The Selection and Preparation of Mathematics Teachers

Teacher preparation is a vital component of any educational system. Evidence from research shows that there is a 39% difference in the achievement levels of students who have most/least effective teachers. The federal government also recognizes the importance of the classroom teacher. The recent No Child Left Behind legislation emphasizes the role that teachers play in achievement. In order to meet the requirements of NCLB, states and universities will have to change the way that teachers are prepared.

Carefully selecting and properly training teachers and then giving them the authority to teach students as they see fit will go a long way to resolving the low achievement of American students. On the flip side, giving low ability and poorly trained individuals the opportunity to teach has produced several decades of low student achievement. Many of these academically unmotivated teachers demonstrate little content knowledge or curiosity and have been among the most flagrant violators of scientific application of educational research. Witness the indiscriminate use of trivial tests (learning styles, right/left brain, multiple intelligences, etc) that pretend to classify students in scant minutes. Worse still is that the learning theory behind these fads may in fact be even more suspect than the test. The current generation of American teachers firmly believes that lecture is a universally poor method of instruction, standardized tests are fatally flawed and the group learning is much superior to individual learning, all without scientific justification.

If America is to close the achievement gap with other industrialized nations it must be willing to set aside political correctness and educational faddism to place competent teachers in the classroom. There is constant pressure for education departments to find new pedagogy, criticize the old pedagogy and generally churn the academic waters so that their existence can be justified. Teacher preparation programs need to focus on only those aspects of educational research which have been proven to produce achievement gains and stop experimenting on prospective teachers and their dependent students.

The primary reason I am pursuing a doctoral degree in mathematics education is to have the credentials needed to teach mathematics pedagogy courses to prospective teachers at a four year institution. I feel strongly that my experience as a teacher and the intellectual training I am now acquiring will let me
make a positive contribution to the cause of producing competent teachers.

The area of teacher preparation is being extensively researched and is currently a high profile issue in education. Much new research is being and will be conducted in response to the NCLB legislation. The NCLB legislation mandates that by the end of the 2005-2006 year all teachers in core academic subjects be highly qualified. The core academic subjects include virtually all teachers with the exception of vocational instructors. Although some flexibility is allowed by individual states it is certainly true that school districts will have to pay more attention to the qualifications of teachers. Unfortunately most districts will leave these decisions in the hands of the state certification bureaucrats who are driven by economic rather than educational data.

As a result of this governmental pressure there is no shortage of research papers published by the government and other groups in research periodicals, books and the Internet. I have chosen a mix of federal and state government sponsored papers, private research articles, books, and the materials that were discussed in MATH 791 to address the topic of teacher preparation.

If the validity of educational research is to be established in the minds of American citizens it must provide useable information. In this paper I will attempt to discuss briefly what I have found current educational research has to say about the following four areas of teacher preparation. An area that is of much interest and holds great promise for improving and strengthening mathematical teaching involves the support and in-service given to teachers once they are in the field. That topic is beyond what I will address in this paper.

1. Initial Selection of Teachers
2. Pedagogical Preparation of Teachers
3. Content Preparation of Teachers
4. Non-educational Forces Shaping Teacher Preparation Programs

The first three areas address the larger portion of what needs to be considered in teacher education programs. The fourth area discusses some of the limiting pressures that will bend the design of teacher education programs in ways that defy good practice. While these are surely deplorable they also reflect realities that cannot be easily altered.

The quality of teachers is an issue of growing importance. The issue is also becoming legally charged as parents realize the effect that a poor teacher has upon their students. Districts with high poverty rates are pressing the issue of why they must endure a poorly qualified staff. Parents of gifted students are also
realizing the potential that is being wasted when their children do not receive the stimulation of a qualified instructor.

Initial Selection of Teachers

An issue that education seems to be avoiding is the initial selection of individuals to receive teacher preparation. Currently anyone who “likes” children and wants to be a teacher is assumed to be a good candidate for teacher preparation. Notice that this is not the same as liking “mathematics”, “history” or some other content area. There is solid evidence that this criterion is not a good one. Studies have shown a significant positive relationship between teacher ACT scores and student achievement. Teachers’ verbal scores are also positively correlated with student achievement. The correlation between student achievement and teacher ability is stronger than most other measures of teacher qualification that are assumed to be important. It is stronger than the pedagogical background of teachers, the number of advanced degrees a teacher holds, or whether a teacher is certified or not. Studies have shown that higher ability students are less likely to enter teaching and more likely to leave during teacher preparation or after teaching for but a few years. High ability teachers have a solid positive effect on students but their supply depends on getting high ability students into the teacher preparation programs. There is also the long term effect of low ability administrators as a result. Most of these administrators come from the teaching ranks as they properly should, but since the ability bar was so low to enter teaching we are by default admitting large numbers of unskilled administrators into leadership positions.

