Journal of Siberian Federal University. Humanities & Social Sciences 5 (2018 11) 740-752
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УДК 37.01

Development of Adaptive Educational Course in the SibFU E-Learning System

Vladislav V. Kukartsev, Ekaterina A. Chzhan, Vadim S. Tynchenko, Oleslav A. Antamoshkin and Alena A. Stupina*
Siberian Federal University
79 Svobodny, Krasnoyarsk, 660041, Russia

Received 12.01.2018, received in revised form 27.04.2018, accepted 04.05.2018

E-learning has been in progress recently. To date, there are a large number of platforms and developed courses, the lack of adaptability being their main disadvantage. This paper presents the results of designing an adaptive e-learning course on the Moodle platform: the course bases on the tree of concepts and the academic discipline operations; the course content implies various standards; training takes different paths depending on the students' characteristics and level of knowledge that leads to the students' performance improvement. The paper also provides with the results of the development and introduction of the adaptive electronic course intended for the full-time second-year students. In their studies the students follow a certain path, each path presenting the material of different complexity.

Keywords: e-learning, adaptive course, path, the tree of concepts.

DOI: 10.17516/1997-1370-0267.

Research area: culturology.

Introduction

The modern world faces a change of learning paradigm – from the "preschool education – school – institute" scheme to Life Long Learning system. It has become obvious that online training, including massive open online courses, e-learning courses, etc., is an integral part of this system. While the key problem at the stage of e-learning emergence and formation was the difficulty to implement the teacher's feedback, modern platforms can solve this problem and provide with a wide range of tools for implementing the feedback.

E-learning courses have been actively introduced during the last decade. The demand and need for them can be explained by the following factors (Solovov, 2006; Clark, Mayer, 2016). Firstly, learning technologies should be appropriate to modern realities (Sakhaltueva, Tynchenko, 2015; Siabrenko et al., 2016), which, in their turn, are widely applied in various fields (Sheenok, Kukarcev, 2013; Antamoshkin et al., 2014; Kukartsev, 2009; Medvedev, Kornet, Chzhan, 2016). The use of informatization and computerization achievements in education has apparent advantages. Traditional education, when only the blackboard and chalk

* Corresponding author E-mail address: AStupina@sfu-kras.ru

were used, seems a slightly outdated model already. Secondly, e-learning courses make education more accessible. So, the material can be learnt not only within the walls of the lecture-rooms, but anywhere, provided that there is a computer or a mobile device and Internet access. The students' autonomy development is an absolute plus as these are the students themselves who plan time and duration of classes.

One of the main didactic problems of the educational process is an individual approach to each student. This requirement is difficult for traditional (face-to-face) teaching methods. No solution has been found for the decades of group learning. On the contrary, e-learning makes it possible to use the individual approach to the students, which is an undeniable advantage over the traditional methods. Whereas in the early years of e-learning courses development the "individual approach" meant the unequal time the student spent to study the material, currently there is an opportunity to implement and provide with a choice of an individual path of learning the material. This kind of e-learning courses is called an adaptive one due to the fact that the course can adapt to the student's individual characteristics and preferences. When using the individual paths of face-to-face learning, the students have problems with the assessment of real achievements, productivity, and, most importantly, the choice of the most suitable learning path (Sysoev, 2013). The regulation of the rate of mastering the material as well as the initial choice of the path take place in the automatic mode, without the teacher's participation (Graf, 2005; Paramythis, Loidl-Reisinger, 2003; Shute, Towle, 2003), these being the peculiar features of adaptive e-learning courses. Learning paths development is an important stage in the course design. The paths are closely related to the metadata of the object of learning (Zaitseva, 2008). The standard (Hodgins, Duval, 2002) defines five values of difficulty for the object of learning: very easy, easy, medium, difficult, very difficult. The authors (Zaitseva, 2008) mention the sufficiency of three paths (high, medium and low) and their correspondence to their five-level type of metadata. The relevance of this approach to the e-courses implementation can be considered by the results of a six-month project on monitoring the opportunities for the realization of the young people's potential in the scientific and technical sphere. The project was conducted by the Center for technological modernization and scientific and technological development monitoring. As its result, 14 reasons forming the "new" education were singled out. Adaptive learning takes the first place as it implies the use of computers and mobile devices in the learning process with their capacity to adapt the material to the students' needs.

