Bologna Declaration and Mathematical Education in the Countries of the Former USSR (by the Example of Russia and Latvia)

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***Abstract*—More than twenty years have passed since the adoption of the Bologna agreements, and disputes between their supporters and opponents do not cease. In general, in Europe until recently two education systems dominated: Anglo-Saxon, i.e. German, and Latin. As a result of the adoption of the Bologna agreements, it turned out that the Latin system won. As math teachers of Higher School, we are interested in changes regarding the teaching of mathematics in Higher education. In this article the changes that had occurred as a result of the signing of the Bologna Convention were analyzed using the examples of Latvia and Russia**.

***Index Terms*—Bologna agreements, education systems, teaching of mathematics in higher education, Riga technical university, Plekhanov Russian university of economics**

I. Introduction

The Bologna Convention, which aims to create a unified educational space, was adopted in 1999. 29 countries, including Latvia, immediately signed the Bologna Convention. Russia joined a little later, in 2003. The authors of this article received education in the USSR. Some of them had pedagogical experience in the Soviet Higher School. Now we are working in new conditions: after the involvement of our countries in the Bologna process, much has changed in our work. After a short introduction, we will focus on changes in the teaching of mathematics.

The Bologna Convention was initiated by the administrations of European Universities, as students and professors studying or teaching in different countries were interested in a clear system of unification, allowing the recognition of certificates issued in one country by other countries.

One of the authors, a graduate of Faculty of Mechanics and Mathematics of Lomonosov Moscow State University, had a chance to study at the post-graduate school of the Rouen University in France in 1991-1995, i.e. a few years before the adoption of the Bologna agreement. According to memories, at a meeting of compatriots, one of the first questions was the following: "And how did you have your Soviet diploma re-credited?" The problem for soviet graduates was that in France in order to get a certificate of higher education ("Maitrise" in French) 4 years was enough, while in the USSR it was necessary to study 5 years (and in some Universities - 6 years). In France, the 5th year of the DEA (or DESS) belonged to the third stage of education. DEA studies preceded postgraduate studies. In the USSR after receiving this certificate, it was possible to enter graduate school immediately, without an additional year of study. In fact, most of our compatriots had to study an additional year for obtaining a DEA certificate. It should be noted the certificate of Faculty of Mechanics and Mathematics of Moscow State University was recognized as DEA.

For countries where many foreign students studied at Universities there was an urgent problem of re-crediting not only the certificate, but also individual courses and disciplines. As a measure of the passed disciplines the so-called "credits" were accepted. In Latvia they are called "credit points", in Russia-credit units. Coordination of curricula, development of unified approaches for assessing the quality of education, definition of clear units of measurement of trust, called "credits" was required. Note that even the word "credits" is taken from the banking vocabulary.

Young people, who perceive the possibility of choosing not only the University, but also the country of study, need a similar agreement in almost any country of the world.

But still, why are there negative notes in professors' opinions about the level of teaching mathematics in our Universities?

II. History of Riga Technical University and Plekhanov Russian University of Economics

Our universities have a rich history. Of course, this is not a centuries-old history, as some Universities in Western Europe, but more than a century.

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Riga Technical University (RTU) is one of the oldest higher education institutions in the Baltic States. Its history spans 157 years. In those years Riga was one of the largest cities of the Russian Empire. Permission to establish a Higher education institute in Riga was obtained in May 1861, and in the autumn of 1862 the first students began their studies at the Riga Polytechnic Institute. Its work was interrupted by World War I. In 1918 the faculties of the Polytechnic Institute were incorporated into the Latvian Higher School, later called the University of Latvia. In 1958 (already in Soviet times) Riga Polytechnic Institute resumed its work, and in the mid-70s of the last century it became the largest educational institution in Latvia. In March 1990, Riga Polytechnic Institute was renamed Riga Technical University (RTU), and when Latvia became an independent state in September 1991, RTU began training foreign students, and students and teachers were able to study and work in different European Universities. Currently it has more than 15,000 students.

The date of Foundation of the Plekhanov Russian University of Economics (REU) – February 19, 1907, in those years the University was called the Moscow Commercial Institute, i.e. it was also founded in tsarist Russia. In 1919 it became known as the Moscow Institute of National Economy. In 1991, it changed its name again to the Plekhanov Russian Academy of Economics, and in 2010, having received the status of the University, it was renamed Plekhanov Russian University of Economics.