Currently schools do not want and make no attempt to hire high ability teachers. I have held several secondary teaching positions during my career and never once was my academic background questioned, my portfolio of accomplishments evaluated, or my content knowledge tested. Schools instead relied upon references, certifications, coaching ability, college affiliation, or a firm handshake to decide whether I was a suitable teacher. Only when I became a college instructor was I asked to actually demonstrate teaching ability and content knowledge to the individuals that would decide whether to hire me.

Liping Ma’s observations of teachers clearly indicated vast differences between teachers in China and teachers in the United States. To assume that these differences are the result of only better preparation and teaching arrangements seems too much to believe. After reading the insightful and interesting comments made by the Chinese teachers I cannot believe that their selection process is as weak as ours. Chinese teachers may have come to teacher preparation programs from the ninth grade but their ninth grade is equivalent to slightly more than twelve years of school by our time standards. The time spent in serious mathematics classes is also much longer as mathematics is studied each year for all students. Considering that perhaps only 50% of Chinese
students enter high school and we sent over 70% of our students to college (where teachers are drawn from the bottom of that 70%) it seems reasonable to conclude that the Chinese system is much more ability restrictive than the American method.

Pedagogical Preparation of Teachers

I will borrow from Alan Schoenfeld’s work to define general pedagogy as those learning theories that are for the most part domain-independent. These would be principles that would apply to all students regardless of what subject they happen to be studying. Teaching this type of pedagogy currently absorbs a large portion of teacher preparation programs. Exactly how general pedagogy affects student learning is unclear. This is largely because there is no data that separates and correlates general vs. mathematical pedagogical content to student achievement. Studies do show that there is a small positive correlation between traditionally certified teachers and student achievement and a small negative correlation between alternatively certified teachers and student achievement. Very interesting are studies that show that institutions that have a low proportion of education majors and a low proportion of the institutional budget devoted to education produce teachers that score better on certification tests. Problems with these studies include using certification as a measure of general pedagogical preparation when the programs are so very different from university to university and state to state. Other problems with these studies are the relatively small set of alternatively certified teachers and even more problematic is the fact that these studies are done by institutions of education and thus are biased by an obvious conflict of interest.

My hope is that mathematical pedagogy as partially described by Lee Schulman will be one of the keys to good teacher preparation. Mathematical pedagogy is that body of material that specifically relates to theories of mathematical instruction, methods of teaching mathematics, attitudes toward mathematics, and knowledge of mathematics not usually considered as mathematical content. I would include the specific knowledge needed to teach individual topics in mathematics. This type of knowledge would involve items like knowing how to explain why division by zero is incorrect, the best known examples of ways to teach specific topics (like the Chinese teaching books), historical anecdotes and examples, identifying and correcting common types of mistakes and hundreds of other items an experienced teacher learns over time. This knowledge is not infinite in scope and can be taught if more time was given to mathematical pedagogy courses.

I believe that Liping Ma’s work shows that mathematical pedagogy is far more important to student achievement than general pedagogy. Teachers in China did almost everything considered archaic by American standards (presentation by lecture, strong discipline, individual work only, etc.) and yet
produce high achieving students. Most teacher preparation programs and certainly the ones myself and teachers of my generation went through relegated mathematical pedagogy to a single methods course. Interestingly enough most of my colleagues would rank this course along with student teaching as the most valuable experience in their teacher training program. The material covered in Polya’s How to Solve It (heuristics) is of much more use to teachers than general pedagogy.

Student teaching involves practical application of both general and mathematical pedagogy. It is certainly the most important test of a prospective teacher’s ability to apply what has been learned during the years of preparation.

Content Preparation of Teachers

Subject matter preparation is not the same thing as mathematical pedagogy. There is clear evidence that teacher knowledge of content is positively related to student achievement. The wrong conclusion to draw is that more is always better. There is reason to believe that demanding extensive content knowledge from teachers that do not teach advanced mathematics has no beneficial effect on student achievement. Time spent covering advanced material would be better spent learning the material they will be teaching in greater depth. Advanced degrees do not correlate strongly with any group except secondary mathematics and science teachers.