The work (Zaslavskaia, Kravets, 2010) can be considered an example of an adaptive e-course development. This kind of course was implemented for the Computer Science discipline, the main feature of which was the use of dynamic integrated assessment of the student's level of knowledge. The proposed method of assessment makes it possible to introduce the values of marks for the material taken, stability in mastering it, which would be impossible with non-adaptive e-learning courses. The values of grades the learner has got serve the basis for the formation of a certain sequence of presenting the material, which would be the most appropriate to the learner's abilities, as well as for its adaptation for every student.

The paper describes the implementation and use of an adaptive e-learning course developed for the full-time students. It has the following structure: Introduction, Problem statement, Justification of the course content, E-learning courses adaptability, Learning paths implementation, and Conclusion.

Problem statement

Adaptive e-learning courses development and implementation aim at increasing the student's achievement. They make it possible for the students to learn at their own pace, when focusing on difficult and complex parts of the course for more details. The student learns to plan his / her academic activities to achieve the final result (Sumtsova, 2015). Integration of e-learning courses into the traditional (full-time) learning process has its advantages not only for the students but also for the teachers. So, it eliminates the routine work: checking tests, filling in the register, etc. The paper describes the adaptive e-learning course designed for the second-year full-time students. The key point in the development of each course is its structure, theoretical and practical material. The basis of the developed course is a tree of concepts which is worth our further detailed consideration.

Justification of the course content

When developing an e-course (adaptive or traditional), special attention is paid to the theoretical material that forms the course basis. The course content is in compliance with the following normative documents: the Federal State Educational Standard, professional and international standards. The current standard does not clearly regulate the course content of the course (lecture material topics). Thus, developing the courses takes into account both the previous standards and the future ones, which have already been made public but will come into force in the near future.

The e-learning course material consists of several logically related sections or modules. These concepts will be identified further. One of the ways to structure the material is making a tree of concepts. A tree of concepts of the "Design and architecture of information systems" course, presented in Fig. 1 below, serves an example of it, the tree tops marking the concepts, the connecting lines pointing to the logical links between them. The tree in Fig. 1 shows that the course is based on two basic concepts – information system and methodology.

In the course of training within the e-learning course framework the students learn not only theoretical material; they also acquire some skills and abilities while performing various tasks. The tasks for practical and seminar

