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

Vladik Kreinovich\textsuperscript{1}, Olga Kosheleva\textsuperscript{2}, and Ann Gates\textsuperscript{1}

\textsuperscript{1}Department of Computer Science and \\
\textsuperscript{2}Department of Teacher Education
University of Texas at El Paso, \\
El Paso, TX 79968, USA

emails vladik@utep.edu, olgak@utep.edu, agates@utep.edu
1. Synopsis

- **Fact:** many internationally renowned scientists have been educated in the former Soviet Union, especially in mathematics, physics, and computer science.

- **Reasonable conclusion:** many features of the Russian education system were good.

- **Session objective:** to (briefly) describe the features that we believe to have been good:
  
  - 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.
2. Motivations and Clarification

• *Why Russian experience:* two of us have been educated in Russia.

• *This is not a comprehensive survey:*
  
  – we omit all the features that we we consider bad (and there were many), and
  
  – 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 session will be useful.

• *Main objective:* 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.
3. 3-Tier System of Students

- Based on (mostly discipline-specific) tough entrance exams, accepted students are divided into 3 tiers.
- The best students are accepted into a *full-time* program:
  - state supported through stipends (kept as long a certain GPA is maintained);
  - needy students and students with good GPAs get an extra stipend;
  - free dorms or University-mediated and -subsidized room rental;
  - fast track.
- Second tier: *work-study* students:
  - work full time;
  - attend special evening classes;
  - take longer to graduate;
  - best work-study students move to full time status.
- Third tier: *distance learning* students:
  - receive handouts, assignments, and comments by mail,
  - every semester, a month-long on-campus crash course to solidify their knowledge before the finals;
  - take even longer to graduate.
- Same material in all tiers, but employees prefer full-time (smartest) students.
4. Clusters and Groups

- **Before the senior year**: pre-determined sequence of classes (*clusters*), 6 hours of classes weekday and Saturday, a lot of homework.

- **After the first three years**: students choose a *specialization*, after which they get more freedom in choosing their schedules.

- **Main advantage of clusters**: ability to *correlate* different courses taken at the same time.

- **Example**: when physics and calculus are taken at the same time, mathematical and physical aspects of derivatives are taught simultaneously and help students relate different areas.

- **Additional advantage of clusters**: special sections of, e.g., physics *tailored* towards CS students; this tailoring improves the understanding of the material.

- **Groups**: most classes are 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 are divided into *groups* of 15–20 students in each.

- Students are assigned to the same group for all classes, exceptions:
  
  - *foreign language* (division by language and by mastery level); where students are divided into *different* groups:
  
  - *physical training* (by sport and by mastery).
5. **How to Divide Students into Groups**

- *Division into groups is important:* students in a group study together, help each other.

- *Result:* much thought was given on how to divide students into groups.

- *Two types of groups:*
  - an *advanced* group, mostly students who graduated from a special University-supported boarding school;
  - other groups, to which 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.
6. **Group Advisors**

- To each group, three advisors were assigned:
  - two *doctoral student* advisors, and
  - a *faculty* advisor.

- **Graduate student advisors:**
  - *time spent*: few hours per week;
  - *duty*: teach learning skills, providing advise on how to study and to relax best.

- **Everyone benefits:**
  - advisees get help;
  - advisors loved the chance of being treated like gurus with infinite wisdom.

- **Requirement:** every doctoral student is required to be an advisor, with a (Pass/Fail) grade every semester.

- **Faculty advisor:** advises several groups.

- **Main duty:** handle conflicts or emergency situations that required the authority of a professor.
7. **Main Function of a Group: Study**

- **Potential:** due to tough initial selection, most students have the potential and the background to succeed.

- **In practice:** in each subject, some students were somewhat ahead and some were somewhat behind.

- **Problem:** those who lag behind slow down others.

- **Solution:** members of the group semi-voluntarily help each other in small groups of 2-5.

- **Motivation:**
  - helpers improve their knowledge;
  - helpers get help in other subjects and in other parts of the material.

- **Time management:** a special self-study weekly period is allocated for this mutual help.

- **Group advisors:** help structure mutual help sessions.
8. A Group as an Exercise in Self-Government

- **Elected positions:** each group elects, every year:
  - a group leader,
  - an academic leader,
  - a political information leader,
  - a cultural leader, etc.

- **Leadership opportunity:** variety of positions and yearly re-elections allow all students to practice leadership within their personal skills and preferences.

- **Higher leadership:** there are also elected readers at Department-wide or University-wide student bodies.

- **Example of self-government:** a group decided on whether to give a student with low GPA a second chance.

- **Reason:** the group worked with the student all semester long, they know whether he or she is doing one’s best – and they will be the ones to help the student if this student stays.

- **Another example:** resolve (rare) conflicts between their own students – at least give it a first try.
9. **Not Nerds**

- Much effort was made not to let students become nerds.

- A group’s *cultural leader*:
  - organizes parties;
  - promotes (and distributes student-oriented free and discount tickets to) cultural events at the University and in town;
  - promotes active participation in University-wide events such as poetry readings, talent competitions between groups, etc.

- A group’s *political information* leader:
  - prepares short weekly 5-10 minute oral news reports – usually, in the appropriate humanity-oriented class; layer, during scheduled study sessions;
  - purpose: not only inform, get students interested;
  - helps in designing and posting department-wise newspaper-type news digests.
10. From Study to Research: 3-Tier System of Seminars

- **Formal** seminars present published or publishable results.

- **Main objective**: understand 100%.

- **Method**: ask questions; enhanced by seminar leader.

- **Benefits**:
  - presenters improve their papers before submission;
  - students learn state-of-the-art research.

- **Working seminars**: a group of researchers regularly get together to work on open problems. Students:
  - start with presenting a paper that the seminar leader assigns, and
  - eventually, present their own results.

- **Interdisciplinary** seminars provided an opportunity to learn about research in other disciplines. Many important ideas originated on these seminars.

- 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.
11. From Study Groups to Research Groups

- During their senior year, students rearranged themselves into new (research-oriented) groups.
  - In these new groups, students:
    - not only studied together, but
    - they also *helped* each other do research,
  with a seminar faculty leader taking the role of a faculty group advisor.
- Students with more experience in this area play the role of student advisors.
12. 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.
- 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.
13. Additional Income for Students

- **Main income**: stipend.
- **Additional income**: paid internships.
- **One more source of income**: summer jobs.
- **Incentive**: companies that hire students for summer jobs get substantial tax exemptions.
14. We are Currently Trying to Use this Experience

Innovative teaching techniques that we use:

- 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.

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.
15. **Important Appendix: Who Pays?**

- *Companies pay:* companies interested in the department’s graduates pay money to the University (via the state budget).
- This money covers part of the university budget and the students’ stipends.
- *Benefit to the company:* a company is guaranteed to get a certain amount of graduates.
- *How:* a student is contractually obligated to work for a university-assigned company for a certain amount of time (usually 3 years).
- *University’s incentive:* if a successful graduate is deficient in skills and cannot find a job, the University is required to continue training him and paying him a stipend until he finds a job.
- *Problem:* requires long-term planning and commitments.
- *Actual solution:* flexible change in degree plan when market demand changes.
- *Actual example:* minor in CS for all math majors.