



Relations between the MetaMath project and the ongoing reform of higher education in Russia

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Outline

1. State educational standards of the second generation that acted in Russia before 2011
2. Federal state standards of the third generation
3. Some difficulties of their implementation
4. How results of the MetaMath project can help to solve the problems of Russian education



State educational standards

- **Russian educational standard** is the system of mandatory requirements to an educational programme. The accordance of the educational programme to the state standard is checked during the state accreditation.
- Before 2011, **state educational standards (SES)** of the second generation acted in Russian higher education.
- SES strictly regulated the content of the educational programme, the set of mandatory disciplines, the amount of every discipline in hours and quality of education.

Fragment of SES for bachelors in the area of studies

"Applied Mathematics and Computer Science"

Name of disciplines and their main subjects	Total hours
General mathematics and natural sciences	2076
Calculus: Functions of one and several variables (continuity, differential and integral calculus, extremums); functional sequences and series; Fourier series and Fourier transform, a function of a complex variable; measure and the Lebesgue integral	816 (=22 credit units)
Geometry and Algebra: analytical geometry; matrix theory; system of linear algebraic equations; linear spaces and operators; elements of general algebra	357
General professional disciplines	2248
Differential equations: general theory of differential equations and systems; Cauchy problem and boundary value problems; linear equations and systems; stability theory; partial differential equations of the first order.	204
Probability theory and mathematical statistics: axiomatic theory of probability; random variables, their distributions and numerical characteristics; limit theorems of probability theory; random processes; point and interval estimation; statistical hypothesis testing; linear statistical models	204

State educational standards

- In accordance with the standard there was the set of didactic units for every discipline and an adequate electronic system of the independent verification of corresponding student's knowledge and skills.
- It was **FEPO-system (FEPE, Federal Exam of Professional Education)** of Yoshkar-Ola Institute, that was used for the state accreditation.



Federal state educational standards

- Since 2011, modern **Federal state educational standards (FSES)** were enacted in Russia. The purpose of them is the implementation of European Bologna principles in Russian education. The main principle is the **competences approach**. The essence of this approach is that the learning outcomes are described by the system of competences.
- *A competence is the dynamical combination of knowledge, skills, abilities and personal qualities that a student should be able to demonstrate after his or her education.*
- The competences should be transparent, i.e. understood for employers, teachers and students.

Federal state educational standards

- Moreover, FSES introduced **credit units** for measuring educational work corresponding to **ECTS (European Credit Transfer and Accumulation System)** and a **two-tier system** of education.
- 1 credit unit = 36 hours
- Russian system before 2011: specialist (5 years)
- Two-tier system: bachelor (4 years) + master (2 year)
- New standards have the framework structure. With the introduction of FSES, Russian universities have obtained more independence and freedom in the development of educational programmes, in the selection of their content.
- But in other hand some problems have appeared.

Difficulties

- Now there is an opportunity for unscrupulous participants of the educational process to unreasonably reduce the content of disciplines and requirements for their mastering.
- Earlier, if a discipline was too difficult to learn for students, universities sought an opportunity to increase its contact hours. Now universities reduce its content.
- In particular this is due to the [Unified State Exam \(USE\)](#) that leads to decreasing the student's input mathematical level of the most universities.



Difficulties

- The transition to a two-tier system of education has led to the reduction of hours devoted to mathematics. Such reduction reaches up to 50% for various engineering programmes compared to the same requirements of SES.

University	Complexity (credit units)
University #1	18
University #2	20
University #3	21

*Amount of discipline "Calculus" of the same programme "Applied Mathematics and Computer Science" in three Russian universities
(SES – 22 c.u.)*

Difficulties

- Formulations of FSES competences are vague and difficult to verify. These competences are transformed into abstract declarations with very broad and conflicting interpretations.

Competence “The ability to understand and apply in research and applied activities modern mathematical apparatus and the basic laws of science”

1. *What does it mean?*
 2. *How does it can be verified?*
 3. *What is the mandatory set of disciplines that form the competence?*
- New standards do not have answers for the questions. It is necessary to develop the concretization of competence meaning.

Difficulties

The order of Russian Education and Science Ministry No1367 (19.12.2013 redact. 15.01.2015) requires for an educational organization to develop own funds of assessment tools (FAT). The funds must contain indicators, descriptors and assessment scales for every competence. In other words the funds must contain the maps of competences to reveal their content.

Expert exam procedure of the educational programme quality during the state accreditation:

Firstly an expert considers the fund of the educational programme. If the expert finds the fund is valid then he/she chooses 7 competences and verifies a degree of their formation among a student's group (50 students) during 20-30 minutes using verifying procedures of the educational organization.

It is necessary for the educational organization to have verifying tests in particular for the successful state accreditation. But it is very difficult for universities to develop own FAT.