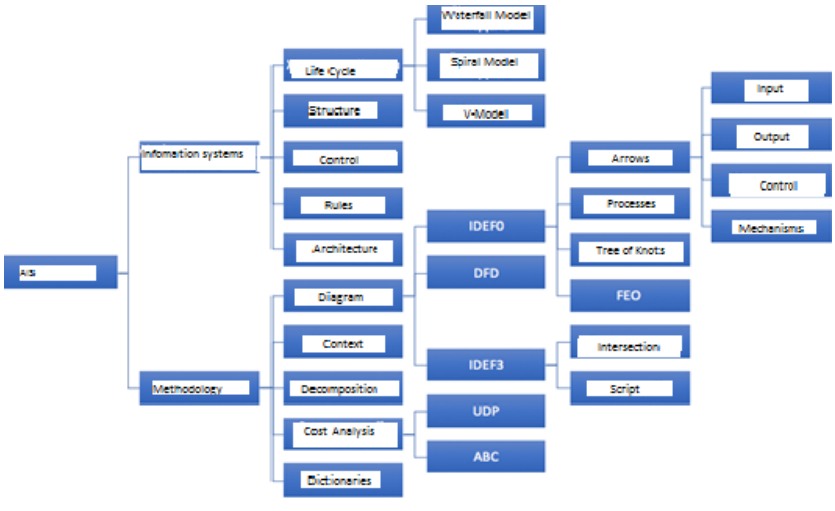

Fig. 1. The tree of the course concepts

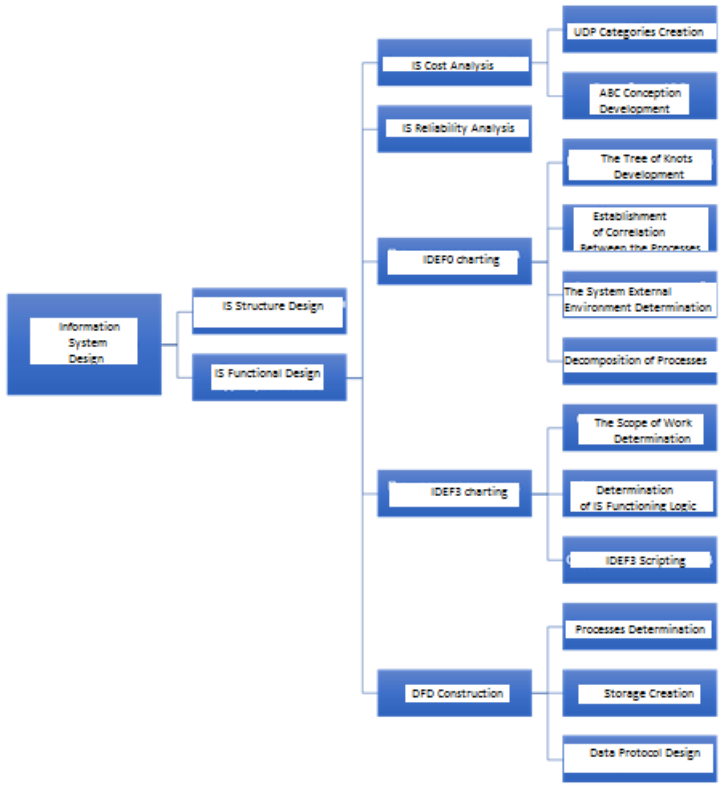

Fig. 2. The tree of course operations

classes are developed according to the following tree of operations (Fig. 2).

The standard e-course does not take into account the students' individual characteristics. This is considered to be the main problem of presenting the material in it. This problem can be solved by means of adaptability introduced by different learning paths. Theoretical material as well as the material for practical classes and seminars is presented in different forms and volume, depending on the learning path. The information below provides with a closer look at implementing the adaptability.

E-learning courses adaptability

Adaptability can be realized through different approaches. Depending on their preferences, abilities and a number of other factors, the students master the same course but make use of different materials or do it in different ways (Tarkhov, 2005a; Tarkhov, 2005b; He, Kinshuk, Patel, 2002). Different learning paths can be taken, for example, depending on the type of perception which can be determined by the entry tests. There are 4 types of perceiving individuals: visual, audio, kinesthetic and discrete ones. For example, the lecture material for the visuals contains a large number of illustrations, maps, and graphs that support the specific information with associated visualizations. The auditory learners can be provided with the recorded video lectures, links to the lectures by the prominent scientists and experts in the subject area. The training material for kinesthetic learners includes the examples, analysis of typical situations, case studies, and various interactive components. For example, in the e-learning courses these might be such elements as time lines, representing a sequence of chronological events, or gamification. As it is

difficult for the kinesthetic learners to keep their concentration and attention for a long time, so the material should be presented in a compressed form. Discrete learners are the most rarely encountered category. The material for them can include statistics, chains of facts, inferences and statements. Yet, the issues of testing the knowledge and developing the material remain open. Thus, is there a need for different tasks for different categories of students?

For the adaptive courses creation the authors (Graf, 2005) suggest using the meta-model, which is based on the Felder-Silverman learning system. It is supported by the idea that, using the e-learning platform, the authors of the course design different learning blocks for different categories of students. These are the students' individual preferences that determine the following learning styles:

– Group or individual learning. Active students try to understand the material by interacting with other students. Reflective students think over the material on their own.

– Learning that depends on the degree of abstract thinking. Sensual style captures the specific material with clear instructions. Such students are practical and accurate. Intuitive learners are likely to have a better perception of abstract material such as theories and their meanings and tend to be more innovative.

