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Mathematics Education in Russian Federation

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Introduction

This report consists of current issues of and expectations to reforms in Russian Mathematics Education. It is primarily based on my personal experiences for three decades. I would like to express deepest gratitude to Director Ivan Roschisravovich Vysotsky of Laboratory of Probability at Moscow Centre for Continuous Mathematical Education for giving such a valuable opportunity.

In the following, I will structure my essay in accordance with the short but extremely important formal document of "The Conceptual Framework for the Development of Mathematics Education in the Russian Federation" approved by the Government of Russian Federation on December 24, 2013. The Conceptual Framework is of crucial not only for domestically but also for internationally. Eminent mathematicians and mathematics educators, among others Field's laureate Stanislav Konstantinovich Smirnov and ICME IPC member Ivan Valerievich Yashchenko, made significant contributions. The Framework presents a systemic view on the basic principles, aims, tasks, and main directions of mathematical education in the Russian Federation. With the recognition of main issues of motivation, content, and human resources, it proposes main leading directions ranging from all kinds of educational system to professional development, which bring Russian mathematical education into the leading position in the world. Specific character of the Framework lies in directions or levels to which mathematics education addresses. It is indeed the first document in Russian Education when the leading principle of equality is replaced with principle of efficiency.

I think it legitimate way of structuring my essay so as to cover the strengths and limitation inherent in current Russian mathematics education. This report consists of three parts: legacies, problems, and expectations that might be taken into account by public citizen as well as policy makers. First, the Conceptual Framework refer exclusively to future directions, I believe, there would be timeless world legacies of Russian mathematics education. Second, since the document is comprehensive, I would like to refer to some seemingly peripheral and inessential features to the insider, but key features that deserve attention to the outsider:

budgeting system; standards; textbook; assessment; and teacher education. These features, quite different from ours and therefore are actual features that might supplement the Conceptual Framework.

Legacies of Soviet and Russian Mathematics Education

As Conceptual Framework clearly stated that the system of mathematical education developed in Russia is the direct heir of the Soviet system. On the occasion of 100 years of Russian revolution, I would like to point out, among others, five legacies of Soviet and Russian mathematics education.

Equality and Equity Principle

First of all, Soviet Government established school system with both equality and equity principles. It provided equal and free access to education and rich mathematics curriculum developed with sound experimental evidence based research. This nationwide system had achieved the highest level of mathematical literacy for all nations as well as promoting special mathematical competencies of each child by specialized school for advanced learning and several kinds of supplemental education system. Regardless of low income, school teachers, researchers and professors made significant contributions to the development of the great country with the ethos of "intelligentsia".

Coherency in Mathematical Curriculum

Second, we have witnessed golden ages of Russian mathematics education during political and economic stagnation period. Modern mathematics reform guided by Andrey Nikolaevich Kolmogorov and his colleagues during 1964- 1981 seems to me an ideal age of Russian mathematics education in that the reform bring the progressive reform movement of 1920s into realization as well as it establishes a coherent "mathematics" program for ten-year complete general education. Especially, the new mathematics program not only introduced set theory, geometric transformation, and vector algebra, but also introduced intuitive geometry and elementary algebra in elementary and middle grades, analytic geometry and elementary analysis as well as basic informatics in the upper grades, thus it established articulated mathematics curriculum throughout primary to secondary schools. It seems to me that the reform program for general mathematics education came to its sophisticated peak in Soviet mathematics education in contrast to the New Math reform movements only for talented students in the Western countries.

Standardization and Differentiation

Third, compared to the general educational reform during "Perestroika" period of 1984-1991, apparently, few actual reform was implemented on the part mathematics education. However, during 1988 - 1990, many documents of provocative proposals or "Conceptual Frameworks" by innovative collectives and Research Institute of Content and Teaching Methods in Academy of Pedagogical Science were issued in the journal "Mathematika v shckole". These documents proposed contemporary thoughts: idea of "standard" instead of detailed prescribed program; idea of many types of "differentiation"; inclusion of statistics and probability as new content; emphasis on mental estimation and ill-structured problem solving; humanization of teaching-learning process; capitalize computational technology, and so forth. It was indeed progressive idea that standard consists of two kinds of differentiation: the "inner" and "external" differentiations. The former consists of compulsory and advanced levels for every grades. The latter consists of establishing course for deeper learning or group of courses in view of future profiles mainly in upper grades. Especially, amalgam of standardization and differentiation is promising and unique idea which set the basis or model for the main direction of contemporary Russian Mathematics Education. However, as a matter of fact, such a progressive idea has only been realized in some magnet schools and for economically stable families. In that sense, current Russian mathematics education is, I believe, nothing but the seek for realization of the ideas elaborated before the collapse of Soviet Union.

