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Using E-Learning Tools to Enhance Students-Mathematicians' Competences in the Context of International Academic Mobility Programmes

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Introduction. The article is concerned with the use of special electronic teaching tools to increase the students' understanding of the subject and adaptation to the professional language environment of the host country, taking into account the mathematical education. Our purpose is to develop a methodology of multilingual support of mathematical courses in the host country to improve the effectiveness of students' academic mobility using e-learning tools.

Materials and Methods. The basis of the research was methods of system analysis and descriptive and analytical methods, primarily experimental. To identify advantages of the proposed approach the methods of empirical research were used (observation and comparison). To prove the efficiency, classical methods of measurement were used.

Results: We analyzed the existing electronic learning environments and defined an e-learning environment Math-Bridge that allows for creating mathematical courses in several languages in parallel. For example, the e-training course "Optimization Methods" was developed in three languages for training Russian-speaking Master programme students. The comparative analysis of the target and control student's groups showed that 100 % of the students in the target group achieved an excellent level of mastering competencies, while the control group has only 75 %. For the control group, the degree of motivation to mathematical studying has not virtually changed (increase by 0,86 %). In the target group the level of student interest to the mathematics increased from 0,9 % to 8,9 % (mean 2.21 %).

Discussion and Conclusion. The results described in the article will be useful for the staff of international departments, administrations and deans, as well as teachers of those universities that participate in the students' international academic mobility programmes.

Keywords: multilingual, academic mobility, distance learning courses, computer training, professional competencies, learning math, motivation to learn

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Применение инструментов электронного обучения для международной академической мобильности неанглоговорящих студентов-математиков

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Введение. В статье предлагается подход к организации обучения с использованием специальных электронных обучающих инструментов для более глубокого понимания математики и адаптации обучающихся к математическому языку, используемому в профессиональной среде в принимающей организации (в зарубежной стране). В связи с этим становится актуальной проблема мультиязычной поддержки изучаемых студентами курсов в принимающей стране для более эффективного погружения обучающихся в языковую академическую среду. Цель статьи – описание разработки методологии мультиязычного сопровождения математических курсов в принимающей стране для повышения эффективности академической мобильности студентов с использованием электронных средств обучения.

Материалы и методы. В основу проведенных исследований легли методы системного анализа, а также описательные и аналитические методы, преимущественно экспериментальные. Для определения преимуществ предложенного подхода были использованы методы эмпирических исследований (наблюдение и сопоставление). С целью подтверждения эффективности использовались классические методы измерений.

Результаты исследования. Авторы проанализировали существующие электронные обучающие системы и определили электронную образовательную среду Math-Bridge как позволяющую создавать математические курсы параллельно на нескольких языках. В качестве примера разработан учебный курс «Методы оптимизации» на трех языках для обучения русскоязычных студентов магистратуры. Сравнительный анализ целевой и контрольной групп студентов показал, что в целевой группе 100 % студентов достигли превосходного уровня освоения компетенций, в то время как в контрольной группе такого же уровня компетенций достигли лишь 75 % студентов. Степень мотивации к изучению математики в контрольной группе практически не изменилась, увеличение составило всего 0,86 %. Однако в целевой группе уровень интереса к изучению математики возрос с 0,9 до 8,9 % (в среднем рост составил 2,21 %).

Обсуждение и заключение. Результат проведенного педагогического эксперимента показал эффективность предлагаемого подхода при обучении студентов на английском языке в рамках международной академической мобильности. Полученные результаты будут полезны для сотрудников вузов, участвующих в программах международной академической мобильности студентов.

Ключевые слова: многоязычность, академическая мобильность, дистанционный учебный курс, компьютерное обучение, профессиональные компетенции, обучение математике, мотивация к обучению

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Introduction

In the context of the global educational market, the issues of constructing and implementing international educational trajectories are very relevant in the university environment. The transnational (joint degree) graduation increases the competitive advantages of the university implementing this or that academic programme. Also, the number of the alumni graduated from joint degree programmes helps university to improve its ranking.

