The level of the contemporary ICT, methodological theory and practice of digital and distance learning can create organization and pedagogical conditions for shaping the learners' readiness to select their individual educational paths of learning, self-educational activity (Beishuizen and Steffens, 2011; Chigisheva et al., 2017; Tarman, Baytak & Duman, 2015; Tarman &Chigisheva, 2017; Yücel et. al., 2010)**.**

However, it is not always the case that e-learning dovetails with realia of the academic process of higher education institutions successfully and efficiently. It is well known that quite

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frequently some educational institutions use e-learning in a completely formal manner, with e-learning being interpreted largely as a strict necessity of following some attitudes and timeserving reasons (Zakharova et al., 2017).

It is so-called *blended learning* that gains a special part of all kinds of e-learning. Blended learning is a combination of traditional classroom learning forms with e-learning methods and with using the distance educational technologies which is of especial importance and prospects for the development of the contemporary education as a whole and for a certain academic process in particular. Blended learning allows organizing a flexible academic environment which ensures self-regulated learning – one under which students can determine the parameters of learning independently and in accordance with the requirements of the academic environment: its objective and strategy of learning, timing and results of learning, as well as alter them while mastering a subject (Pintrich, 2000). With regard to this, students have to have an opportunity of independently evaluating the scope of performed work on solving a selected task of learning, the skills obtained, and using the evaluation for selecting a new academic task.

The contemporary course of computer science at higher education institutions is an integral system of disciplines and is currently becoming extremely important not only as a basic fundamental science but also as a tool for professional training of the future specialists. For students, it has to ensure conditions for gaining skills of information activity, shaping the abilities of modeling their academic and professional sphere using ICT (Andreeva & Pak, 2015). Provided that they learn skills of self-assessment and tasks selection, this can considerably increase the volume of knowledge the students can get during self-regulated learning. The knowledge and skills obtained are used by the students as a means for gaining new knowledge and skills. Self-regulated learning is intended for improving the level of knowledge of students in the area of knowledge acquisition. Students select their strategies of learning up to their preferences and desirable results in learning and their self-assessment (Kintu et al., 2017). As for the latter, misjudgment leads to a wrong selection of tasks and building a "roaming" strategy of learning (Kostons et al., 2012).

With regard to this, the question arises: how can conditions be created for efficiently organizing the students' blended learning when studying the course of computer science at higher education institutions?

Recently, roadmaps have been used when designing complicated projects that involve different variants of fulfillment. As applied to the educational process, learning roadmaps can allow essentially democratizing the academic activity of students, "legalizing" their personal preferences in achievement of educational results (Andreeva & Pak, 2015; Pak et al., 2015).

Unlike the project-fulfillment procedure plans and programs, where all measures are strictly planned out with resources, performers and deadlines, a roadmap is projective (Pak, 2008) and it implies variability of achieving the end result based on new ideas, technologies, resources that emerge during fulfillment of the planned measures.

The objective of this work is to give grounds for and to design a way of using the learning roadmaps in organizing the students' blended learning within the academic process of the computer science course.

Literature Review

Regrettably, the traditional methodological systems of teaching computer science to students are already not up to the contemporary requirements of the society and the level of scientific and technical advance in computer systems and information and communication technologies (Záhorec et al., 2012).

Pedagogues have high expectations for tailoring of learning in collective academic process forms based on the principles of student-centered education paradigm. They fairly believe that this can foster shaping and developing in students the critical, creative thinking, team work skills, ICT literacy, leadership qualities, inquisitiveness, initiative and other 21st-century skills that help establishing a successful and competitive individual in the today's labor market (Crumly, 2014; Hannafin & Hannafin, 2010; Wright, 2011; Tarman, 2016; 2017; Tarman & Dev, 2018).

Clearly, it is on the basis of one of the kinds of e-learning – the blended learning – that it is more convenient to ensure the conditions for organizing the student-centered approach.

The term "blended learning" (blended, hybrid, integrated learning) came into common use among methods of learning after Bonk and Graham published their "Handbook of blended learning" in 2006 (Bonk and Graham, 2004).

The researchers Christensen, Horn and Staker (2013) single out the following compulsory properties of blended learning:

1. Student ownership implies it is the students and not teachers who are responsible for educational results, for choosing the ways of achieving them; it enhances the students' readiness to the expected mode of university studies and teaches them to independently set the objectives and tasks; it also improves the level of their motivation and achievements;

2. Personalized academic process enables the learners to build their own individual educational paths and study at their own pace;

3. Mastery-based learning implies transition to a new material only after the required level of mastery has been confirmed for the studied one;

4. Orientation to high achievements in each child is a psychological and pedagogical phenomenon that promotes high commitment and internal motivation;

5. Attaching importance to relations building involves equal relations of learners with their teacher, classmates, and representatives of third-party organizations of various ages that participate in the educational process.