Some of the decisions about how much content prospective teachers should learn have been taken from educational and state departments by the NCLB legislation. The NCLB has specific standards which aim to place a highly qualified teacher in each classroom. This is certainly a step in the right direction because it focuses on content knowledge instead of general pedagogical training. Education departments dislike the NCLB legislation because it implicitly assumes that traditional education certification with its heavy emphasis on general pedagogical training has failed to produce effective teachers. NCLB has reinforced this assumption by advocating alternative paths to certification.

Non-educational Forces Shaping Teacher Preparation Programs

Society and government place many restrictions on the scope and type of teacher preparation. A school of education’s desire to remain autonomous and resist change dictated by state departments of education will not prevail. An example of this is the unsuccessful attempt by the University of Wisconsin-Madison’s to resist change mandated by state agencies.

The cost of the preparations must also be bearable by both the institution giving the instruction and the student receiving the preparation. In addition the
requirements for certification must also be liberal enough or the financial and lifestyle rewards high enough to attract a sufficient number of teachers into the field.

An unintended consequence of unwise use of educational dogma is the expectation by the public that there are only a series of specific problems that hinder a child’s learning and that these are reasonably understood (after all they have names don’t they?) by educational professionals. These expectations have increasingly been codified into law (NCLB, special education laws, etc.) and now present huge problems for school districts nationwide. After believing what colleges of education and professional education organizations have been telling them for decades schools find themselves in court suing for the right to remove special education children from the testing required by the NCLB legislation. It appears that all children cannot achieve at anywhere near the levels that NCTM optimistically set forward.

Although there is a significant correlation between graduates of five-year programs and retention of teachers and their job satisfaction it appears unlikely that these programs will become the norm in fiscally troubled times. Again there is the tension between the costs of ideal programs and doing what is correct educationally.

Application

All teachers must first be selected on the basis of academic quality. Reasonable requirements would be minimum ACT/SAT scores that compare favorably with other professional degrees. To allow individuals who are not capable of learning deeply to continue to fill teaching positions will doom all attempts at reform. This is especially true in mathematics.

Ideally mathematics would be taught by specialists in mathematics at all levels. We blur the picture when we consider teacher preparation for all types of teachers and do not focus specifically on the preparation of mathematics teachers. This might also help solve the problem of selecting mathematically talented individuals as presumably these individuals would enjoy mathematics for its own sake or they would not have pursued a mathematics specialist career. Economically this is not likely to impose any additional financial burden on school districts, but would require a rethinking of how students are taught in the elementary school. Schools routinely provide specialists in music and art so doing so in mathematics is certainly feasible.

The content needed by these mathematics specialists would vary according to the level they would be teaching. Elementary specialists should not be trained as mathematicians or general teachers but their degree should consist of courses that demand deep understanding of the material they will be teaching.
supplemented by intense preparation in mathematical pedagogy. There is little need for these teachers to take mathematical content courses beyond a year of Calculus. Middle school and high school mathematics specialists should have an undergraduate degree or advanced degree in mathematics and this should be supplemented by courses in mathematical pedagogy. These mathematics pedagogy courses should also contain strong links to physics, computing, and other disciplines that rely heavily on mathematics. Research needs to be done to determine the threshold of content knowledge for each level of mathematics teaching.

For all mathematics specialists a single course of general pedagogy would suffice to prepare teachers to use general principles of education. Teachers need to be trained in mathematical pedagogy and only slightly in general pedagogy. All mathematics specialists would be required to student teach in their area. The end of teacher preparation must be practical experience. It might be preferable and educationally sound to give prospective teachers an apprentice teaching experience before student teaching. This would be tremendously hard to adopt due to the scheduling and financial burdens that would have to be borne by the students and school districts.

There is no way to guarantee that any teacher preparation program would always turn out reliable and competent teachers. The best that can be achieved is to follow practices that increase the odds in favor of becoming a good teacher.
Bibliography


Schoenfeld, Alan, When Good Teaching Leads to Bad Results: The Disasters of the Well-Taught Mathematics Courses. Class packet.


Tobias, Sheila, They’re Not Dumb, They’re Different. Class packet.


Ball, Deborah, Unlearning to Teach Mathematics. Class packet.


Illinois State Board of Education. Illinois Criteria for Meeting the NCLB Requirements for Highly Qualified Teachers.
http://www.isbe.state.il.us/nclb/pdfs/highly_qualified_teacher_criteria.pdf.