In most cases, joint degree programmes are implemented in English, and the majority part of such programmes are postgraduate: master or PhD (doctoral) programmes. However, the educational content leading to the formation of needed competencies in the specific university from a non-English-speaking country is already prepared in the national language.

In particular, at German-Russian Institute of Advanced Technologies of KNRTU-KAI one semester, within the second year of Master degree programmes, Russian-speaking students in order to obtain double Russian and German diploma get their education in a German university in English and German languages. The students mark substantial difficulties they faced in mastering specific mathematical subjects in Germany despite of high level of their basic training in mathematics, e.g. received in Russia. That type of problems leads to poor academic performance in the hosting country, and might lead to expulsion from the university.

Developing methods that can help students of joint degree programmes easier master the specific mathematical terminology of the host country is a very relevant task. The development of such methods is the main purpose of this article. As a means to achieve this goal, we propose to use e-learning systems (educational e-resource).

The integration of multilingual educational content into one educational e-resource can significantly expand the opportunities for implementing joint degree programmes, promote academic mobility, improve existing educational technologies, etc.

The various electronic environments were studied to develop electronic textbooks. The investigation of possibilities using electronic tools was done to provide multi-language support for mathematical educational courses. Totally, four electronic media were studied by media sources in the literature and enriched by the personal experience of researchers. Their strengths and weaknesses were revealed in the way of adequately representing mathematical concepts and mastering practical mathematical competencies in various languages.

On the basis of conducted analysis the electronic educational tool package Math-Bridge was selected to carry out the practical experiment. In this package, the mathematical course “Optimization Methods” was developed with simultaneous support of three languages: English, Russian and German.

Literature Review

International educational trajectories are often implemented as Double Degree Programmes and Joint Degree Programmes. The issues of academic mobility are discussed in detail in the book by the President and CEO at AFS Intercultural Programmes Daniel Obst and Matthias Kuder (John F. Kennedy Institute) [1], for example, implemented within the framework of the well-known European academic programme ERASMUS + [2].

Reforms in recent years, both in the Russian Federation and in the countries of the European Union, are mainly related to the introduction the Bologna Process into the Tertiary education. One of key tasks of Bologna Process is the development of mechanisms for recognition periods of study or qualifications (degrees) obtained abroad. In this way, universities contribute to the creation of a united European Higher Education Area (EHEA) [3]. At the same time, academic mobility of students and teachers is an integral part of joint degree educational programmes, the number of which is steadily increasing. Moreover, mobility can be either real or virtual, for example, when the learning process is implemented in a distance form using electronic educational resources. In the Russian Federation, the possibility of implementing educational programmes in a network form is stabled by legislation[1] .

Currently, only a few e-learning systems provide an opportunity to present the educational content in several languages simultaneously [4]. One of them is a Math-Bridge system. The Math-Bridge system was developed at the German Research Center for Artificial Intelligence (Deutsches Forschungszentrum für Künstliche Intelligenz-DFKI) in Saarbrücken, Germany, and it is now widely implemented in the educational process of the leading technical universities in Germany [5], France [6], Finland [7], and since 2014 it has been used in Russia [8]. The introduction of this technology was actively promoted by such eminent scientists as the Professor Jörg H. Siekmann (Saarland University), Professor Christian Mercat (Claude Bernard University of Lyon 1), Dr. Sergey A. Sosnovsky (Utrecht University), Professor Seppo Pohjolainen (Tampere University of Technology), Professor Svetlana V. Novikova (Kazan National Research Technical University named after A. N. Tupolev-KAI), and others.

Materials and Methods

Two criteria were used to measure objectively the effectiveness of the developed multilingual course: (I) enhancing a quality of education (based on a rating system) and increasing a level of mastering professional competencies (based on the SEFI standard), and (II) increasing students' motivation for studying mathematics (based on a special questionnaire of 25 questions, developed under the guidance of Professor Christian Mercat from Claude Bernard University of Lyon 1) [9].