– Learning that depends on the way of gaining the information. Visuals better memorize what they've seen, whereas verbal learners better understand through words regardless of whether they speak or write.

– Organization of learning process. Successive students prefer linear learning with no deviation. The pathway of teaching global learners involves jumps, comprehensive study of the material, and use of an integrated approach.

For example, the course for successive students has a clear structure; learning is organized through one possible predetermined path. All links to the additional material are given at the end of each block. The course for global learners provides the links to other sources or even more complex material through the process of mastering the course. It is obvious that there are more characteristics of the students, which the authors (Graf, 2005) suggest taking into account in the future when creating the adaptive e-courses.

The adaptive approach, which is most common today, is that of introducing the learning paths depending on the material complexity. As mentioned above, the best option would be to have three paths: high, intermediate, and low which correspond to "satisfactory", "good" and "excellent" grades. Grouping as per learning paths is based on the entry test results. However, during the process of learning, the students can navigate the learning paths depending on success of their assignments. According to an *a priori* assumption, the students with higher entry points who master the material through a "high" learning path can be given the material in a more compressed form (for example, with fewer examples or explanations). Accordingly, the material for the "low" learning path students is presented with maximum details.

Learning paths implementation

Three learning paths can be implemented in the adaptive course, as this corresponds to the five-mark grading system to the greatest extent. Theoretical and practical material is presented in different volume; each section requires a test at the end. It should be noted that the material differs depending on the learning path; final tests after each section on each learning path are also different. First, the tests are based on the material presented in different volume. Secondly, if all the learning paths had the same test, there would be no need in the learning paths as such – the student can master the material through a low learning

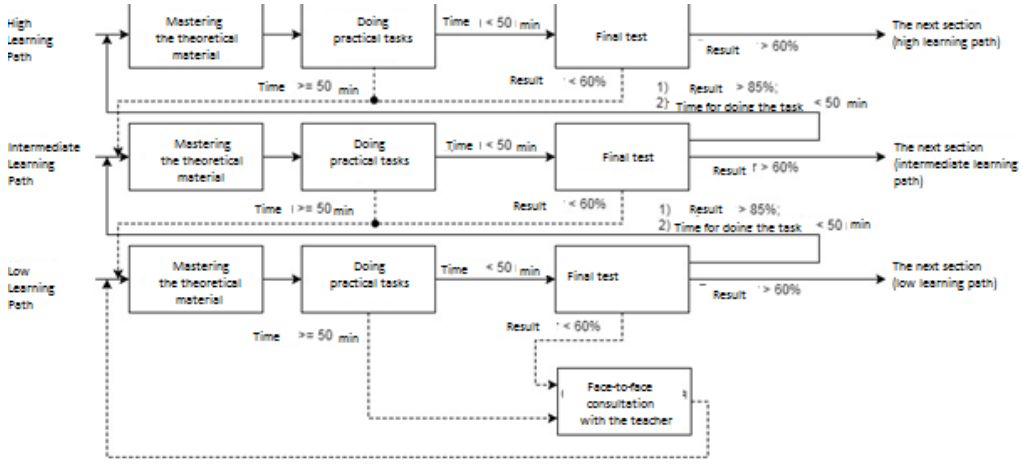

Fig. 3. The scheme of the section implementation in an adaptive e-course

path but get "excellent" for a test. Depending on the test results, there are several options: lowering or improving the learning path, face-to-face consultation with a teacher or keeping to the path in mastering the material.

The figure below presents the scheme of the discipline development within one section. It is after the entrance test in Section 1, or after the test in the previous section, the student is on one of the three trajectories – low, intermediate or high, the theoretical and practical material as well as the content of the final test being different on each learning path.

If a student has successfully completed more than 85 % of the final test on the material of this section and the test has taken him / her less than 50 minutes, then he / she has an opportunity to move to a higher learning path and, having completed all the required tasks, to get an opportunity to improve the grade. However, a student can move to the next section without changing his / her learning path.

Implementation of the students' progress assessment system in the e-learning course

The e-learning course was developed in the Moodle system. These are the tests that are used as the main element to control the degree of the students' results. There are several test types: true-false, multiple choice, matching, and open. A great variety of types makes it possible to assess the understanding of the material, but not just its memorization and reproduction.