Supplementary Education System

Forth, Russian education has long and unique traditions of so called "supplemental educational programs": mathematical circle; project works; kinds of problem solving competitions or Olympiads; summer school; academics conferences. These supplementary programs recently became a compulsory part of exemplary general school program. There are also rich resources for supplemental materials, such as "Popular lectures in Mathematics", "Kvant", and more recently "Kvanchik". ICT supported distant learning systems are widely developed in Russia that enable students, among others physically challenged or weak students, to engage in mathematical activity spatially and temporally. These rich systems may match students' needs and satisfy their respective interests.

Teacher Education

Quality and self-pride of Russian mathematics teachers, as far as I have met and observed, are very high. Russian mathematics teachers provide quality mathematical teaching by considering, developing and shaping the learning and everyday interests of different groups of students. Because teaching is complex and creative practice, it is preferable to for

prospective teachers to study authentic mathematics and teaching methods in five years' specialization course at a university or a specialized pedagogical institute. However, adherent to Boronia Process, restructure of institute to university, and declining the numbers of pedagogical specialized institutes, quality of teacher education courses have deteriorated. Education board was responsible to allocate teacher to each school so as to warrant quality of education. However, in 1980's such a centralized system had started falling and there remains unstable teacher employment system. Concerning professional development, both Soviet and Russian system has provided teachers variety of opportunities for taking in-service qualifying professional development courses and graduate study which are organized by education board, continuous education center, and institutions. Many kinds of supplemental and enrichment literature of scientific journal, didactical material, and newspaper are published for teacher's professional developments.

I hope that Russian mathematics education to maintain dignities of Soviet and Russian period so as to provide qualified specialists for science-intensive and high-tech production.

Crucial issues of Russian mathematical education

Crucial issues posed in the "Conceptual Framework" are pressing and serious. I do expect the Russian specialists call upon the excellence of intellectual capitals so as to collaboratively resolve them. In the following, I would like to raise some issues of Russian mathematics education in accordance to the legacies mentioned above.

Educational Budget System

Equality principle, in general, is collapsed by the new Russian financial system in education that gives each school educational budget based on the numbers of pupils enrolled. Recently, we observe that many schools, especially in Moscow, are integrated so as to get more budget. It is true that the scale of a school become bigger, the school has rich equipment and human resource that enable the school to organize variety of educational activity and profile courses. Current public education system is economically driven and it will cause unequal opportunity both for the teachers and students. Though such financial system has nothing to do with mathematics education, it is deep disappointment to those who favors Soviet equality tradition.

Standards

The idea of standard was realized in 2004 firstly as "National Education Standard" that is based on the "Concept on Modernization of Russian Education". However, in pursuit of a

strong “Unified Space of Education”, the standard itself and textbooks stay far behind from global tendency: competency based education promoted OECD/PISA. In 2007, in accordance to the seventh item of new education low “On Education”, the standard is revised as “Federal National Education Standard” which includes competency aspects of “Universal Learning Actions” (УУД) which consist of for key dimensions: personality, cognition, communication, and regulation. However, the notion of universal learning actions is too abstract to realization in mathematics contents and processes. This ambiguous notion leads to chaos and inconsistency in mathematics curricula. I would like to point out two issues. One is to develop coherency and articulation of mathematics curriculum among elementary, basic, and upper grades. Another is to elaborate functional and authentic assessment system.

First, the continuity between educational levels is disrupted. In the primary level, variety of mathematics programs that have underpinning of idiosyncratic psychological theories are prevalent. However, neither system, so far, proposes coherent program throughout general education. Mathematics curriculum in the middle grades, I believe, is crucial in that it bridges primary and upper grades and it is transitional level of thinking from concrete to abstract. On the other hand, lack of sound principle for curriculum design in the middle grades that bridge the gap with missing link. ***I believe it more appropriate that accumulation of expertise of mathematician and methodologists develop coherent and articulated mathematical curriculum in general education.***

In upper grades, many advanced profile courses are developed, some of them are called “Special Scientific Research Center” (СУНЦ) in collaboration with higher educational institutes. However, there seems to be shortage of modules that might be widely and commonly used in many centers. In view of global tendency that mathematics takes a significant role in interdisciplinary fields. Such idea is obvious in STEM movements. Thus, ***it is expected that expert mathematics teachers, and researchers of mathematics education as scientific discipline, and professional mathematician collaborate with science and technology specialists to develop as many as STEM modules that are widely used for throughout the country.***

Textbook Development

One of possible low motivation for study among pupils is, I believe, connected with outdated textbooks that consist of plain description of mere mathematical facts and procedures followed by collection of exercise. Since Soviet period, textbook development and accreditation process is highly systemic and there are quite rich classical textbooks. However, many outdated textbooks are still reprinted and used. Some textbooks often start formal mathematical definition, followed by illustrations of so called know-how to adopt these formal

knowledge and skills with exercises. Many mathematics lessons which are characterized as mechanistic process that substitute of creative practice of teaching by "demonstrating and coaching" so as to let the students master these mere facts and procedures. The choice of content in mathematical textbook and related materials are still obsolete and remains formal and detached from life. Future professionals' needs in mathematical knowledge and mathematical methods are insufficiently taken into account.