Our universities went through several changes of governments and even were universities of different States, without moving anywhere. Continuity was established in education as more experienced teachers passed on their experience to younger ones. Each University has its own style and a certain school of teaching, in particular, teaching higher mathematics.

Changes in the curricula of mathematical disciplines were extremely rare. But it is true that there have been no significant changes in Calculus in the last 150 years.

But still, in connection with the computerization of society, in addition to Calculus and linear algebra, it was necessary to introduce other mathematical disciplines, such as discrete mathematics, the operations research. In Plekhanov Russian University the course of linear algebra also includes economic applications, such as the linear programming and the transport problem. Such disciplines as financial mathematics, financial calculations and mathematical workshop for economists were also introduced. In order to master all these mathematical disciplines, students must initially possess a certain amount of knowledge, and must also have enough hours to master these courses.

III. About the Initial Level of Students

Our experience shows that it is much easier to study at a University if you have accumulated good basic knowledge in mathematics [1]. Indeed, in the Soviet Universities, applicants entered, having passed a competitive selection, having previously passed the entrance exams to the selected institution. In some Universities, the competition could be quite small-2-3 people per place, and in some Universities, the competition was simply off the scale. Not entering the UNIVERSITY, the young man had to miss at least 1 year. Some tried to enter again and again, and some young people were limited to secondary vocational education. Thus, higher education was not mass, but elite. Competitive selection provided a certain level of knowledge received. Teachers could teach higher mathematics, not doubting that students know how to add fractions, arrange brackets, know the multiplication table and the formula of reduced multiplication. Teachers were outraged that the students could forget some of the trigonometric formulas or rules for working with logarithms.

Entrance exams to universities in Latvia were canceled long ago. Enrollment is based on the results of school centralized examinations (CES) and grades in the secondary education document. CE results are measured in percentages: from 0% to 100%. Of course, for some specialties, such as future architects, an entrance exam in drawing is held.

In Russia, entrance exams are held for a very narrow class of applicants: graduates of secondary special educational institutions and for those long graduated from high school long ago. Enrollment in Universities is carried out according to the results of the unified state exam (use). Exam results are measured on a 100-point scale.

However, there are Universities that in addition to the exam also conduct additional entrance tests (DVI). But such Universities are in a clear minority, they do not play a key role, although the teachers of these privileged institutions are also dissatisfied with the level of students.

From the sharp opponent of the exam there was a transition to the camp of his supporters [2]. After all, during the existence of the exam itself in mathematics exam has become very reasonable and, indeed, tests the knowledge of mathematics. When Russia first introduced the exam (beginning in 2001), we were told that one of the goals is to stop corruption in Universities, then that students from all regions should have equal opportunities. Those distortions, which later took place, can serve as a topic of a separate study, but for us it is a mystery how having passed the CE or the exam, yesterday's students do not know the basics of mathematics of Junior classes.

The situation in Universities is complicated by the fact that the number of budget places in Universities is constantly decreasing, and most students do not enter by competition, but on extra-budgetary places, i.e. their education is paid not by the state, but by their parents. And here can enter the University and those who have a very low exam score.

Regardless of the results of the CES, teachers of the Department of engineering mathematics of RTU at the first practical lesson conducted verification work on elementary mathematics [3]. Teachers of the Department of higher mathematics of the Plekhanov Russian University of Economics also do the same. The teachers of the Department of engineering mathematics of RTU has organized the following:

1. Intensive courses in elementary mathematics before the beginning of training, unfortunately very few students used it and the Department no longer conducts such classes;

2. Published lectures on elementary mathematics in Latvian (available on YouTube);

3. Has developed a new subject "Basic parts of elementary mathematics", which meets the two credit points and is mandatory in the evening and correspondence departments, as well as for all those who badly wrote the above test work.

This last point should be adopted by many Universities, because it is at least some way out in terms of reducing the initial level of knowledge of students in mathematics.

IV. Number of Hours

Certainly, the main work of the teacher should consist of giving lectures and conducting seminars, and the main activity of the student should be attending classes, which are for him the main source of knowledge. Of course, in this age of information, any knowledge can be obtained not only in lectures. However, the vector of the development of mathematics is a live presentation of the material in a certain sequence, and then the solution of problems by students at the blackboard under the guidance of the teacher.