A rating assessment system of academic performance allows to assess the quality of the skills by a 100-point scale.

The score-rating system is the following:

– from 86 to 100 points is equal to the grade "Excellent" (in digit it is "5"),

– from 71 to 85 points is equal to the grade "Good" (in digit it is "4"),

– from 51 to 70 points is equal to the grade "Satisfactory" (in digit it is "3"),

– less than 50 points is equal to the mark "Unsatisfactory" (in digit it is "2").

Generally during the semester all students have to pass 1 test and perform 5 individual laboratory works. When all these tasks are successfully done, they are allowed to pass a final exam. Exam is a form of attestation when student has to answer (to describe in details) two questions that are randomly given, and briefly answer some additional questions. Prior to this, all the students of the group do the test of 20 questions, which allows to determine the readiness of every one student for the exam. The final grade is determined by the examiner depending on how successfully all parts of the exam have been passed, as well as taking into account the results of the test, practical works and laboratory works have been completed during the semester. The final grade is mathematically dependent on the total number of achieved points in accordance with the rating system, established in the university.

SEFI standards are developed by the European Association for Engineering Education and they describe a list of skills and knowledge that students and graduates in engineering professions should possess [10]. The standard covers the basic mathematical disciplines studied in technical universities: Linear Algebra, Mathematical Analysis, Discrete Mathematics, Probability Theory and some others. The standards are as specific as possible. Each discipline has a list of compulsory sections, and each section has a list of competencies required as a result of mastering it. The competencies are grouped according to the level of complexity. In total, 4 different levels of mastering are described: from the basic initial level (Level 0) to the maximum (Level 3). Such a clear organization of the standards makes it easy to organize an automatic verification of the level of mastery of the

[1] World Bank. World Development Report 2007: Development and Next Generation. Washington DC; 2006.

competencies, since there is no subjective component in the assessment.

An experiment was conducted with Russian-speaking master's degree full-time students which additionally used the multi-language electronic course "Optimization Methods" (14 participants in the target group). The results of mastering competences were compared with similar results in the control group (8 participants). Most of them are young people (more that 60 percent). These young people are aged from 22 to 23 years. The course is studied in the second year of Master degree programme, namely in the third semester.

Results

Choice of the electronic educational environment for the implementation the multilingual mathematical course. The main emphasis is placed on mastering the students' practical skills in design and computation when studying engineering technical disciplines, in contrast, for example, the humanities [11–13]. In KNRTU-KAI students mastering Aircraft Engineering programmes the disciplines such as Design of Aircraft, Strength of Constructions, etc. are a priority in their education and therefore require deep practical skills [14–17].

The University mainly distributes two software environments for the creation of electronic distance learning courses – Lotus Learning Space [18] and BlackBoard [19]. The second system is of relatively recent introduction into teaching practice, whereas Learning Space has been used in the educational process since the beginning of distance learning (for more than 10 years).

Both software environments have the necessary tools for filling out lecture courses, forum organizations and test module creation.

Despite the fact that both systems have a high degree of universality, that is, the same system can be used for teaching different subjects, it is difficult to use them for teaching different sections of mathematics with its specific features. In this case, these systems have to be modified, i.e. to make in these systems the necessary changes and additions [20].

In addition, both systems do not imply the possibility of automatic duplication courses in different languages. Thus, in order to create a course in two languages, in fact, you will have to create two different, unrelated courses.

MOODLE, an electronic environment, is also widespread as a creation distance textbooks [21; 22]. The main advantage of this software package is its free distribution. However, it has all the disadvantages of two environments discussed above: they are the lack of tools for creating practical and laboratory works, and the inability to create a course in several languages at the same time.

The Math-Bridge system, developed at the German Center for Artificial Intelligence, stands out. E-learning system Math-Bridge is a highly tailored learning distance environment for teaching mathematics and related engineering disciplines in technical universities.