In the Russian education, implementation of self-regulated learning has so far remained at the level of small projects, brief papers reporting the experience of use with emotional replies to any positive results obtained. Meanwhile, the analysis of studies (Zimmerman & Schunk, 2011; Beishuizen & Steffens, 2011) confirms that the methodological foundations of this educational technology is understudied and the experience of its use in real practice is not vast.

Nevertheless, there are increasingly frequent attempts of integrating the elements of e-learning into the traditional academic process. For example, the case when resources of massive open online courses (MOOC) are used in the traditional academic process seems quite appealing, particularly in computer science (Andreeva & Pak, 2017).

MOOC have to and may be used in the academic process of higher education institutions owing to the following factors. First of all, they combine the opportunities of distance and online learning provided that there are comprehensive digital learning and teaching support kits in the subjects. The study material is broken down in short sections, delivered in presentations and accompanied by audio and video recordings. Learning is based on gaining the knowledge independently in the process of step-by-step acquisition of the material. Second, a distinctive feature of MOOC is giving a great part to interactive communication of students and teachers via forums in the process of learning. Mutual assessment and discussion of works belong to the paramount methods of learning within MOOC (Andreeva & Pak, 2017).

However, here numerous organization and methodological difficulties arise that should be overcome at the expense of creating special subject information environment. In this environment, a mechanism for seamless inclusion of MOOC elements into all convenient kinds of the students' independent work has to be provided for. It is the technology of learning roadmaps (Andreeva & Pak, 2015, Pak et al., 2015; Nikolaeva & Pak, 2017) that can serve as a mechanism of this kind. A roadmap is a tool of planning. It is a diagram mapped along the temporal axis and reflecting the current or target condition of an object, and possible target achievement scenarios.

Kappel (2001) points out the twofold nature of the roadmap – it forecasts what may happen in the future while at the same time determining the scenario for further actions. The most important particularity of roadmaps is the opportunity to adjust the scenario being performed in line with the objectives that may change depending on circumstances and the situation. Thus, roadmaps allow taking advantage of the opportunities that have opened up and serve as a support in decision-making concerning further progress toward the objective (Phaal et al., 2004).

The starting point for developing a learning roadmap in computer science is students' educational need of the IC-competency. In the academic process on computer science (given the competency-based approach), the IC-competency is simultaneously the result of learning and the tool for achieving it. A higher level of IC-competency is reflected in students' preferences concerning the results of mastering the computer science; they may include them in their roadmaps and edit the roadmaps while learning. Students determine the level of their aspirations, fill another stage of the roadmap with academic activities and compare their actions to the teacher's roadmap and the discipline acquisition schedule. They can adjust the content, duration and performance of each stage as they progress along the roadmap within the general requirements for mastering the discipline. In case of deviations from the expected results, students can complete additional correction assignments to replenish any understudied academic material and edit the submitted solutions of assignments.

Teaching computer science with the use of roadmap technique reduces the risks arising in conditions of e-learning: it eliminates the cases of piecewise material acquisition, makes it possible to identify a student's personal contribution into the solution submitted by the student in a face-to-face talk, and allows avoiding the excessive "website scrolling" during the independent search for information in open-access resources.

Methodological Framework

The effectiveness of training the students for self-education in the educational process depends on the teachers' ability to pedagogically skillfully manage the students' self-education, and, certainly, on the extent of the students' being prepared for this kind of activity and on the appropriate means (Ryabov, 2009). In the work (Umarkhadzhieva, 2015), teaching methods are considered that shape the students' readiness for self-education.

By transferring the pedagogical functions on themselves, people thus master the system of the relevant "meta-cognitive abilities" (Mushtavinskaya, 2011, p. 148).

In order to create the multitude of conditions for drawing up learning roadmaps, a specially designed subject information environment (SIE) has to be created (Robert, 2010).

For building the methodological system of students' blended learning in computer science, the system of some general didactic principles has to be transformed.

The *principle of non-linearity of an individual learning path* is fulfilled due to the necessity of individualizing the learning and taking into account the personal and oriented pedagogical strategy of learning. It grants the students a right to consciously "breach" the sequential acquisition of topics and sections organized by the teachers. *The principle of professionally oriented learning* determines having to bring the computer science content in line with profile subject and professionally focused disciplines by creating special integrated academic projects the completion of which requires knowledge and abilities of using the information technologies.