In the Soviet era, or rather 80-90-ies, in the Plekhanov Russian University of Economics at most faculties (we are not talking about the faculty of Economic Cybernetics, where mathematics was much more) the picture was as follows. The course of higher mathematics lasted two years, i.e. four semesters. Each semester, both autumn-winter and spring-summer, included 17 weeks, during which one lecture was given weekly and one practical lesson was held. Currently, during this period mathematics is not given every week. Lectures are given from the beginning of the module and last a few weeks. The practical classes are given from the fourth or fifth week and last to tell to the module (trimester).

Let's give concrete figures, having carried out comparison of curricula in mathematics of the first and last generation (curriculum 3++) on a specialty "Applied Informatics in Economy".

In 1996, the first generation curricula was adopted. The whole discipline was called "Mathematics" and consisted of 5 sections [4]. Distribution of hours was as follows:

- Lectures: 200 hours;
- Example classes: 206 hours;
- Laboratory sessions: 44 hours;
- Classroom lessons in total: 450 hours.

According to the third generation curricula adopted in 2015, students study three mathematical disciplines: mathematics, discrete mathematics and probability theory and mathematical statistics. Summing up the hours in all three disciplines, we got the following:

- Lectures: 106 hours;
- Example classes: 116 hours;
- Laboratory classes are not provided;
- Classroom total: 222 hours.

So, the total number of classroom hours decreased more than twice.

As for the situation in the Riga Technical University the study time in recent years, RTU has reduced the study time provided by the curricula for higher mathematic has been reduced:

- 527 hours, 4 semesters in 1985;
- 384 hours, 4 semesters in 1989;
- 144 hours, 2 semesters in 2015;
- 176 hours, 2 semesters in 2019.

The total number of hours decreased in comparison with 1985 three times, and in comparison with the 90-ies twice! However, the content of courses in RTU has changed little, and students come with a lower level of training. Therefore, the teaching staff have an additional burden-teaching higher mathematics, it is necessary to explain the concepts of mathematics that would need to be mastered in high school.

Thus, the problems in the teaching of mathematics courses in the Riga Technical University and in the Plekhanov Russian University of Economics are similar.

Specialty "Applied Informatics in Economics" appeared in the Plekhanov Russian University of Economics in 1996. Therefore, we could not make a comparison with what was in Soviet times. Let's talk about the situation with the teaching of mathematics in the 80-90-ies in the Plekhanov Institute at the "non-mathematical" faculties. The matter is that in Plekhanov Institute there was a faculty of Economic Cybernetics on which the number of mathematical disciplines was essentially more, than at other faculties. Now this faculty is called Institute of digital economics and information technologies.

In the first semester were given the basics of analytical geometry and linear algebra, at the end of the semester began Calculus. The second semester was devoted to Calculus. The third one was probability theory and mathematical statistics, and the entire fourth semester students mastered economic applications, the course was called "Mathematical programming". Total, for the year: 68 hours of lectures + 68 hours of example classes, i.e. 136 classroom hours, which totaled 272 classroom hours in mathematics. At the same time, at the end of each semester, students took the exam. Now at each faculty the number of hours varies, depending on the specialty. Consider the situation that has developed to date in the specialty "Economics". A year-long course is provided for the study of Calculus, and it takes 68 hours in one semester and 52 hours in the other, which is quite commensurate with what it was in the 80s and 90s. Also, 52 hours are provided for the study of linear algebra and probability theory, which amounts to a total of 224 hours.

We can say that the reduction of hours is not so significant. But note that today the course of linear algebra is a combination of courses of linear algebra and mathematical programming, the total number of classroom hours is 52, and in Soviet times, the development of these disciplines spent more than 100 hours! This is very sad because the linear programming problem, the transport problem are very useful sections

for economists. It seems that the solution is that this course is estimated at 4 credit units, although in depth and volume it is not inferior to Calculus.

The situation is particularly outrageous at the faculty of digital economics, where the number of hours in the direction of "Economics" coincides with the number of hours in other faculties, despite the fact that students receive a specialty "Mathematical methods in Economics". Earlier the students at the faculty of digital economics studied the Calculus for two years. Now this discipline is reduced twice and lasts for 1 year.