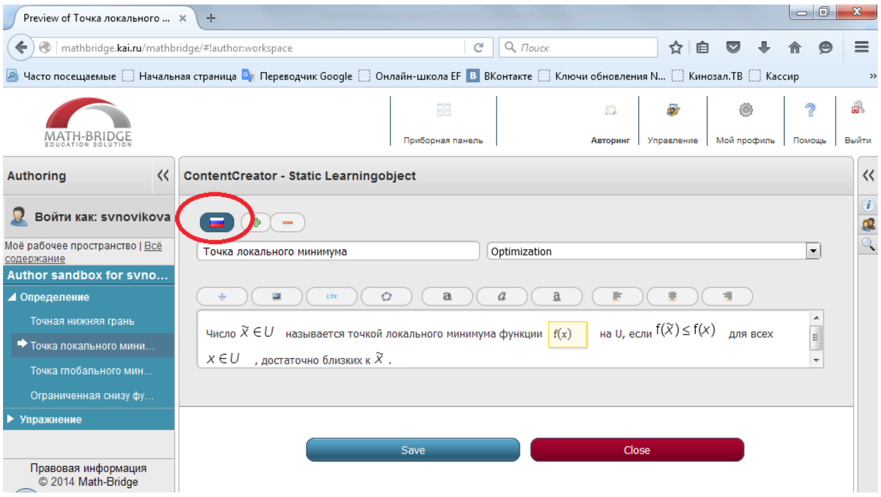
A distinctive feature of the Math-Bridge system is the ability to adjust intelligently the educational trajectory of the trainee, as well as the possibility of using dynamic interactive objects for teaching students to perform complex mathematical calculations [23]. Math-Bridge is one of few electronic systems that allows us to develop simultaneously educational content in several languages. In this case, the trainee can choose independently the language of information presentation for each section.

Practical implementation of multilingual training courses. In Math-Bridge, there are two types of learning objects: so-called dynamic and static. Dynamic learning objects are interactive. A student must answer questions, and the further trajectory of learning will depend on the correctness of these answers. Static learning objects are an educational text where no interaction with the trainee is required. Both types of objects in the system can be translated into one of 14 languages available in the system: English, Russian, German, French, Spanish, Italian, Hungarian, Dutch, Arabic, Georgian, Chinese, Finnish, Czech, Armenian [24].

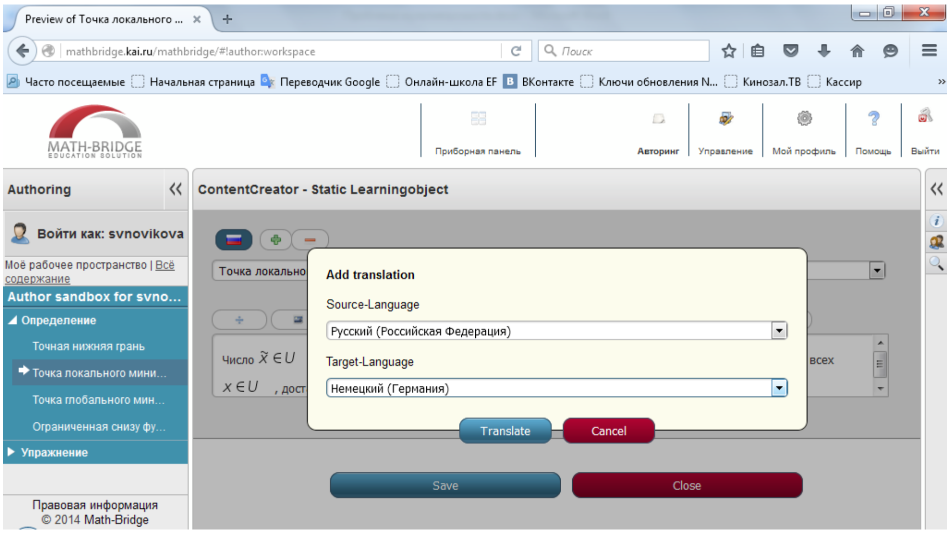
Initially, the learning object is created in the language that has been selected as the system interface language.

