EXCHANGING STATISTICS PEDAGOGY BETWEEN THE MASTER TEACHER AND THE FUTURE TEACHER

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Cal Teach is a science and math teacher preparation program modeled after UTeach at the University of Texas, Austin. Math for America (MfA), Berkeley, which is part of the national MfA effort, is a 5-year master teacher fellowship program for experienced math and science teachers. Both programs aim to prepare K-12 teachers to excel by strengthening their pedagogical content knowledge and their science content knowledge. We describe the role that statistics education plays in these two synergistic programs and make recommendations how aspects of these efforts might be more broadly adopted.

INTRODUCTION

In 2005 in the face of a critical shortage of trained math and science teachers, California Governor Schwarzenegger and University of California President Dynes joined forces and committed to training a new generation of science and math teachers. Up until this time UC Berkeley had no undergraduate teacher training program, but the science, math and engineering faculty were eager to help. They developed a program to prepare students with majors in STEM fields to become excellent science and math middle and high school teachers. A few years later, we began a second, complimentary effort: a five-year professional development program for highly talented teachers with at least three years of teaching experience. Together these two programs aim to raise the caliber of science and math K-12 education in the San Francisco Bay Area. In this paper, I outline the structure of these two programs, with a focus on statistics training and opportunities for interactions between current and future teachers. As the co-director of both programs and a statistics faculty member, I describe my involvement with these programs, and draw on my experiences to make suggestions for how to adopt key aspects of these programs elsewhere.

CAL TEACH

Cal Teach is part of a University of California system-wide program and the National Math and Science Initiative. Its main goal is to encourage and prepare science, engineering and mathematics undergraduates to pursue careers in mathematics and science teaching, particularly in urban schools. Cal Teach students simultaneously complete their full disciplinary STEM degree and earn their teaching credential. Math majors are required to take an introductory calculus-based statistics course that includes practice analyzing data with the statistical software R.

Cal Teach is an integrated program that allows aspiring teachers to develop both deep subject matter understanding and exemplary pedagogical skills. The program consists of a sequence of 8 STEM-oriented pedagogy seminars and courses, modeled after the UTeach program at the University of Texas, Austin. Importantly, science and math majors take these courses together, giving them the opportunity to share content knowledge and collaborate on projects and classroom lessons and activities. These courses are integrated throughout the undergraduate student's career giving the student an opportunity to participate in field placements that gradually increase in complexity and duration as he or she matures academically and as an educator. The program is fortunate to have a group of about 100 mentor teachers who welcome our students into their classrooms on a weekly basis.

The program begins with freshman and sophomore seminars that include field placements in local elementary and middle schools where Cal Teach students have an opportunity to observe a classroom firsthand and to prepare and carry out two or three short science or math activities. Seminar topics include inquiry-based pedagogy, assessment techniques, and lesson plan design and revision. I have co-led these seminars on several occasions, and include statistics activities adapted from Gelman and Nolan (2002) and Great Explorations in Math and Science from the Lawrence Hall of Science.

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The remaining six courses in the program range from research methods to history of science to how children learn math and science concepts. Statistics forms a substantial portion of the research methods course, which I developed with George Johnson, Professor of Engineering, and Elisa Stone, who holds a PhD in biology and taught high school science for several years. We closely followed a course designed by Michael Marder, Professor of Physics at UT Austin. In both versions of the course, students undertake four in-depth projects that include the design and analysis of a simple experiment, a student survey, and two more open-ended projects that can involve analyzing authentic data collected by researchers to answer an important scientific question or designing and conducting an experiment from scratch. Two basic aims of this course are to give students experience in developing scientifically sound laboratory activities and to provide them with the skills to bring research practices to bear on their teaching practice. Unlike the UTeach course, at Berkeley the students carry out their data analyses in R. Another difference is that the survey project is a whole-class endeavor where the class chooses a topic related to student learning; each student contributes questions to the survey, assists with the data collection and entry, and carries out an analysis of the survey results.

Lastly, the capstone course, called Project-based Instruction, has students design and carry out a multi-lesson project in an area of science that is inherently cross-disciplinary, such as earth science. It also typically involves data collection and analysis. Students take this final course in the sequence prior to applying for the credential and apprentice teaching.

The program is well aligned with the Common Core State Standards for Mathematics that calls for practice in applying mathematical ways of thinking to real world issues and challenges; emphasizes mathematical modeling – the use of mathematics and statistics to analyze empirical situations, understand them better, and improve decisions; and recognizes that when making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data.

MATH FOR AMERICA, BERKELEY

Math for America, Berkeley provides a five-year master teacher fellowship program for outstanding mathematics and science teachers in the San Francisco Bay Area. The program includes research into teaching practice, support for National Board Certification, a summer research experience at Berkeley, and teacher-leadership activities in the final years of the program. The program begins with a focus on research and individual practice and evolves to a more outward-looking approach. M*f*A Berkeley provides teachers opportunities to become effective mentors, coaches, professional development facilitators, and instructional leaders within their schools and districts.

The first year of the fellowship begins with an action research project motivated by questions about the fellows teaching practices, student learning and other educational issues. With its focus on building a community of teachers, this work provides an ideal structure within which a cohort of M*f*A master teacher fellows establish trust and camaraderie that lasts the duration of the fellowship and beyond.

In the summer between their first and second years, fellows enrich their content knowledge through a summer research experience working with STEM faculty on the Berkeley campus. They simultaneously develop an education transfer plan to incorporate aspects of their research experience into a lesson plan appropriate for their own classrooms. I have worked with two fellows over the summer. In both cases, the fellows enrolled in an undergraduate statistics course, the same one required of our future math teachers. Additionally, they analyzed data to address a question of interest to them. One fellow analyzed data from the Early Childhood Longitudinal Study by the National Center for Educational Statistics with an aim to study the relationship between student performance and student diversity in the classroom. This question was born from her classroom experience teaching different populations of students. The data are rich and complex and collected via a statistically sound design. I have since incorporated similar projects with these data into my undergraduate courses.

