Helping Students to Become Researchers: What We Can Gain from Russian Experience

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Abstract— The fact that many internationally renowned scientists have been educated in the former Soviet Union shows that many features of its education system were good. In this session, we briefly describe the features that we believe to have been good. Some of these features have already been successfully implemented (with appropriate adjustments) in affinity research groups at the Department of Computer Science of the University of Texas at El Paso.

Index Terms - Russian experience, seminars, clusters, affinity groups

Introduction

Many internationally renown scientists have been educated in the former Soviet Union, especially in mathematics, physics, and computer science. This fact leads to a reasonable conclusion that many features of the Russian education system were good.

The main objective of this paper is to (briefly) describe the features that we believe to have been good, with the hope that they may be useful in the American education as well. These features include emphasis on student groups – where students study and do research together, emphasis on working research seminars, etc.

Some of these features have already been successfully implemented (with appropriate adjustments) in UTEP's affinity research groups; see, e.g., [1, 2, 7].

Motivations and Clarification

Why Russian experience? Two of us have been educated in Russia: Vladik received his Master's degree from the computer-related division of the Mathematics Department of St. Petersburg University and his Ph.D. from the Institute of Mathematics of the Siberian Department of the Russian Academy of Sciences; Olga received her Master's degree from the Novosibirsk University, Russia. Both observed the Russian educational system as students and as teachers, so we are very familiar with different aspects of this system.

This paper is not a comprehensive survey. We omit all the features that we we consider bad (and there were many), and concentrate only on the features that can be useful. Our choice of useful features is (inevitably) subjective – mainly based on our own experience and on our collaboration with Prof. Nesterov (St. Petersburg, Russia). We hope, nevertheless, that in spite of this subjectivity, this paper will be useful.

Our main objective is to attract attention to (not well known) educational techniques – especially since we have tried some of these techniques, and they seem to work pretty well. Readers interested in more details of the aspects of the Russian educational experience emphasized in this paper can study [3, 4, 6, 8, 9] and references therein.

3-Tier System of Students

To get admitted into a Russian university, it was necessary to pass entrance exams. Every Department had its own set of entrance exams, usually, very tough, and usually, very specific. A student whose knowledge was not sufficient for a selected department could prepare better and try again next year.

At first glance, it may sound different from many American state universities, where every student with a valid high school diploma can get admitted, but in reality, the situation is not that different. For example, at our University of Texas at El Paso, every high school graduate can become a student but it does not mean that every high school graduate can become a Computer Science or Engineering major. Every incoming student takes placement tests based on which a few best students are placed directly into the Computer Science or Engineering program, but most take remedial classes until they successfully attain the needed level of knowledge. In other states, like in Russia, remedial classes are taught outside the university (e.g., at Community Colleges).

Based on the results of the entrance exams, accepted students were divided into 3 tiers.

Full-Time Students

The best students were accepted into a *full-time* program. These students were usually given *stipends* that provided (minimal) subsistence, so they did not have to work. This stipend was kept as long as a certain GPA is maintained.

Full-time students from out of town were also usually given a free place in the dorms or a possibility to (cheaply) rent a room through a special University-mediated and University-subsidized placement service. Full-time students were on the fast track, they got their B.Sc. and M.S. degrees in five years.

Work-Study and Distance Learning Students

Since every full-time student was financial supported, the number of full-time students was limited by the available funding. Students who passed the entrance exams but not so well as to qualify for this status became either work-study students (if they live in the same town as the university) or distance learning students (if they live out of town).

Work-study students worked full time. To accommodate these students, they attended special evening classes. Of course, since work-study students also worked, they could not take as many classes as full-time students, so they took somewhat longer to graduate than full-time students.

Out-of-town work-study students became distance learning students. Throughout the semester, these students received their lecture notes, handouts, and assignments remotely, sent their assignment by mail, and got them graded and checked. To compensate for the lack of direct contact with professors, at the end of every semester, these students came to town for a month-long on-campus crash course to solidify their knowledge before the finals. These students took even longer to graduate than work-study students.

The best work-study and distance learning students usually became full-time students: some of the original full-time students failed, some decided to change their field of study, so some full-time slots opened, and the best work-study and distance learning students took these slots.

Students from All Three Tiers Received the Same Knowledge

It is important to emphasize that the same material was taught to students of all three tiers, and the final exams for all these three tiers of students were given by the same professors at the same level of difficulty.

In principle, students from all three tiers gained the same level of knowledge. However, in general, employees preferred full-time students – because they got higher grades originally and so they have a reputation to be smarter than others. This preference was an additional incentive for work-study and distance learning students to study harder so that they would graduate as full-time students.

Clusters

Until the senior year, full-time students had practically no choice: they had to take the pre-determined sequence of classes (clusters) every semester. This was a very heavy studying load: about 6 hours of classes every weekday and Saturday, with a large amount of homework for each class.