The content of Math-Bridge objects is edited by entering text inside the content editor area (fig. 1). The content area always displays the current content of the object in the selected language. The language of input is indicated by showing the flag of the corresponding state.

When you transfer the selected object to another language, you create a physical copy of it – an instance of the object that preserves unchanged complex text objects (drawings and formulas), and allows you edit the textual component. To add or delete an object instance in a new language, there are “plus” and “minus” buttons at the top of the main panel to the right of the flag icon of selected language. Adding a new instance in the new language, a dialog box opens (fig. 2), where you can select the source and target language. By clicking on the button “Translate”, the learning object is translated into the selected target language, and thus the new instance of the object is added.



F i g. 1. Entering the text for the static object “Definition” in Russian



F i g. 2. Selecting the language for the translation of the learning object from one language to another one

After adding an instance in the new language, a new button with a flag icon corresponding to the new language appears, before "plus" or "minus" buttons (fig. 3).

The created multi-language object, for example, the theorem, is represented as a single semantic unit for a trainee. By clicking on the buttons with the flags images each student can see various variants of translation the learning object into the selected language (fig. 4).

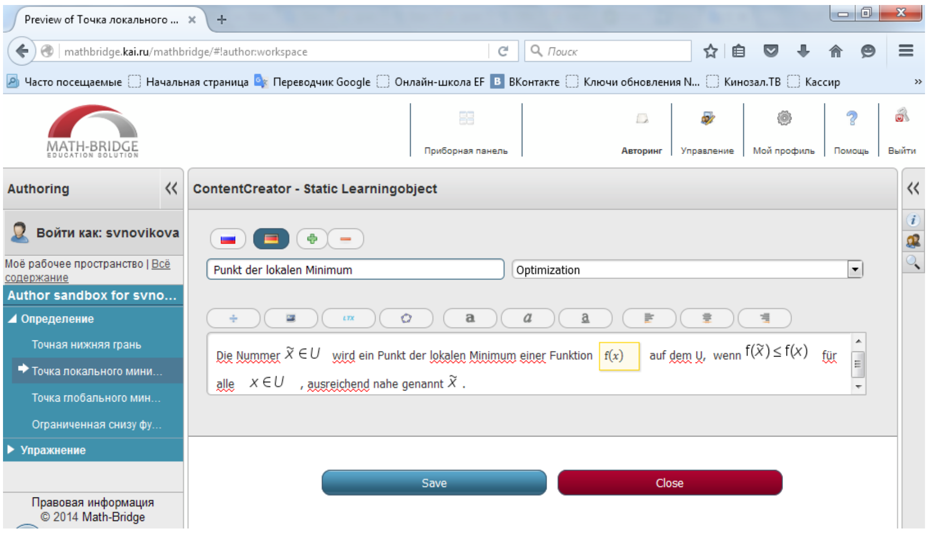
Objective verification of the professional competences mastering degree. An additional advantage of the Math-Bridge system over other e-learning systems is the possibility of automatic, and therefore objective, verification of the level reached by the trainees' professional competencies.

The competences of SEFI are the basis of the tools for testing the effectiveness of mastering the teaching material in Math-Bridge. SEFI's competences are strictly specified, do not allow double interpretations and are easily verifiable. At present, the assessment of practical mastering material degree is increasingly based on SEFI standards in Russia [25; 26].