In the course of mastering the material the students gain knowledge, skills and abilities. The knowledge is assimilated in the process of studying the theoretical material. Various tests based on lecture material are the most simple to assess this component. The tests can be classified as non-adaptive and adaptive that depends on the method of forming the test content. The non-adaptive methods include such methods of creating a test as a strict static pre-assigned sequence of questions, a random sample from the database of tasks or a combined method. The test in the combined method contains several mandatory tasks for all students, whereas the tasks in the rest methods will be formed at random. This option is not adequate for an adaptive course. Therefore, a partially adaptive approach was used: the questions are formed at random, each section having its own bank of questions on each learning path.

Application of the acquired knowledge in practice: doing the tasks and laboratory works

form the skills. It is here where the transition from theory to practice takes place. Assessment of practical tasks in the adaptive e-course can be implemented in several ways. For example, the student downloads his / her practical tasks into an e-learning course and the teacher assesses or sends the task for completion. Another option is creating the tests to assess the students' skills. For example, charting or searching for errors in an implemented solution.

The discipline is mastered in an automated mode, with the help of the developed e-learning course. There are a number of problems on this way, one of which is the final assessment of the students' performance. The student can move along the learning paths, it is necessary to take into account the number of the attempts to pass the test. The issue of a final grade on the basis of all the grades received remains open. To date, the Moodle system has implemented the weighted average method when the final grade for the entire course is calculated as a simple estimate of the mathematical expectation of all the grades the student has got for the tasks done.

Approbation of an adaptive e-learning course

The analysis of the adaptive e-course effectiveness in teaching the students of the School of Space and Information Technologies of Siberian Federal University was carried out within the framework of the present research. The adaptive mode was applied to the "Methods of testing the software systems" course for the 4th-year students and to the "Design and architecture of information systems" course for two groups of the 3rd-year students mastering the "Software engineering" programme.

The number of students in the groups involved in the research of the adaptive courses effectiveness was the following:

- group No. 1 – 18 fourth-year students;
- group No. 2 – 23 fourth-year students;
- group No. 1 – 25 third-year students;
- group No. 2 – 21 third-year students.

The initial grouping as per the learning paths was based on the results of the entry test that assessed the knowledge necessary to master the discipline. The students could also have a face-to-face consultation with the teacher on the subject of changing the learning path assigned by the system.

It is worth while considering the results of mastering the "Methods of testing the software systems" course.

The final grouping at the initial stage of training is shown in Fig. 4.

The percentage of this grouping is shown in the pie chart (Fig. 5).

The grouping by the learning paths after moving to new sections of the discipline has undergone some slight changes (Fig. 6).

The students' final grades were distributed as follows (Fig. 7).

The percentage of this grouping is shown in the pie chart (Fig. 8).

Below there are the results of mastering the "Design and architecture of information systems" discipline by two other groups of students.

The final grouping at the initial stage of training is shown in Fig. 9.

The percentage of this grouping is shown in the pie chart (Fig. 10).

The grouping by the learning paths after moving to new sections of the discipline has undergone some slight changes (Fig. 11).

The students' final grades were distributed as follows (Fig. 12).

The percentage of this grouping is shown in the pie chart (Fig. 13).

Approbation results show that both focus groups (the groups of students studying two different disciplines) tend to increase their