The principle of consistency of knowledge and learning in independent work allows integrating the special knowledge, abilities, skills in both online and offline work. It is important and essential because it is targeted at ongoing generalization and systematization of the students' acquired knowledge during their self-educational activity.

The fourth one, *the principle of accessibility, sufficiency, and non-redundancy of the academic and methodological materials for mastering a discipline* is intended to optimize labor consumption and efforts of students when looking for the required information during the independent work. Fulfillment of the fifth *principle of consistent and objective diagnostics of the training level* focuses on finding out the extent of success of the learners' progress along their individual learning paths, on controlling and self-controlling the competencies being gained by them, and on the corrective and managing academic actions of teachers.

Finally, the sixth *principle of multitude in communication between the subjects of the academic process* is associated with situational and accessible student-teacher communication opportunities being necessary in the process of their remote communication and with the communications having to be mastered as a subject of learning.

The methodological system of blended learning in computer science has been developed supporting the above didactic principles. The components of the methodological system are: the target one, the content-related one, the procedural component and the assessment and performance one (Fig. 1).

The target component of the methodological system of blended learning in computer science reflects the educational demands of the society, family, and the state, the requirements of the state educational standards, and the demand for information technologies in all spheres of life. It is the basis for determining the content and kinds of academic activity, the regularity of its pace and means of assessment.

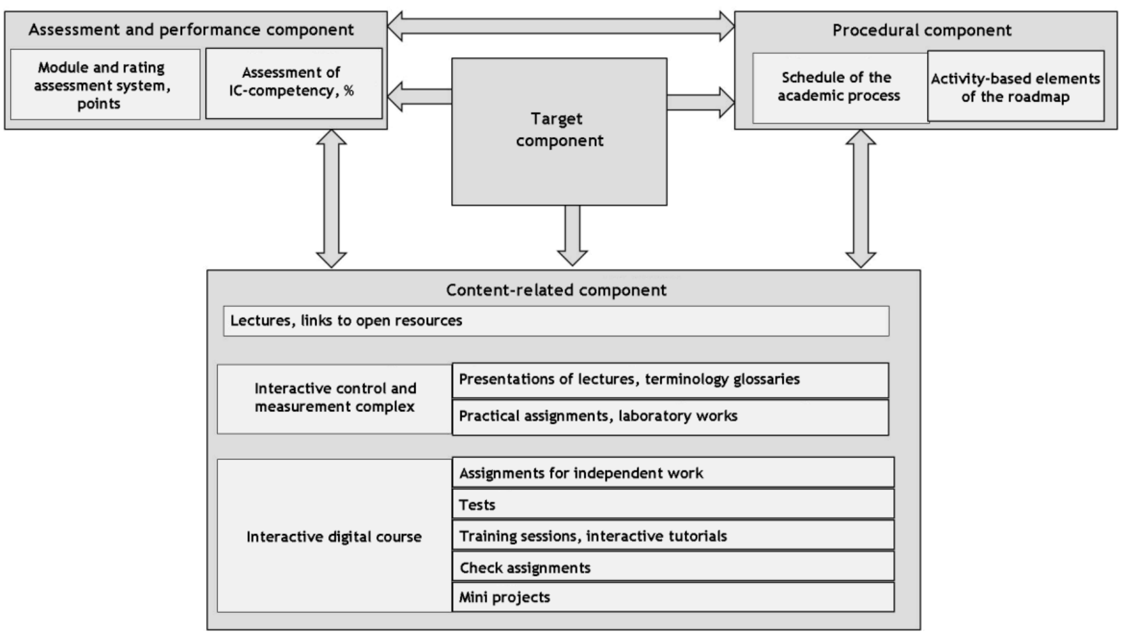


Figure 1. Components of methodological system of blended learning in computer science
Source: the authors

The results of mastering the computer science depend on the level of information and communication competency (ICC) formation in students. This is a multi-component assessment, with its structure determined by the direction of training of the students.

The assessment and performance component includes the module and rating system of assessing the students' activity in mastering the discipline and the procedure for correlating the score to the ICC development level. At each point of time, students can know their currently accumulated scores for all completed assignments, find out their ICC formation levels – see what they have mastered and are ready to perform and what sections they should pay closer attention to.

The content-related component, alongside with the subject learning, ensures the development of skills of information activity in information environments, the formation of abilities of independently searching for and mastering the new information, and modeling of academic and professional activity using the information and communication technologies (ICT). The professional focus of computer science for students of various directions of training is reflected by the topics range of problems and practical assignments, as well as by the standard information processing practices.