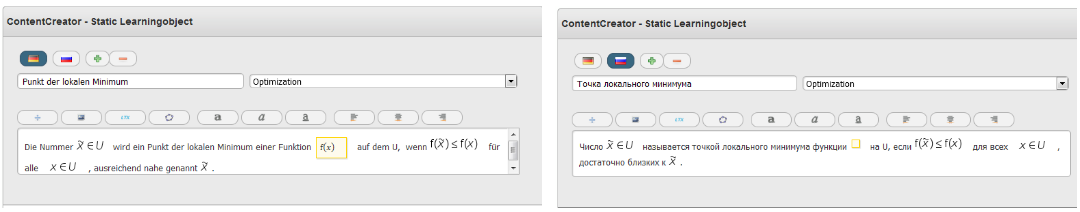
A dynamic training object as "Exercise" is created in the Math-Bridge system to make an element that verifies the degree of mastery of competence. The process of creation such objects is described in details in books [27; 28]. However, the object by itself is not yet a mean of control. If any of created tasks is to be able to check automatically the competence, it is necessary to configure a special metadata parameter of the learning object named "Relationships".

A list of competences is available when configuring. The list is organized as a hierarchical structure "Level of Learning-Training Course-Theme-Competence" (fig. 5).

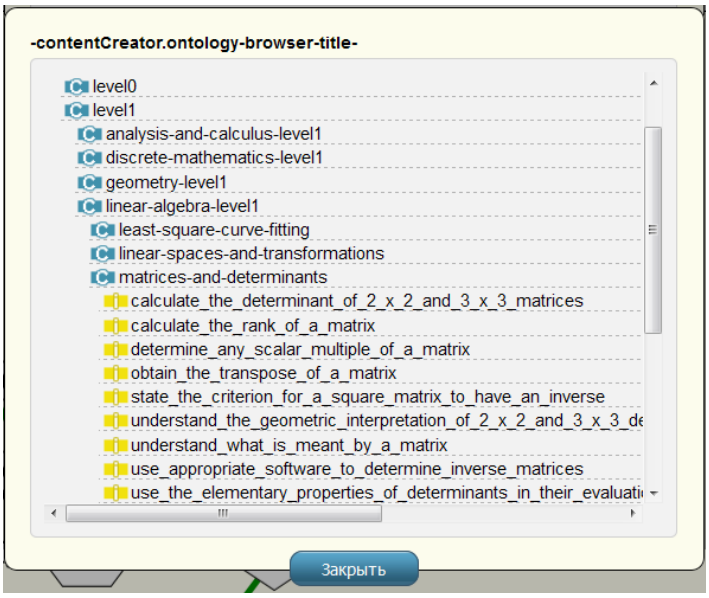
You can add several competencies to the exercise. It means that one and the same exercise is able to assess the mastery of various competencies (fig. 6).



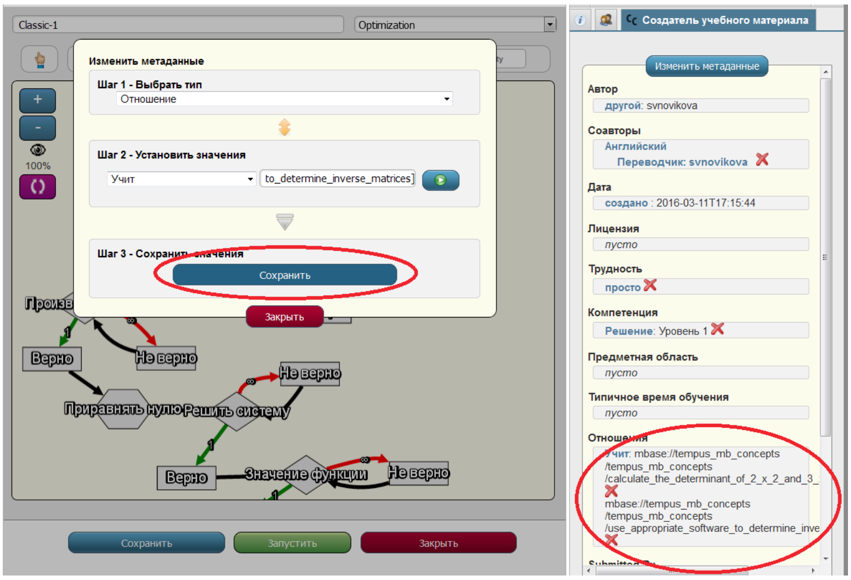
F i g. 3. Instance of the learning object in German