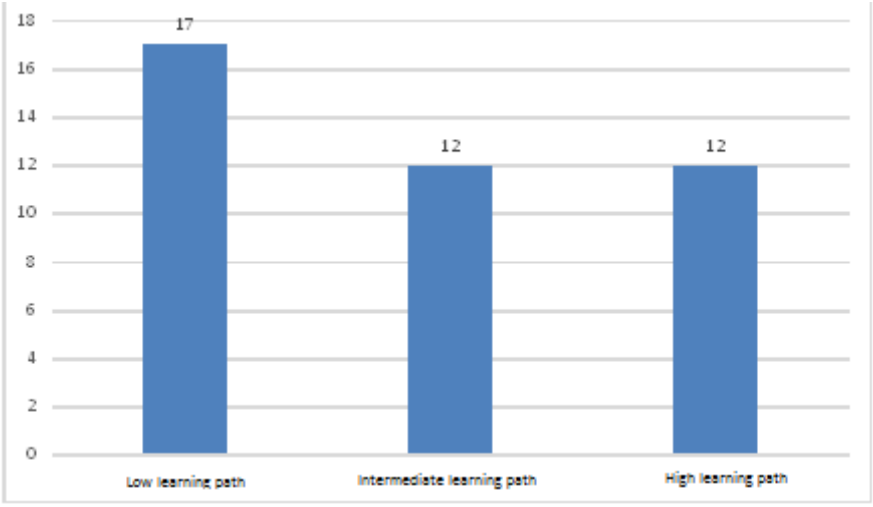

Fig. 4. Grouping the students as per the adaptive course learning paths at the initial stage of training

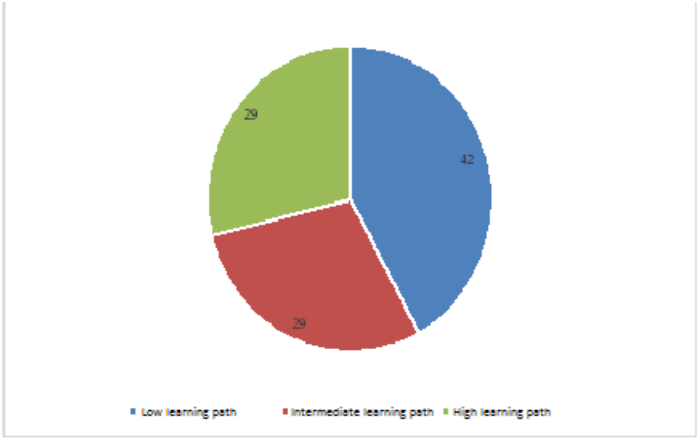

Fig. 5. Grouping the students (in their percentage) as per the adaptive course learning paths at the initial stage of training