In the second year of the program, fellows pursue National Board Certification, a process that entails critical examination of and deep reflection on teaching and learning. In the third year, fellows participate in a teacher-on-loan program at UC Berkeley where they work with faculty in

their STEM discipline and in education to create a professional and leadership development program tailored to their needs and interests. There are an enormous variety of opportunities, including enrolling in upper division and graduate-level courses in math, science and education, participating in the Cal Teach program as co-teacher or field supervisor and joining research groups in the Graduate School of Education.

In the last two years of the program, each fellow assumes a leadership role in their school and district all the while continuing to improve upon their practice through workshops, conferences, etc. During this time, fellows meet monthly to share how their new strategies are working and discuss their opportunities for leadership as master teachers.

COMMON THEMES AND POINTS OF INTERSECTION

Cal Teach and M*f*A, Berkeley have much in common. Both have a significant focus on science and mathematics content. Both focus on applying research methods to continually improve teaching practice. Both aim to create teacher-leaders. Both take an inquiry-based approach to teaching math and science and are well aligned with the Math Common Core and the Next Generation Science Standards.

These programs have several points of intersection which enable the current and future teachers to benefit from and support each other. Over the first summer, some M*f*A fellows have the opportunity to be paired with a Cal Teach future teacher in a research lab. During their teacher-on-loan year, M*f*A fellows often co-lead a Cal Teach freshman or sophomore seminar, support an advanced course, or assist with field supervision. In this capacity they have the opportunity to mentor their junior colleagues. Throughout the five-year program, the M*f*A fellows regularly host Cal Teach students in their classrooms for field placements. Here the Cal Teach interns have the opportunity to observe and learn from the best teachers in the Bay Area. Likewise, these M*f*A master teacher fellows regularly tell us how beneficial it is for them to have these bright eager future teachers in their classrooms.

The two programs hold shared events that include opportunities to highlight each group's work. The graduation ceremony for Cal Teach students includes a poster session where first-year M*f*A fellows present their findings from their research into their teaching practice. At the semi-annual M*f*A Berkeley meeting, the Cal Teach graduates present posters on some aspect of their first or second year of teaching, and one breakout session is geared toward new teachers' concerns.

Cal Teach interns and M*f*A fellows jointly prepare and refine lesson plans for inquiry-based science and math activities, called Cal Teachables, and make them available for others to adopt and adapt.

RECOMMENDATIONS

My experiences with Cal Teach and Math for America, Berkeley have informed the following recommendations on ways in which teacher training programs, math and science faculty, and master teachers can facilitate meaningful statistics professional development for science and math teachers.

1. Statistics Training:

Future mathematics teachers are well served to take an introductory statistics course that integrates theory and application as part of their content preparation. Summer sessions on university campuses might target secondary mathematics teachers to enroll in a similar course during the summer. Ideally, this would include a tuition reduction or fellowship program for the teachers.

2. Science and Math Teacher Collaborations:

Creating opportunities for science and math secondary teachers to collaborate on developing curricular materials where students can collect data in the school science laboratory and analyze these data in the statistics classroom would build needed connections between science and mathematics that is prominent in the Next Generation Science Standards.

3. Computational Skills:

In order for teachers to engage students in authentic data analysis, they need computational skills. No one carries out a data analysis on a calculator. The open source statistics software R and the environment RStudio have great potential for the high school classroom. Unfortunately, many resources for learning R get unnecessarily technical too quickly, creating a barrier for learning. Exceptions include Dalgaard (2004) and an R Video series (see references).

4. Networks:

Future teachers, master teachers, and university faculty can gain a lot from each other by interacting over science content and teaching practices. Universities can create these opportunities by hosting events and creating/supporting networks of secondary and post-secondary teachers.

5. Research Opportunities:

The National Science Foundation and other funding agencies have supported research experience for teachers. Statistics faculty can seek out these opportunities and work with program officers and local industries to develop new opportunities. With funds, university faculty can create statistics research apprenticeships for teachers (both future and current) to work on authentic data analysis projects and develop transfer plans to bring their analysis into the secondary teacher's classroom.

CONCLUSION

The Next Generation Science Standards and the Common Core Standards for Math call for curricular changes that align with concepts fundamental to understanding the nature of science. These include developing and using models, analyzing and interpreting data, constructing explanations, and engaging in argument from evidence. Clearly statistics is key to these concepts. Statisticians have a tremendous opportunity to get involved with the statistics training of teachers and the development of statistics content in secondary math and science curricula.

WEBSITES

- Cal Teach: http://calteach.berkeley.edu
- Common Core Standards for Mathematics: http://www.corestandards.org/about-the-standards/key-points-in-mathematics
- GEMS: http://lhsgems.org/
- Math for America Berkeley: http://www.mathforamerica.org/berkeley
- National Math and Science Institute: http://www.nms.org/
- Next Generation Science Standards: http://www.nextgenscience.org/
- R: http://www.r-project.org/
- RStudio: https://www.rstudio.com/
- R Video Tutorials: http://www.stat.berkeley.edu/share/rvideos/R_Videos/R_Videos.html
- UTeach: http://www.uteach-institute.org/

REFERENCES

Dalgaard, P. (2004). *Introductory statistics with R.* New York: Springer-Verlag.

Gelman, A., & Nolan, D. (2002). *Teaching statistics: A bag of tricks*. Oxford: Oxford University Press.