F i g. 4. Switching the definition "Local minimum point" from German into Russian



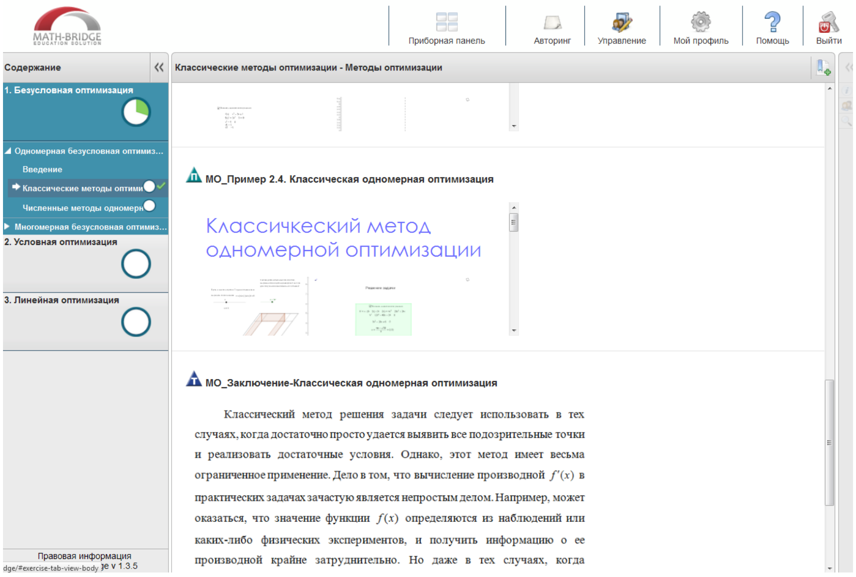
F i g. 5. Selection of specific competencies verified with the help of the created exercise



F i g. 6. Addition metadata to the learning object allowing you to evaluate two selected SEFI-competencies

After publication, the educational facility with competency testing should be included in the curriculum or test for subsequent presentation of the teaching material to the students.

The training course which contains the elements for assessing the level of mastering competences has an indicator diagram, namely the circle where degree of filling corresponds to the number of mastered competences. The same circle indicator contains each section of the course with interactive evaluation elements (fig. 7).



F i g. 7. Presentation of the course to the trainees with interactive elements for assessing competences mastery level for each section (indication of the state of "competence in the section" Unconditional Optimization "is mastered by 30 %, the sections" "Conditional optimization" and "Linear optimization" are not mastered")

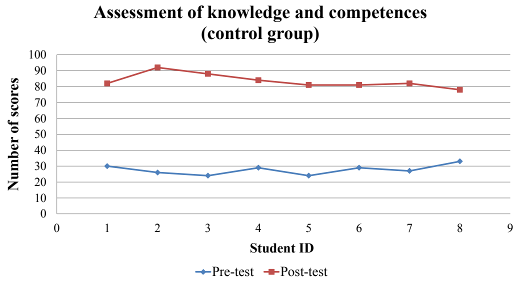
Results of pedagogical experiment. In the 2015-2016 academic year, a group of Russian-speaking Master's degree students of the second year of study (the 3rd semester) was pilot-surveyed. They studied the subject "Optimization Methods" in the traditional way in English, without using the multi-language electronic course developed in the Math-Bridge system. This group of students was a control one. Eight (8) people were trained in this group aged from 22 to 23, three of them were females. Preliminary tests and interviews were conducted to reveal the initial level of mathematical training of the group and the degree of motivation to study mathematical disciplines in general. After completion of the subject, the final test was conducted and the second survey was conducted to identify changes in the level of motivation of students to study mathematics.