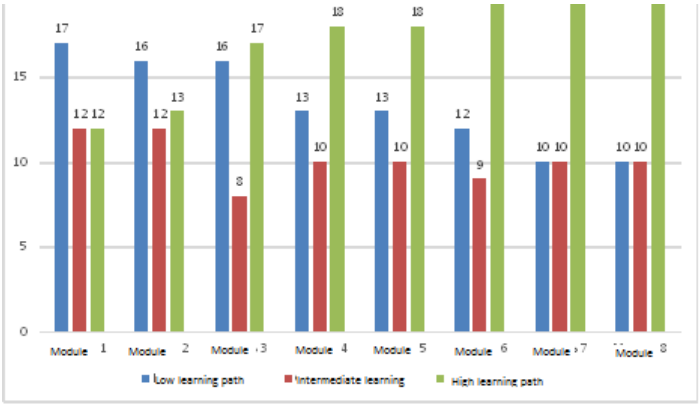

Fig. 6. The students' transition along the learning paths

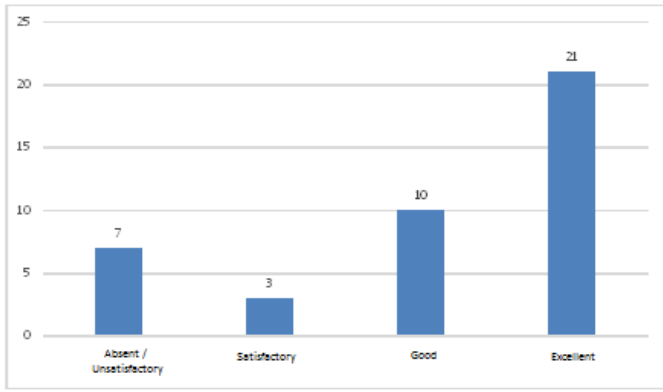

Fig. 7. The students' final gradesv

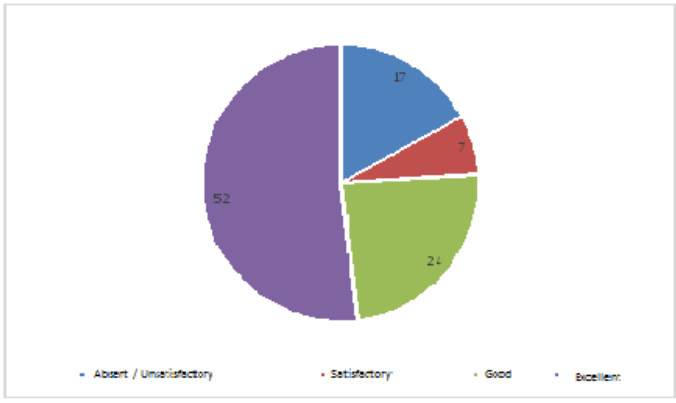

Fig. 8. Percentage of the students' final grades

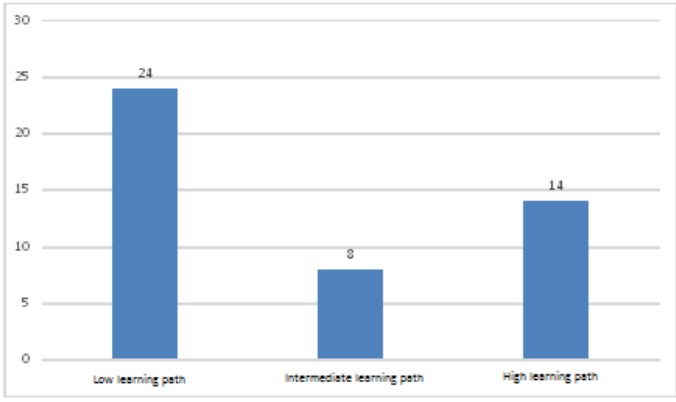

Fig. 9. Grouping the students as per the adaptive course learning paths at the initial stage of training

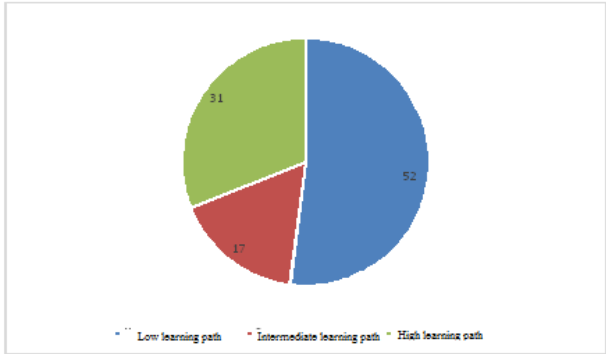

Fig. 10. Grouping the students (in their percentage) as per the adaptive course learning paths at the initial stage of training