After the first three years, the students chose a *specialization* within their discipline, after which they got more freedom in selecting their classes.

The main advantage of clusters was the ability to *correlate* different courses taken at the same time. For example, when physics and calculus were taken at the same time, both professors could correlate exactly when, say, the notion of a derivative was introduced in math and in physics, so that mathematical and physical aspects of this notion were taught simultaneously and helped students relate different areas.

An additional advantage was that when the entire class of students from, say, Math or Computer Science, goes into physics or philosophy, there were enough students to organize a special section of this class, in which the corresponding course was specifically *tailored* towards students from this very major. This tailoring improved the understanding of the material.

Groups

Most of the classes were taught in two parts:

- a big lecture for the entire class, and
- additional (closed) labs for smaller *groups* of students (usually, 15–20).

To accommodate this, all the incoming full-time students were divided into *groups* of 15–20 students in each.

Students were assigned to the same group for all classes, with a few exceptions such as:

- *foreign language*, where division is by language and by mastery level;
- *physical training*, where division is by sport and by mastery.

Similarly, work-study students were also divided into groups.

How to Divide Students into Groups

Division into groups is very important: students in a group study together, help each other. As a result, much thought was given on how to divide students into groups.

Some students came to the University from a special university-sponsored advanced boarding high school, where they studied together. These students were already accustomed to working together, so they were usually placed into one group.

Other students were distributed *uniformly*, so that each group would contain:

- approximately the same proportion of A, B, and C students,
- approximately the same proportion of male and female students, etc.

Group Advisors

To each group, three advisors were assigned:

- two *doctoral student* advisors, and
- a *faculty* advisor.

Graduate student advisors spent a few hours every week with a group. Their main duty was to teach the group learning skills, to provide advise on how to study and to relax best. Everyone benefited from this arrangement:

- advisees got help;
- advisors gained pedagogical experience – and they enjoyed being treated like gurus with infinite wisdom.

Since the student time was very regulated, advising was regulated as well: every doctoral student was required to be an advisor, with a (Pass/Fail) grade every semester.

A *faculty advisor* was usually advising several groups. Once in a while, a faculty advisor met with the group and/or with individual students. The main duty of a faculty advisor was to handle conflicts or emergency situations that required the authority of a professor.

Main Function of a Group: Study

The main function of the group was to *study* together. Due to tough initial selection, usually, most of the students had the *potential* and the background to succeed. In *practice*, however, in each subject, some students were somewhat ahead and some were somewhat behind. Students who lag behind slow down others. To avoid this problem, members of the group were supposed to spend some time together and *help* each other within small *study groups* of 2–5 students. This arrangement was beneficial to all the students:

- helpers improved their knowledge;
- helpers got help in other subjects and in other parts of the material.

Special self-study weekly periods were allocated for this mutual help. Group advisors supervised and helped to structure mutual help sessions.

This study was especially important, since in advanced classes, professors rarely followed textbooks. Thus, *notes* taken by students were extremely important. Although attendance was required (only straight A students got a special permission to study on their own and spend the saved time for early entrance into the world of research), once in a while a student would have to skip a class or two. In this case, he could always rely on the notes of other students from his small study group.

A Group as an Exercise in Self-Government

In addition to *studying*, a group was supposed to be an exercise in *self-government*.

Students elected several representatives:

- a group leader,
- an academic leader,
- a political information leader,
- a cultural leader, etc.

The variety of positions and yearly re-elections allowed *practically all* students to practice leadership skills by using their personal skills and preferences. This leadership experience helped those who went towards their Ph.D. to become successful group advisors. (And, of course, those who really had strong leadership skills could run for election in the Departmental or University-wide student bodies.)

A group had a strong degree of self-government. For example, in general, the rule was "one strike, you're out": one F means out of school. F's did happen: personal problems, bad luck, laziness, ill-

nesses. Whether to give a student a second chance was up to the group. After all, the group worked with the student all semester long, they know him the best:

- If they saw that she really tried, they usually recommended her to stay, and by this recommendation, implicitly agreed to help her if needed.
- On the other hand, if he was simply goofing, they usually recommended his expulsion, because they did not want to waste time on helping a person who does not want to study (and besides, they knew very well that there are work-study student willing to study hard and eager to take a place of a goofing student).

Another example of a self-government was to resolve (rare) conflicts between their own students – at least give it a first try. If the group could not resolve the conflict, then the higher authority (usually, a faculty advisor) could use not only the "he said – she said" rumors, but the opinion of the group.

Not Nerds

A lot of effort was made not to let students become nerds. For example, one of the duties of a *cultural leader* was to organize group parties and participated in the organization of University-wide parties. The University usually gladly allowed the students to use its facilities and dorms.