The target group of trainees (14 people aged from 22 to 23, including 5 females) was subjected to the same procedure within the 2016-2017 academic year, who was trained with the additional support of the multi-language electronic course "Optimization Methods".

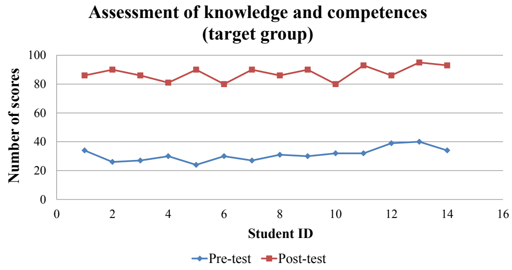
The comparison analysis showed that the level of mastering teaching materials is quite high in both groups: the average score of knowledge is ranged from 78 to 92 in the control group, and an average is 83,5 points (fig. 8); in the target group – from 80 to 95 points, and an average is 87,6 points (fig. 9). However, 100 % of the students achieved an excellent level of mastering competences in the target group, while the control group has only 75 %.

More strongly, the presence of the multilingual training course had a significant impact on students' motivation for further mathematical disciplines training. In the control group, after completion of the course "Optimization Methods" without the support of an electronic course: three out of eight students (37,5 % of students) showed a decrease in interest but the rest of the group showed an increase in interest from 0,9 % to 2,9 %. On the average, the degree of motivation in the group has not practically changed, increasing by 0,86 % (fig. 10).

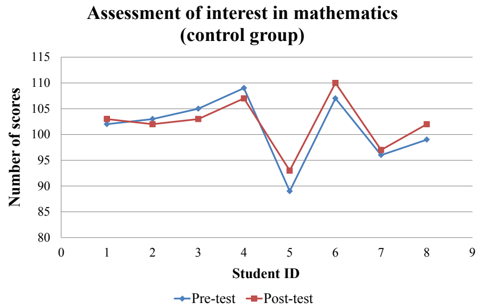
Whereas in the target group, only two out of fourteen students (14,28 % of students) lost interest, the interest level increased from 0,9 to 8,9 % (2,21 % on average) (fig. 11).



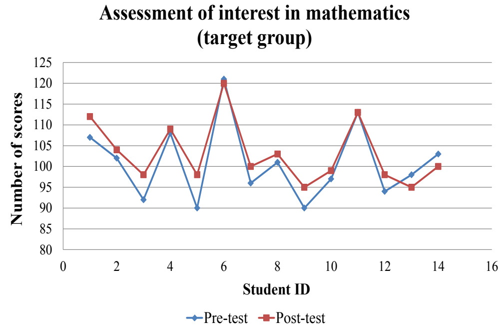
F i g. 8. Level of assimilation of the teaching material in the control group



F i g. 9. Level of assimilation of the teaching material in the target group



F i g. 10. Change in the level of motivation in the control group of students



F i g. 11. Change in the level of motivation in the target group of students

Discussion and Conclusion

Presenting educational content simultaneously in several languages is an important component of ensuring academic mobility of students within the framework of Double or Joint Degree academic programmes. Currently, only a few e-learning systems provide such an opportunity.

The electronic learning environment Math-Bridge provides a convenient interface for the presentation of learning objects in 14 languages, which makes it an universal tool for distance learning of mathematics in conditions of international academic mobility.

The use of multilingual courses increases the level of mastering knowledge and professional competencies of students, and it increases the motivation for studying mathematical disciplines in general. Such multilingual courses ensure the soft entry of mobility students into the professional mathematical environment in the host foreign country. This increases their academic performance and chances to successfully complete a Double Degree programme, and finally to obtain two diplomas.

The developed methods based on electronic educational resources, as well as practical recommendations for creating multilingual courses, will be useful for universities that host foreign students in international academic mobility programmes. Universities all over the world are interested in such methods. The European Union has a special Erasmus+ programme, which provides ample opportunities for further research in this direction. The authors have experience of participation in this programme, and hope to continue research with its support.

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