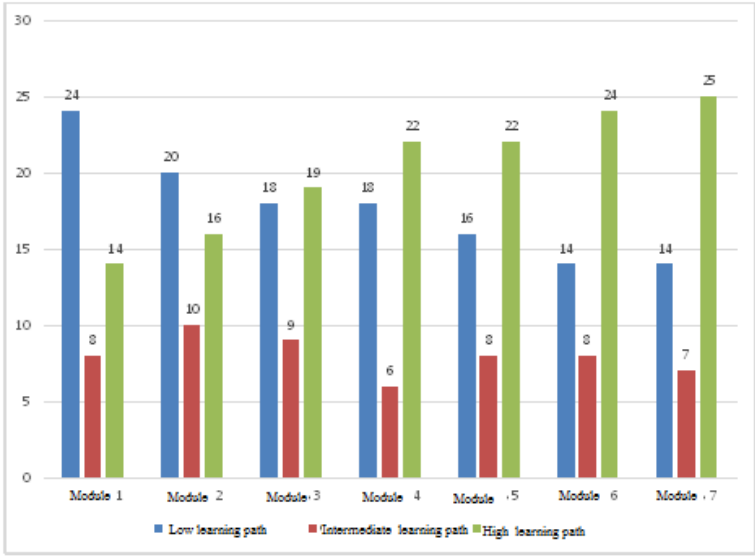

Fig. 11. The students' transition along the learning paths

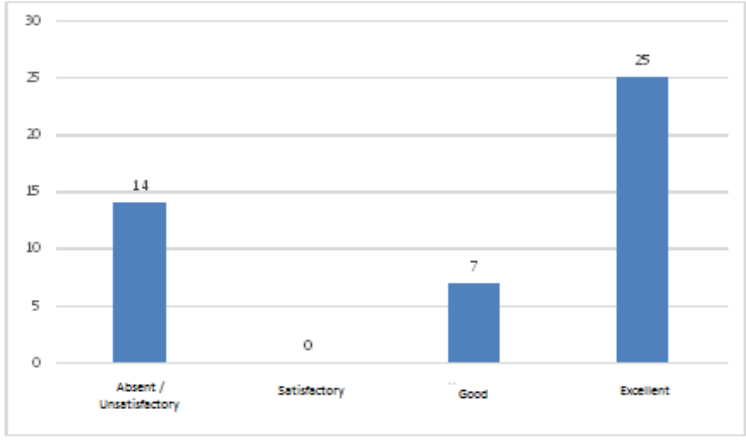

Fig. 12. The students' final grades

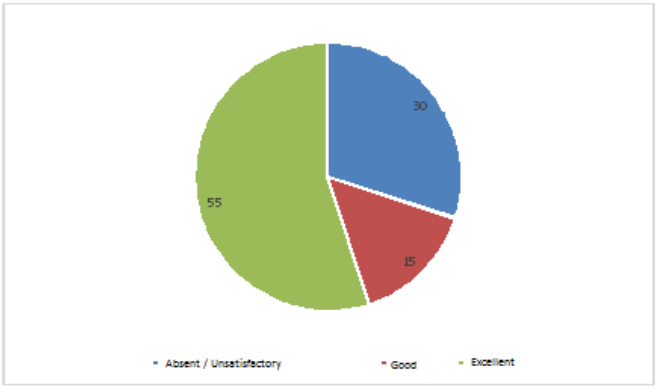

Fig. 13. Percentage of the students' final grades

learning path in the process of mastering the adaptive course.

The groups of the 4th-year students studying the "Methods of testing the software systems" discipline showed low entry test results, whereas the share of excellent grades for the interim test was more than 50 %.

The second focus group of the 3rd-year students showed similar results: nearly half a group managed to improve their entry test results. At the initial stage more than 50 % of students were grouped as the low learning path students, by the end of training they were only 30 %. 55 % of the students got excellent grades, while initially only 30 % of the focus group were considered to be the high learning path students.

The conducted research makes it possible to state the efficiency of adaptive educational technologies to training the higher school students.

Conclusion

The paper discusses the development and implementation of the adaptive e-learning course. Adaptability was implemented by means of learning paths corresponding to different levels of complexity of the material presented. Grouping as per learning paths is based on the entry test results. When mastering the course, the students can move along the learning paths when adjusting their learning schedule to individual preferences and abilities.

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Разработка адаптивного образовательного курса в системе электронного обучения СФУ

В.В. Кукарцев, Е.А. Чжан, В.С. Тынченко, О.А. Антамошкин, А.А. Ступина
Сибирский федеральный университет
Россия, 660041, Красноярск, пр. Свободный, 79

Электронное обучение активно развивается в последнее время. На сегодняшний день существует большое количество платформ и разработанных курсов. Основным недостатком является отсутствие адаптивности. В настоящей работе представлены результаты разработки адаптивного электронного образовательного курса на платформе Moodle. В основе курса лежит дерево понятий и операций дисциплины, содержание курса опирается на различные стандарты. Обучение происходит по различным траекториям в зависимости от особенностей и уровня подготовки студента, что позволит повысить успеваемость обучающихся. Приведены результаты разработки и внедрения адаптивного электронного курса, предназначенного для студентов второго курса очной формы обучения. В процессе обучения учащиеся следуют определенной траектории, на каждой траектории представлен различный по сложности материал.

Ключевые слова: электронное обучение, адаптивный курс, траектория, дерево понятий.

Научная специальность: 24.00.00 – культурология.