The procedural component ensures smooth work of students under the blended form of learning. It includes the schedule of the academic process and activity-based elements of the roadmap, it determines the check points of the academic process and the scope of work completed. The procedural component allows fulfilling variants of the roadmap for mastering a discipline. The reference teacher's roadmap determines the pace and effectiveness of the students' work in accordance with the general requirements for acquisition of the discipline. Students form their roadmaps for mastering the subject up to their own preferences for the results of learning and the regularity of work pace.

Results and Findings

In order to bring to life the methodological system, the subject information environment (SIE) for learning computer science has been developed (Fig. 2).

One of the main elements of the SIE is the *Interactive digital course*. It includes: the methodological support of academic classes, the communication component, and the interactive check and measurement complex (Andreeva & Pak, 2015).

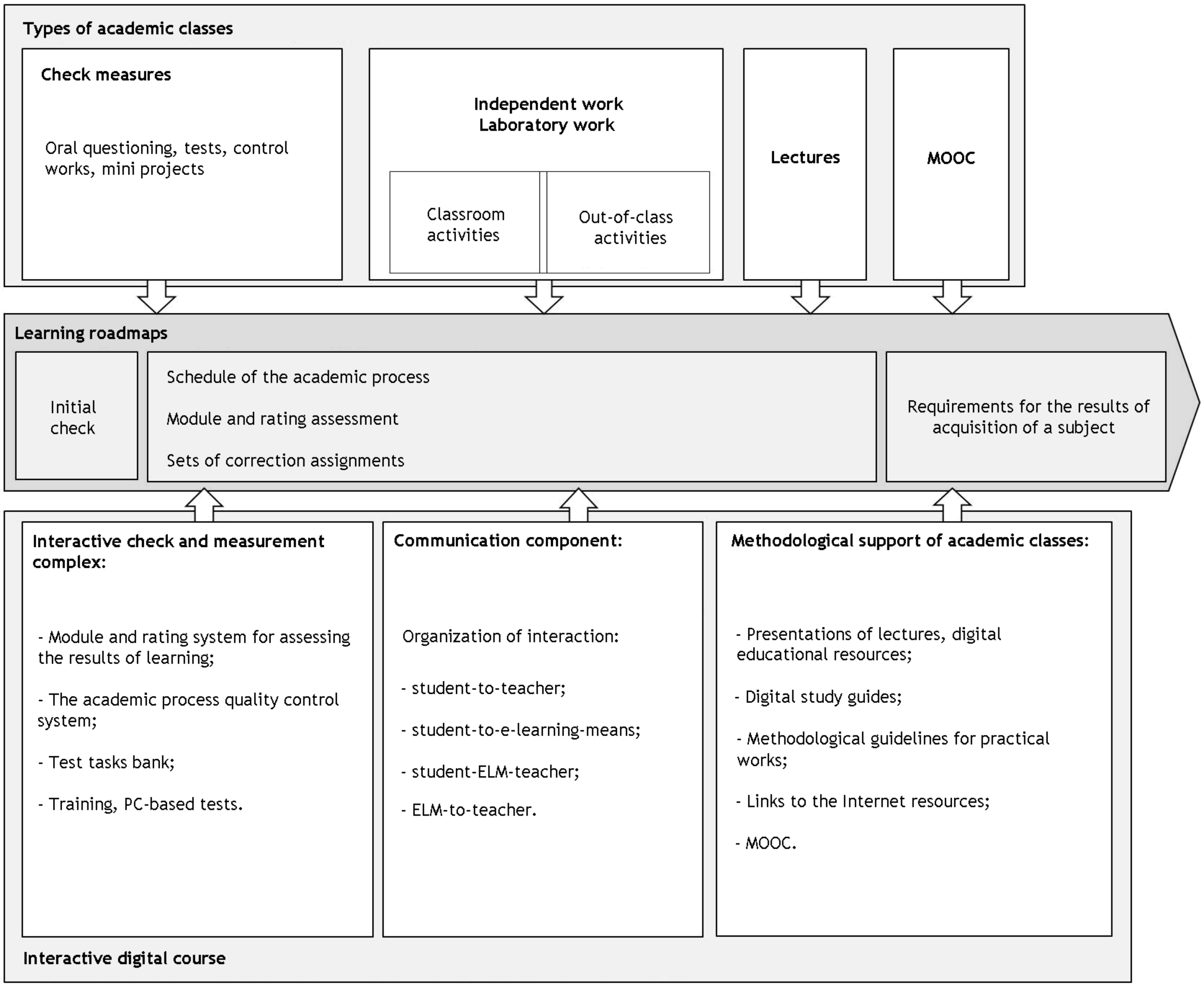


Figure 2. Element structure of the subject information environment

Source: the authors

The organization part of the academic process is ensured by structural elements of the SIE: *Requirements for the discipline acquisition results, Initial test, Types of academic classes, Modular and competency-based learning technology, Schedule of the academic process.*

For independent work, reproductive, productive and creative assignments are offered at various levels.

