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Teaching Physics in America

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Cross-disciplinary

Differences in Physics education in Russia and USA were identified and discussed. Challenges experienced by students in each country were compared. Road of adjusting to a new teaching environment and new student's type was described. Long term advantage of student's exposure to diverse teaching methods was established.

Poster

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Teaching Physics in America

Ten years ago I immigrated from Russia to the USA. My background is research in Molecular Spectroscopy and Optics. I also have experience teaching graduate level courses of science and engineering.
During my first 5 years in America I worked as an Adjunct Instructor and
was lucky to be exposed to different types of the student population. Some students were recent public high school graduates attending Tulsa Community College, others were ambitious petroleum engineering students attending University of Tulsa, while still others were humble, tired, working adults trying to get their college diploma taking evening classes at Rogers State University. Finally I was hired at Oral Roberts University (Tulsa, OK) to teach Physics to pre-med students and Optics and Thermodynamics to Engineering students.

My first year of teaching was very difficult for me and my students.
I did not realize how large the difference is of the knowledge of math, science and physics between Russian and American high school graduates.
In Russia children are required to learn math in elementary school and progress over the years until at graduation. Similar situation occurs with physics. Students are required to start to learn physics in the middle school and spend at least 5 years covering the topics of Mechanics and Modern Physics.

All Programs and textbooks are unified through out the country and approved by the Ministry of Education. Exams are mandatory for math at the end of each year. Physics Exams are required in order to get a High School Diploma. (www.school.edu.ru ; www.edu.ru) Those students who do not want to go to college after middle school enter technical schools where they are still required to finish a General High School program in addition to learning a trade skill. Children gifted in certain areas go to specialized schools such as math/physics schools, foreign language schools, sport schools, and literature and cultural schools.

It is much easier to teach physics at the university level in Russia because all students, no matter what their background, are exposed to the same curriculum in high school. In the USA, 80% of high school graduates have never taken a physics class and their math skills are very limited. Many students do not know basic math rules such as order of work or bracket sequence not to mention elementary algebra and trigonometry. Existing educational standards, including science standards, are not mandatory (www.nap.edu/html/nses). Some schools do not offer physics classes at all due to a variety of reasons such as absence of certified teachers in this subject or poor level of preparation of existing teachers. Low salaries are not helping to attract new teachers

(specifically males) and lead to the migration of experienced teachers to better paying industrial positions. Emergency Certification of biology teachers allows them to teach physics classes but seems to me a very strange choice. It seems more logical to certify math teachers to teach physics. In better schools where physics classes are offered, students usually have a choice of what science class to take, biology, chemistry or physics. The majority prefer to study biology or chemistry which are considered easier subjects. High school physics courses lasts only two semesters and do not include Modern Physics.

Another problem stems from the use of multiple choice questions on tests. Multiple choice questions definitely make grading much faster but allow student to "gamble" with the answer. A person with normal "common sense" knowledge can make a "C" on most multiple choice exams without reading a textbook. This makes it very difficult to measure a student's true skill level and I believe also leads to poor tests taking skills.

I made a lot of changes after teaching my first semester of physics. First I started to spend at least 1 to 2 lessons in the beginning of the course entirely on math skills. I try to use a lot of examples and demonstrations from everyday life. I try to engage students in actively thinking aloud about main concepts and particular conceptual questions.

The main challenge for my students was to learn not to be afraid of making mistakes. Naturally the majority of my students did not want to look "foolish" in the eyes of their pears and prefer to be passive in class. They do not expect to be put "on the spot" as pupils in Russia or Europe are when they take turns answering the teacher's questions or solving problem at the board in front of the whole class.
My best students are usually "homeschoolers". I think there are several reasons for that:
1. Parents play active role in child's education confirming the importance of studying.
2. Students know how to work with the textbooks, do information searches, and prepare homework regularly. They read for themselves actively and analytically.
3. Most of the time students studied individually and learned to relay on themselves and not wait for somebody else's answer.
4. They are much more disciplined, more diligent, pay better attention to the task, and have better time management and prioritizing skills.
5. They are use to being tested on a regular basis.

As a teacher, I am lucky with a type of students in my class. The majority of them are in a pre-med program and need physics to pass MCAT exam to enter medical school. Their motivation is extremely high in comparison with students for whom physics is just a degree requirement. They must understand the subject concepts and memorize all formulas in order to pass the MCAT exam. They try really hard to do all assigned work. This is quite challenging for me. I spend many extra hours in one-on-one and group tutoring. Very often I have 5 to 10 students in my office doing different assignments. At

the end of the day I feel completely exhausted but I am happy to see this great desire to learn. It is much better than indifference. I usually see results of our mutual hard work by the end of the first semester. Students who at the beginning of the semester could not solve simple equations are now doing comfortable with the algebra required to understand and solve most physics problems. They have learned to pay much more attention to the details for example, remembering to convert units, draw needed diagrams, identify physical principles, identify the known and unknowns, select proper equations, solve them for the unknown quantities and do a "reality check" (Is the answer reasonable?). In the beginning, very few students could conduct "common sense" checking of the result and I am very pleased with their progress in the area of logic, reasoning and critical thinking by the end of the semester.

