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

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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.