Massive open online courses (MOOC) are used as interactive study guides on individual sections of computer science, without any compulsory requirements for checking the results of mastering the courses.

Students may fulfill their roadmaps both according to the classical learning option and within the e-learning. The use of digital technologies in organization of practical discipline acquisition work enhances the efficiency of the process of learning (Koldaev, 2012; Semenova, 2012; Skuratov, 2009).

When commencing to master a subject, students determine the result – the desirable IC-competency formation level after the completion of learning (within the general requirements of the main curriculum on acquisition of the discipline). So the students "fill" their roadmaps being guided by their educational needs and personal preferences.

Fig. 3 shows the block diagram of building a student's learning roadmap when studying computer science.

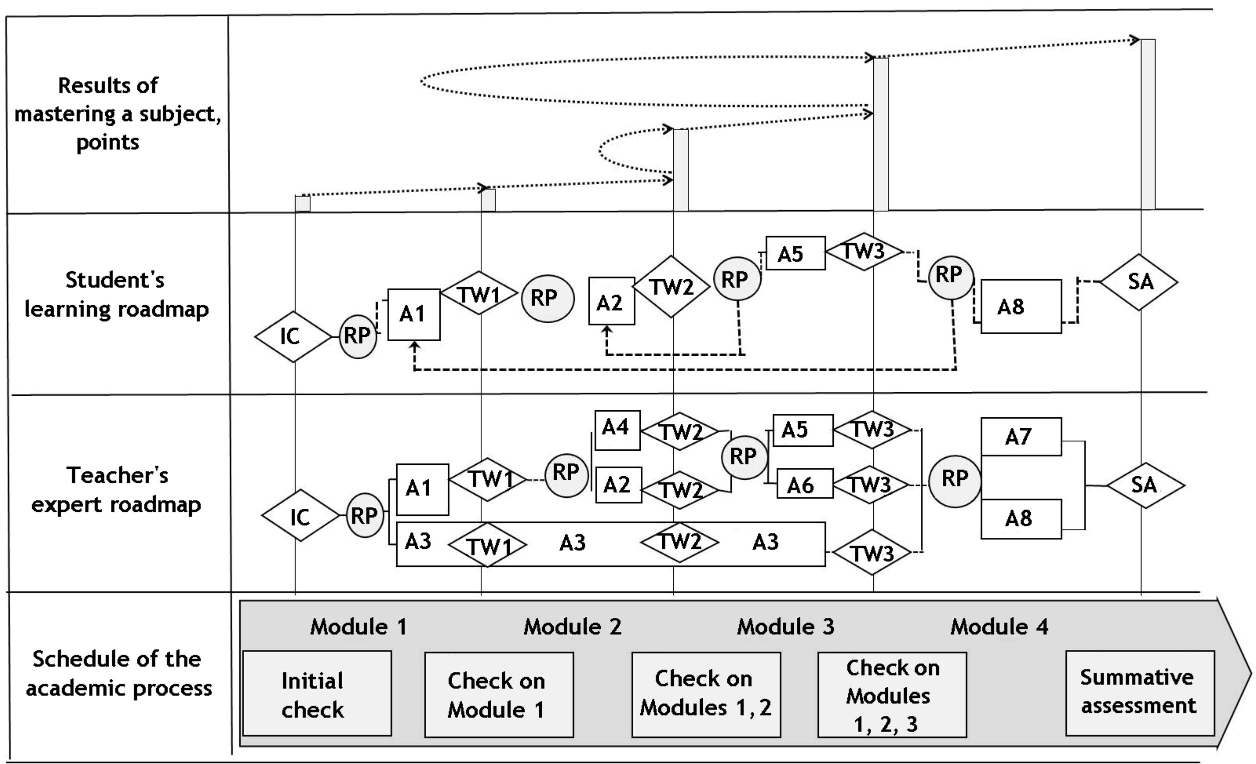


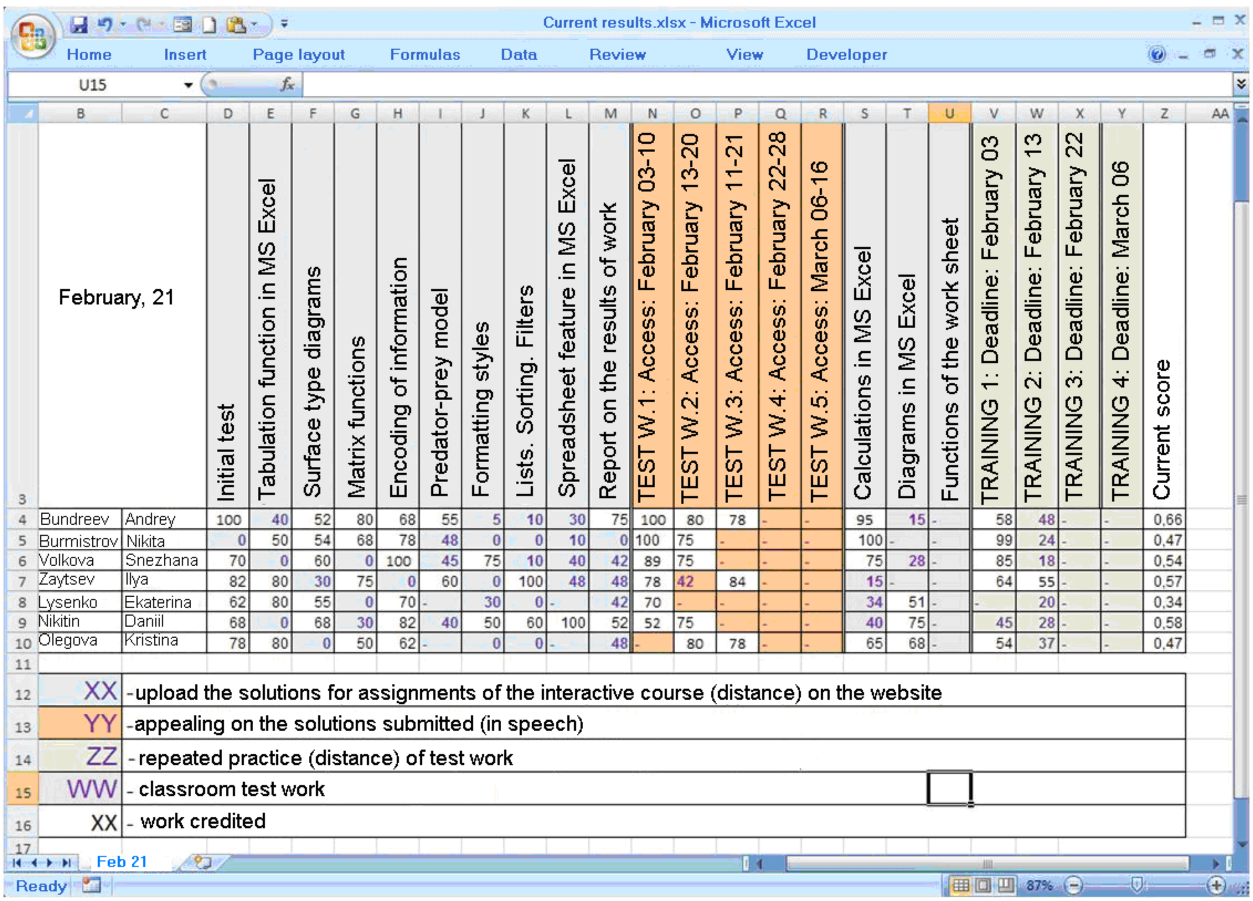
Figure 3. Block diagram. Designing a student's learning roadmap

Source: the authors

For those preferring to study in line with the teacher's requirements, and as a sample for drawing up one's own roadmap, there is the expert teacher's roadmap provided. Among other things, it determines the correction behavior scenario of students for their acquiring the required amount of knowledge and practical skills in order to achieve the target IC-competency formation level (or a mark in the subject: satisfactory, good, excellent). The nodal points of the roadmap are:

action points, check points, and risk points. In action points (A1, A2, A3, A4, A5, A6, A7, A8) students perform assignments of various complexity levels. *The check points are*: initial test (IT), test works and submitting of ready solutions (TW1, TW2, TW3), and the summative assessment (SA). The scores marked for completed works determine the current IC-competency formation level of students. In *risk points* (RP), students make decisions about further route of their progress along the roadmap in accordance with the results obtained and their educational needs and preferences. The route of a student's progress along the roadmap can contain cyclical repetitions of any understudied topics.