Textbooks are logically categorized into four different traditions: mechanistic; empiricism; structural; realistic. It seems to me that global tendency moves forward to developing realistic oriented textbooks which emphasize mathematizing of both reality and mathematics itself. The textbook starts realistic context to informal model of situation, then proceeds to elaboration of model for mathematical reasoning, and finally refines into formal mathematics. The realistic textbook promotes sense making activity and provoke "intrinsic" intellectual motivation on the part of the pupils to think mathematically. Another global tendency is to develop different type of textbook in accordance to students' ability, aptitude and interest, especially in upper grades. In some countries, there are four type of textbook for weak students, humanity, science and engendering, and gifted. ***I think it more appropriate that that Russian mathematics textbook authors to take into contemporary global progressive tendency: developing variety of mathematics textbook for life and workplace; interdisciplinary STEM study; advanced IBL study for innovation.***

Unified State Examination

The Unified State Examination (Е Г Э) seems to be an ideal or utopian system which gives every graduate of high school equal opportunity to enter higher educational institutes. In view of vast region of Russian territory, the system is supposed to warrant every student equal and fair access to tertiary education.

As any system has imperfect aspect, there are some difficulties with this examination. On the one hand, in intermediate and final state certification requirements for different groups of students leads to low efficiency of educational process. It is unrealistic that all applicants to wide variety of higher education must take mathematics as "compulsory" subjects. Thus, it has to contain wide variety of test items starting from quite trivial question with multiple choices to dead problems with written answer. On the other, it seems to be difficult even for the expert teachers to cope with pupils with wide range of mathematical abilities and attitudes. Mathematics lessons inevitability run as mechanistic process that substitute of teaching by drill and coaching. Overloaded materials for preparation for intermediate and final state examination are apparent in the mathematics cabinet. Mathematics classroom is occupied with series of exercise books for state examination. On

the side wall of a classroom, exemplar variation of intermediate and final state examination on mathematics and school records and schedules for consultations are put up as notices. As far as the intermediate and final state examinations are developed based on the current obsolete mathematics contents. This examination system, based on our bitter lesson of tired and unproductive examination race, might cause unexpected negative effects on both students and teachers. Ideally, mathematics should not be mere means of selection of students for further education.

Specific competency that Russian mathematics lesson fosters on the part of students is high level of oral justification and explanation. Like former Russian entrance examination, both written and oral aspects are significant in view of "communicative role in mathematics practice". *In view of recent tendency, it is more appropriate that the unified state examination might be reorganized into dual system: examination for certificate for secondary graduation with minimal requirements, and examination for tertiary education with some variation for humanities and science profiles and oral justifications*. Actually, Ministry of Education, Culture and Technology (MEXT) Japan plans to introduce such dual system.

From Results to Evidence Based Reform

There are many kinds of high-stakes examinations and international comparisons like PIRLS, TIMSS, and PISA. In accordance to the accountability principle, Ministry of Education routinely announce ranking of school, say "top 400", based on several indicators. Japanese policymakers often show primary interest in the results: score or ranking itself. That tendency inevitably establishes unproductive competing ethos among schools and high achieving schools attract more children with additional support. I think such tendency seems also true to Russian Federation. *In view of similar attitude to ranking based on testing results, it is important that school as well as research institute and ministry of education make comprehensive analysis so as to provide evidence based suggestions that inform schools and teachers how to improvement their practice.*

Teachers

Shortage of male and young teachers would cause many difficulty, recent reform of pushing up of salaries and bonuses equivalent to the average workers will slowly improve their' life. However, raising teachers' salaries is accompanied with their growth of work road or "stafka", which necessarily cause their overload.

If I understand Russian system correctly, compared to our system, the current system of pre-service teacher education seems to have serious deficits. Unlike former Soviet system, current pre-service education in secondary vocational colleges and tertiary institutes lack

planned and qualified teacher education.

On the one hand, professional standard of mathematics teacher, I think, is not operational. Further, the professional standard and standard of higher pedagogical institution are inconsistent. On the other hand, teacher's recruitment system is operated based on market principle. It is surprising for Japanese character that a principal can decide their teachers through informal employment interview. As a public person, teacher should work not only for her/his own sake but also support student's personal development and citizenship. ***I expect that Russian educational policymakers might establish consistent system in mathematics teacher education and fair and equitable system for in-service monitoring procedure or reallocation of teachers so as to control quality of education and to keep equal educational opportunity of every student.***

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