Low level of exposure to math and science in public school systems results in a low amount of students entering colleges or universities to pursue careers in science or teaching science. According to Oklahoma Site Selecting Magazine (www.siteselection.com) Oklahoma Engineering graduates satisfied a small part of industry needs.
The lack of certified science and math teachers according to USA Today magazine is a growing problem for schools around the nation, particularly those in poor neighborhoods (http://www.usatoday.com/tech/science/2006-01-29).

This was not so noticeable in the past because we still had an older generation of "baby boomers" in the workforce but they are about to retire in 5-10 years. Two powerful sources for filling empty positions in science, which worked for decades, were the immigration of specialists from India, China and Eastern Europe, and, foreign students who stayed in the USA after graduation. More than half the engineering degrees awarded by the nation's universities are given to foreign-born students (www.nasonline.org). Unfortunately the situation changed in recent years due to: (a) economical challenges in America causing a reduction of jobs offers and, (b) foreign countries have become aware of the large scale of "brain drain" and have made big changes in student and specialist's retaining.

Taking into account the tremendous need for Engineering/Science specialists in the USA, we must make these occupations more attractive for our younger generation. Preparation of new physics teachers for the public school system must become a priority for colleges and universities. We need to encourage more students to become physics teachers by making teaching jobs more prestigious and attractive financially. There are some efforts being made on both the national and local levels to improve this situation. In Oklahoma for example Tulsa Public Schools this year gave; (a) 10 rent free apartments to new teachers who agreed to move there, (b) educational loans will be reduced considerably or paid off, depending on amount of years served, for those graduates who teach in low income districts schools. My university (ORU) "adopted"

several distressed local schools where ORU faculty members give monthly science lessons with experimental demonstrations. Our Engineering Department together with other local universities (TU, OSU, and OU) present a two week science course in Union High School as part of a physics curriculum.
On the national level, Physics Teacher Education Coalition (PhysTEC) was formed "To improve and promote the education of future physics and physical science teachers" (http://www.phystec.org). They offer annual conferences and numerous workshops for the teachers on all levels. They give grants and scholarships to schools, colleges and individual students.
To help existing teachers to improve their teaching skills, a web-based system Pathway (http://www.physicspathway.org) was created by NSF Teacher Professional Continuum Program and NSF's National Science, Technology, Engineering, and Mathematics Education Digital Library Program under several grants. It is an extremely useful program which allows any person from their home, at their convenience, to ask questions about physics teaching to leading expert teachers. It is giving teachers access to a video digital library, latest publications and abstracts, useful links, and Power Points for different topics in physics. Unfortunately, this site is still under reconstruction.

Major Publishing Companies (Pearson, McGraw Hill, Prentice Hall, and Houghton Mifflin) provide great supplemental materials for users of their textbooks and organize web seminar for the teachers to improve their pedagogical and technological skills. In recent years numerous tutoring self paced websites have become available: Physics 24/7 (http://www.physics247.com); Dive into math and Science
(http://www.diveintomath.com); Science Tutor (http://www.science-tutor.com), and Physics Tutor (www.physicstutor.org).
I like www.cramster.com which gives access to huge amounts of problems from different textbooks and teaches you step by step how to solve them.
President's Barack Obama emphasized the importance of education for our children. As part of the American Recovery and Reinvestment Act he plans to invest heavily ($165.6 billion dollars) in education as a way to provide jobs now and lay the foundation for long-term prosperity. "Providing a high-quality education for all children is critical to America's economic future. Our nation's economic competitiveness and the path to the "American Dream" depend on providing every child with an education that will enable them to succeed in a global economy that is based on knowledge and innovation.
Teachers are the single most important resource to a child's learning. Educational reform will: (a) ensure that teachers are supported as professionals in the classroom, (b) invest in innovative strategies to help teachers to improve student outcomes, (c) use rewards and incentives to keep talented teachers in the schools that need them the most, and (d) invest in a national effort to prepare and reward outstanding teachers, while recruiting the best and brightest to the field of teaching" (http://whitehouse.gov). As one of the ways to achieve the above mentioned goals it has been suggested to increase the number of hours children spend at school, both by lengthening the days themselves and by

shortening vacations to extend the school year. President Obama said, “American kids spend too little time in school; putting them at a disadvantage with other students around the globe. Now, I know longer school days and school years are not wildly popular ideas… But the challenges of a new century demand more time in the classroom." In America a school year last 180 days compared to Japan’s 243 days (via MSN Encarta). The President’s suggestion is a 200 day school year as in Scotland, Netherlands, Thailand and Russia.

Other suggestions are to make tougher unified academic standards and testing (USA 8-th grade curriculum is 2 year behind competing nations). As a result of changing testing standards in many Oklahoma schools the performance in reading and math among students of all ages dropped by one letter grade (www.tulsaworld.com).

Politicians and business leaders say this isn't just about education — it's about global competition. “Competent and engaged teachers are needed to inspire American children to pursue a career in math or science. If it doesn't happen, the United States' role as leader in technology development and scientific research will wither. We've got to have kids that are the best in science, engineering and math. Otherwise, jobs are going to go to where the workforce has those skills." "The way we keep our jobs from going to China and India is to keep our brainpower advantage in science and technology," said Sen. Lamar Alexander, R-Tenn., who served as education secretary in the early 1990s. Alexander is a prime sponsor of a bipartisan bill, Protecting America's Competitive Edge that would spend billions on scholarships and training programs to boost the number of math and science teachers.