The created SIE allows drawing up individual learning roadmaps and controls the process of their fulfillment. The communicative format of the computer science roadmaps is implemented in MS Excel (Fig. 4).



February, 21		Initial test	Tabulation function in MS Excel	Surface type diagrams	Matrix functions	Encoding of information	Predator-prey model	Formatting styles	Lists. Sorting. Filters	Spreadsheet feature in MS Excel	Report on the results of work	TEST W.1: Access: February 03-10	TEST W.2: Access: February 13-20	TEST W.3: Access: February 11-21	TEST W.4: Access: February 22-28	TEST W.5: Access: March 06-16	Calculations in MS Excel	Diagrams in MS Excel	Functions of the work sheet	TRAINING 1: Deadline: February 03	TRAINING 2: Deadline: February 13	TRAINING 3: Deadline: February 22	TRAINING 4: Deadline: March 06	Current score
Bundreev	Andrey	100	40	52	80	68	55	5	10	30	75	100	80	78	-	-	95	15	-	58	48	-	-	0,66
Burmistrov	Nikita	0	50	54	68	78	48	0	0	10	0	100	75	-	-	-	100	-	-	99	24	-	-	0,47
Volkova	Snezhana	70	0	60	0	100	45	75	10	40	42	89	75	-	-	-	75	28	-	85	18	-	-	0,54
Zaytsev	Ilya	82	80	30	75	0	60	0	100	48	48	78	42	84	-	-	15	-	-	64	55	-	-	0,57
Lysenko	Ekaterina	62	80	55	0	70	-	30	0	-	42	70	-	-	-	-	34	51	-	-	20	-	-	0,34
Nikitin	Daniil	68	0	68	30	82	40	50	60	100	52	52	75	-	-	-	40	75	-	45	28	-	-	0,58
Olegova	Kristina	78	80	0	50	62	-	0	0	-	48	-	80	78	-	-	65	68	-	54	37	-	-	0,47

XX	-upload the solutions for assignments of the interactive course (distance) on the website
YY	-appealing on the solutions submitted (in speech)
ZZ	- repeated practice (distance) of test work
WW	- classroom test work
XX	- work credited

Figure 4. The communicative format of the computer science roadmap for students of "Biology" direction

Source: the authors

It contains lists of assignments, classroom and distance test works, training sessions, as well as marks for the assignments completed, and the current score for mastering the academic material. Any correction assignments and actions that are recommended for students are highlighted in color.

Discussion

For assessing the efficiency of the above methodological system of blended learning, the pedagogical experiment was conducted within the actual academic process in teaching computer science to students at a number of universities of Russia and Kazakhstan: Siberian Federal University (SFU), Krasnoyarsk State Medical University (KrasSMU), Krasnoyarsk State Pedagogical University (KSPU) and Kazakh National Pedagogical University (KazNPU, Almaty, Kazakhstan).

For instance, at Siberian Federal University, the first-year students enrolled in direction "080100.62 Economics", training profile "080100.62.04 World economy" were selected as the control group (CG), the group numbering 23 people. In this group, the classes were held by the lecturer, Professor N.I. Pak, using V.P. Diyachenko's cooperative learning method and the contemporary computer technologies of learning. The remaining students of the same batch, 101 people, were referred to the diagnostic group (DG).

The measurable index of the experimental learning technique is the statistics of the group – the frequency table of its students' learning results.

The group statistics values "as of the beginning of the experiment" are the frequency array of results of the students' first progress check, "upon completion of the experiment" are the frequency array of their final discipline acquisition results.

Table 1 gives frequency series of results of learning for both CG and DG – the statistics of CG and DG "as of the beginning" and "upon completion" of the experiment.

Table 1

Statistic performance of control and diagnostic groups

Assessment intervals	CG1		DG1		CG2		DG2	
	people	%	people	%	people	%	people	%
Low	6	26.09	11	10.89	5	21.74	11	10.89
Average	10	43.48	43	42.57	7	30.43	24	23.76
High	7	30.43	47	46.53	11	47.83	66	65.35
Total:	23	100.00	101	100.00	23	100.00	101	100.00

For identifying the effectiveness of action of the experimental learning technique, Pearson's chi-squared test (χ^2_{emp}) is used that is calculated according to the formula:

$$\chi^2_{emp} = \frac{1}{g_1 g_2} \sum_{i=1}^{n} \frac{(a_i g_2 - b_i g_1)^2}{a_i + b_i},$$

where n is the quantity of score grouping classes (n = 3), with the first group numbering g_1, and the second one – g_2. Vectors A = (a_1, a_2, …, a_n) and B = (b_1, b_2, …, b_n) are ones of statistics of the groups, a_i is the quantity of results of learning obtained by the students of the first group and falling within interval i (i = 1, 2, …, n), b_i is the quantity of results of the second group from this interval.