The University also had special agreements with local professional theaters so that students could get affordable discount tickets; these tickets were usually distributed via the cultural leaders. On top of that, the university environment means the poetry evenings, the University theater, etc., a large number of cultural events for which the cultural leaders served as a promotion network.

The main responsibility of a *political information* leader was not to let students forget that there is a world outside the department.

For that, the leader prepared a short weekly 5-10 minute oral news reports whose main idea was:

- not only to *inform* about the current events, but
- ideally, to make students *interested* in these news.

Usually, one of the humanity classes reserved a few minutes every week for this information. Alternatively, a few minutes were reserved during scheduled study sessions.

For this same purpose, political information leaders help to design and post department-wise newspaper-type news digests.

From Study to Research: 3-Tier System of Seminars

Staring from their freshman year, students were encouraged to attend research seminars. There were three types of seminars.

First, there were formal seminars, to present published or publishable results. The main goal of a seminar was to understand 100%. The main way of achieving this goal was to ask questions. These questions were encouraged the seminar leader. One of the major tasks of the seminar leader was to *ask questions* until the point becomes crystal clear. These seminars benefited both the speakers and the students:

- presenters improved their papers before submission;
- students learned state-of-the-art research results – and also learned the difficult art of understanding (and of asking questions).

What the students did not learn on these seminars was what was behind-the-scene of the glamorous results. This behind-the-scene was learned on seminars of different type: *working seminars.* In *working seminars*, a group of researchers regularly got together to work on open problems. At working seminars, students started with presenting papers assigned by the seminar leader, and eventually, progressed to presenting their own ideas and results.

Starting from the junior year, a student was *required* to *attend a seminar* every semester, to make a presentation there, and to get a *credit* for it from the seminar leader. After attending a few seminars, a student was required to choose an area for his or her Master's thesis.

Finally, there were regular *interdisciplinary* seminars, in which people from different disciplines presented their results. These seminars provided a unique opportunity to learn about research in other disciplines and to progress in interdisciplinary research. Many important ideas originated on these seminars.

From Study Groups to Research Groups

At the beginning of their senior year, students selected a sub-discipline within their major, sub-discipline which would be their main research direction. As a result, students rearranged themselves into new (research-oriented) groups. These students already knew each other from attending the same working seminars.

In these new groups, students: not only studied together, they also *helped* each other *do research*, with a seminar faculty leader taking the role of a faculty group advisor. Students with more experi-

ence in this area play the role of student advisors.

Required Department-Approved Internships

One semester internship is required. A work plan has to be approved by the Department, to ensure that students actually learn something new. There were two types of internship:

- paid internships at companies;
- (largely un-paid) highly competitive internships at top research centers; selected students still get their stipends from the University.

Real-life experience helped the students understand the real-life problems, and helped motivate them in studying different subjects – by showing that these subjects are of actual practical use. Besides, interning for a company improved the student's chances of getting hired by this company.

Additional Income for Students

For full-time students, their main income was their stipend. Paid internships provided additional income. One more source of income was summer jobs. There was an incentive for companies to hire students for summer jobs because they got substantial tax exemptions for that.

We are Currently Trying to Use this Experience

In our Computer Science Department, we use the following innovative teaching techniques partly motivated by the Russian experience:

- the active use of *student groups* (in which students study together, help each other, and do research together);
- the use of *clusters* of inter-related courses instead of more traditional independent courses;
- the use of *recitation sessions* (semi-lectures, semi-labs) taught for small groups of 10–15 students in addition to standard lectures; and
- regular *seminars* on which students are encouraged to referee papers and to present their own results; attending a seminar is now a requirement for incoming Computer Science students and their report of what they learned on two seminars per semester is a part of their grade.

All these ideas seem to lead to very good results, in terms of:

- improved educational results of the participating students,
- larger interest in research, and
- (last but not the least) improved student interest in Computer Science and their self-esteem.

Important Appendix: Who Pays?

Companies interested in the department's graduates paid money to the University (via the state budget). This money covers part of the university budget and the students' stipends. The main benefit to the company was that the company was guaranteed to get a certain amount of graduates. Specifically, a student was contractually obligated to work for a university-assigned company for a certain amount of time (usually 3 years).

However, a company was not obliged to hire any graduate. If a graduate could not find a job, the University was required to continue training him and paying him a stipend until he found a job. Of course, this created problems because this system required long-term planning and commitments. The solution to these problems was to institute periodic flexible changes in degree plans when market demanded changes. For example, one year before one of us (V.K.) started studying at the Math Department, the University realized that there were not enough jobs for pure mathematicians, so all the Math students received a minor in Computer Science.

These arrangements are not that easy to emulate. We are currently trying our best to get in contacts with different companies, and we have pretty good relationships with many of them.

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