If you look at modern curricula, there is another column: independent work of students. According to the authors of this article, different students need different time to master the same material, so it is impossible to plan independent work in principle. However, with this column, you can create the appearance of a large number of hours on the discipline, because these hours appear in the official document.

Within the framework of the curriculum of mathematics of the first generation in the specialty "Applied Informatics in Economics" it was provided 224 hours of independent work. Nowadays the third generation provides 330 hours. In fact, more information students gain at classes, the more time it takes them to work at home. Therefore, it seems to us very doubtful that the current students work independently one and a half times more than their predecessors. But this allows to maintain the illusion of well-being, because it turns out that the curricula of the first generation in the amount of 720 hours, and in the curriculum of the last generation (curricula 3++) in the amount of 676 hours.

V. Intermediate Control: Exams and Tests

The study of any discipline ends with an exam or a test.

After the adoption of the Bologna Convention, this educational stage underwent great changes in our countries. We use the word "stage" deliberately, because during the exam or test, students still continue their education. After reviewing the entire course in its entirety, by the day of the exam they had to understand why every fact, every statement was needed in the presentation of the discipline. During the oral exam or test, the examiner has the opportunity to talk with the student, to clarify some places, even sometimes with the help of an additional question or task.

The examination in the form of testing has a very different character. The test itself is usually a series of traps in which the unlucky examinee must fall, and the thoughtful student must successfully overcome. It is believed that the assessment is more objective, but the form of verification is more superficial.

In addition, the student is deprived of the only opportunity to speak on the subject with the examiner, what is undoubtedly useful for understanding the discipline.

But, on the other hand, with the first approach, a subjective attitude on the part of the examiner is possible and, of course, there are more opportunities for corruption.

In the work already mentioned [5] there is an interesting argument that in Germany the level of confidence in the teacher is much higher than in France. It is the teacher who during the academic year offers individual tasks to students, depending on their level and interests, and it is he who deduces the final assessment without a rigid point system, relying on his perception of how the student has mastered the discipline.

P.-Y. Louis, brought up in a French educational environment (Latin education system) was struck by the degree of trust that is given to German professors (German education system). We found ourselves in the opposite situation, being in the shoes of people who used to trust, and then abruptly ceased to be trusted. Putting aside the ethical and emotional sides of this transition, just note that we are constantly exchanging with each other such phrases: "Well, I know that he (she) does not know anything, but since he (she) has a high score, I am forced to give a positive mark." [5] Sometimes we have to say the opposite. There are situations when a student, starting to study not from the very beginning of the semester, shows very good results, but the point system does not allow the teachers to give a student an excellent mark for his excellent knowledge. Therefore, the objectivity of the assessment formed by the point-rating system seems to us very doubtful.

Apparently, the test system is a new trend of the time, which can not be abandoned, and therefore it must be improved. After all, the Unified State Examination in Russia or Central Exams in Latvia have undergone such positive changes that we have turned from their opponents to their supporters. We are currently working on improving the test system [6]. In favor of the latter, wemust say that students train on the tests with great pleasure. This type of activity appeals to the modern generation more than work with a book, a pen or a pencil. This has to be reckoned with this fact.

VI. Conclusion

Taking into consideration the increasing number of students who go to study abroad, we have to realize that despite the recent negative reviews in Russia about the consequences of the Bologna Convention, the process itself has become irreversible.

As for Latvia, as a country of the European Union, it is a given, that must be accepted.

Currently, Plekhanov University has more than 1,500 undergraduate and graduate students from 70 countries. At the same time, about 200 students study abroad. Thus, Plekhanov University is certainly an integral part of the world educational space.

However the Bologna process is called a process because something new is being introduced into it all the time. These changes are discussed and proposed at the highest level, so it is not very clear whether the opinions of ordinary teachers matter. But we believe that in the process of globalization, in the development of General provisions, it would be right to allow Universities and countries to preserve their characteristics and not to destroy the positive that has been accumulated for decades.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

I. Volodko conducted the research; S. Cernajeva and I. Eglite provided data; M. Maksimenko wrote the paper; all authors had approved the final version.

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