The efficiency of the experimental technique is confirmed by the statistics of positive change in the discipline acquisition results of the diagnostic group (G-test of signs, 95 % confidence level) and the random nature of their occurrence – in the control group (G-test of signs, the level of significance being $p \leq 0{,}05$).

When checking the hypotheses with Pearson's chi-squared test, it has been found that the differences of frequency rows between test results of the diagnostic and of the control group as of the beginning of the experiment are random in nature (at significance level of $p \leq 0{,}05$). Meanwhile, the distinctions between the diagnostic group's characteristics as of the beginning of the experiment and upon completion of the experiment are statistically valid with credibility level of over 95%. Thus, the probability is quite high that the hypothesis about the effectiveness of experimental methodological system is confirmed.

Let another example be given of fulfillment of learning roadmaps with the students of pedagogical universities (KSPU and KazNPU) doing the course "History of computer science".

The leading methodological line of the course is the projective and recursive strategy of learning (Bazhenova, 2015) - "I create a didactic means and I study by means of it" and the students' individual learning roadmaps. The history of computer science is studied by scientific research and exploratory work of students and teachers within the international inter-university cluster.

The complex of credit assignments and their values are as follows:

- attendance of lectures and making digital notes of lectures. For each lecture – 6 points;
- working at seminars, performance of seminar assignments. For 1 seminar – 4 points;

- creating one's own website "History of computer science" – 100 points. The requirements for the website are: history of the main content-related lines of the computer science course has to be described; the information content of sections has to be laconic and interesting; pictures, animation, and audio are recommended; the website has to be a means for studying the topic "History of computer science" within the school computer science course;
- creating a multimedia exhibit for the virtual computer science history museum. For one exhibit –20 points. The requirements are: the topics range of the exhibit cannot repeat the existing ones but it can supplement, expand or make them more profound;
- creating a set of test assignments for the course:
    a) drawing up the tests in the Testosfera test system – 50 to 100 points;
    b) drawing up the tests in a digital form – 10 to 50 points;
    c) the development of an author's means for evaluating the results of learning in the course "History of computer science" – 20 to 100 points;
- a set of presentations of the course: 20 to 50 points;
- an analytical report on the assigned topic. For 1 report – 10 to 20 points.

In order to get a credit, a student has to score at least 100 points.

The 4th-year bachelor's degree students of the physics and mathematics profile of KSPU and KazNPU took part in the academic process. The lectures were broadcast online, recorded and uploaded to the university network for offline viewing. The students were allowed to select the form of classes which was convenient for them. Roadmaps of the students were different in scope. For example, the majority opted for the teacher's expert variant – visiting the lectures and working at seminar classes, with additional low-value measures planned for the case they should miss a lecture or a seminar. It was only 5% of the students who planned the creation of a website which ensures getting the credit.

One month before the term end, 20 students who had developed author's websites and tests on the course got their credits. Two weeks ahead of the credit deadline, it was already 90% of students who overcame the required limit of 100 points. According to the students' feedback, the suggested strategy of learning proved to be a fairly effective one.

Conclusion

Thus, the experience of applying the learning roadmaps in the academic process with students of different universities has shown the following:

1. Junior students have almost no readiness for self-educational academic activity in conditions of blended learning;
2. Senior students are eager to embrace the principles of blended learning, yet they nevertheless prefer the traditional forms and methods of learning;
3. The students gain the experience in designing and fulfilling the learning roadmaps in the discipline, which improves their readiness for self-educational activity and promotes their ability to use the methods and means of e-learning efficiently in the future;
4. The success and effectiveness of blended learning are ensured owing to the tailored SIE having the options of designing and using the students' projective learning roadmaps. With the criteria of its quality being student-centered, teacher-centered and personified in nature, the way the information system "Academic process" is built and implemented at KrasSMU has had quite an effect on shaping the professional information culture in the future medical workers;
5. The methodological system of blended learning in computer science for the 1st-year students of SFU developed by the authors ensures the efficient use of the roadmaps technology in the academic process for achieving the planned results of learning;
6. The developed methodological system of blended learning in the computer science history course for senior students at KSPU and KazNPU successfully brings to life the principles of student-centered paradigm of education and ensures the effectiveness in professional training of the future teachers.

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