Meta-Math project



- The Meta-Math project can help universities to solve the problems.



- If we compare FSES and **SEFI standard** we can note that Russian competences of mathematical training correspond to **general SEFI-competences**:

1. *Thinking mathematically*
2. *Reasoning mathematically*
3. *Posing and solving mathematical problems*
4. *Modelling mathematically*
5. *Representing mathematical entities*
6. *Handling mathematical symbols and formalism*
7. *Communicating in, with, and about mathematics*
8. *Making use of aids and tools*



Meta-Math project



- But SEFI-standard contains the set of **professional competences** that reveal the content of mathematical training an engineer:

Differentiation

As a result of learning this material you should be able to

- *understand the concepts of continuity and smoothness*
- *differentiate inverse functions*
- *differentiate functions defined implicitly*
- *differentiate functions defined parametrically*
- *locate any points of inflection of a function*
- *find greatest and least values of physical quantities.*

- Using SEFI-competences we can develop maps for Russian mathematical competences.

Fragment of the competence map for discipline “Calculus” (UNN)

Indicators	Descriptors			
<i>To know the concept: converging and diverging sequences; continuity of the function; differentiability; smoothness; derivative</i>	presence of major errors in the knowledge of basic material	knowledge of basic material with a number of notable errors	knowledge of basic material with minor errors	knowledge of basic and additional material without errors
<i>To be able to: find limits of sequences; find derivatives of complex functions; differentiate inverse functions; differentiate functions defined implicitly; differentiate functions defined parametrically</i>	major errors in solving standard tasks	ability to solve standard problems with notable errors	ability to solve all standard problems with minor errors	ability to solve standard and non-standard tasks

Meta-Math project



- Using Math Bridge and other electronic systems we can develop useful tools for the competences formation, in particular to create electronic controlled eliminated course (“Elementary Mathematics” developed in UNN). Then we can develop useful FAT for independent verification of competences formation.

Число a является пределом последовательности a_n , если:

☐ $\exists \varepsilon > 0: \forall N \forall n > N |a_n - a| < \varepsilon$

☒ $\forall \varepsilon > 0 \exists N(\varepsilon): \forall n > N(\varepsilon) |a_n - a| < \varepsilon$

☐ $\exists \varepsilon > 0: \forall N \exists n > N: |a_n - a| < \varepsilon$

☐ $\forall N > 0 \exists \varepsilon > 0: \forall n > N |a_n - a| < \varepsilon$

Верный ответ

Из какого высказывания следует, что число a является пределом последовательности a_n ?

☐ $\forall \varepsilon > 0 \exists N(\varepsilon): \forall n > N(\varepsilon) 0 < a_n < a + \varepsilon$

☐ $\forall \varepsilon > 0 \exists N(\varepsilon): \forall n > N(\varepsilon) a < a_n < a + \varepsilon$

☐ $\forall \varepsilon > 0 \exists N(\varepsilon): \forall n > N(\varepsilon) a < a_n < a_n + \varepsilon$

☐ $\forall \varepsilon > 0 \exists N(\varepsilon): \forall n > N(\varepsilon) a_n > a$

Ваше упражнение окончено, пожалуйста закройте вкладку.

Example of electronic test for discipline “Calculus”. The developed tests can be use during accreditation.

- Thus the results of the Meta-Math project are very useful for Russian universities in the conditions of Federal state educational standards¹⁵

Publications

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2. *Zakharova, I.; Kuzenkov, O.; Soldatenko, I.; Yazenin, A.; Novikova, S.; Medvedeva, S.; Chukhnov, A. Using SEFI framework for modernization of requirements system for mathematical education in Russia. Proceedings of the 44th SEFI Annual Conference 2016 - Engineering Education on Top of the World: Industry University Cooperation, SEFI 2016. 12-15 September 2016, Tampere, Finland. 15 p.*
3. *Zakharova I., Kuzenkov O. Experience in implementing the requirements of the educational and professional standards in the field of ICT in the Russian education. Modern information technologies and IT-education. Vol. 12, No 3-1, 2016, pp. 17-31*
4. *Kuzenkov O., Ryabova E., Biryukov R., Kuzenkova G. Modernization of programs of mathematical disciplines of NNGU within the MetaMath project. Nizhegorodskoye Obrazovanie. No1, 2016. pp 4-10*
5. *Soldatenko, I.; Kuzenkov, O.; Zakharova, I.; Balandin, D.; Biryukov, R.; Kuzenkova, G.; Yazenin, A.; Novikova, S. Modernization of math-related courses in engineering education in Russia based on best practices in European and Russian universities. Proceedings of the 44th SEFI Annual Conference 2016 - Engineering Education on Top of the World: Industry University Cooperation, SEFI 2016. 12-15 September 2016, Tampere, Finland. 16 p.*

Thank you for your attention!

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