

This document provides sources, documentation, and calculations supporting the UTeach Impact Report (published in September 2017). For a copy of that report, please see <https://institute.uteach.utexas.edu/uteach-impact>.

National STEM workforce and need for more and better prepared STEM teachers

The need for more STEM workers in the U.S. is well known, and one of the most productive approaches to gaining more STEM workers is to produce teachers who can educate students and prepare them for college and careers in STEM. The following references provide information about STEM worker and STEM teacher shortages.

Bureau of Labor Statistics. (2015, May). STEM crisis or surplus? Yes and yes. *Monthly Labor Review*. <https://www.bls.gov/opub/mlr/2015/article/stem-crisis-or-stem-surplus-yes-and-yes.htm>

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President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Washington, DC: Executive Office of the President of the United States. <http://files.eric.ed.gov/fulltext/ED541511.pdf>

UTeach programs prepare STEM teachers for less

This infographic was constructed by comparing information about UTeach in Texas with Teach for America in the Dallas–Fort Worth (DFW) area. “Leading National Post-Baccalaureate Model” refers to Teach for America in the DFW area; the data are pulled from the 2015 Teach for America DFW Impact Report.

UTeach programs produce teachers at a lower cost than other leading programs

Teach for America —Dallas–Fort Worth area

TFA–DFW reports that 35% of their cohort of teachers are STEM teachers, so, for the purpose of comparison, we used 35% of their reported operating budget of \$10.2 million—\$3.57 million—as the cost of preparing those STEM teachers.

TFA–DFW’s reported corps size of first- and second-year members is 360 teachers, so we calculated their first-year cohort to be 190 of these 360. The TFA website (under “10 Questions People Ask Us”) reports that 88% of their first-year teachers return for a second year. If 35% of a group of 190 new teachers are STEM teachers, that is 66.5 STEM teachers.

We calculated the cost per new STEM teacher by dividing operating budget by number of new STEM teachers produced: $\$3,570,000/67$ STEM teachers = $\$53,283.58$. For readability in the infographic, we rounded this to $\$53,000$. TFA-DFW reports that their funding comes from 63% private sources and 37% public sources.

UTeach in Texas

UTeach program costs are based on both our experience at the University of Texas at Austin and the collective experience of three UTeach replication programs in the DFW area: University of North Texas, University of Texas at Dallas, and University of Texas at Arlington.

The UTeach program at UT Austin (UTeach Austin) has an annual budget of around \$2 million per year, inclusive of all administrative costs. Of this \$2M, approximately 40% each year is from private sources, which include endowment interest income, gifts, and grants or contracts. Sixty percent of the budget comes from university sources, such as funding for instructors and student tuition and fees. UTeach Austin has in recent years been producing around 70 graduates per year. The three programs in the Dallas–Fort Worth area are collectively producing around the same number of graduates with an aggregated budget of about \$2 million as well.

The cost per graduate is calculated as the total annual budget divided by the average number of annual graduates: $\$2,000,000/70$ graduates = $\$28,571$. This cost per graduate takes into account all funding to run the program, including all “leavers” (students who try one or more UTeach courses but do not finish the program), scholarships, internships, other benefits to students, and all administrative costs.

UTeach graduates stay in schools longer

Teach for America —Dallas–Fort Worth area

Average years TFA teachers stay in teaching is the most difficult number to pin down; TFA does not publish or publicize this number. To compute this number, we looked at the number of active teachers reported by TFA–DFW and added other positions that they report are working in schools to get the total number of 407 TFA–DFW grads active in schools: 300 teachers + 26 principals + 45 assistant principals + 28 instructional coaches + 8 school counselors.

We multiplied 407 TFA–DFW grads active in schools by 35% to calculate how many are likely STEM teachers; that produces the number 142. If there are 67 new STEM teachers each year, leading to 142 STEM teachers active in schools at any given time, then teachers are staying an average of 2.1 years in schools.

UTeach in Texas

UTeach teachers persist in teaching at high rates. We use a 5-year average teacher tenure for the purposes of this report. A technical explanation for using a 5-year average tenure is based on the continuity equation; see the section at the end of this document, entitled “Average Years in Teaching.”

Based on an average teacher tenure of five years, in a given year, there would be 70 STEM teachers: 70 STEM teachers * 5 years = 350 STEM teachers actively teaching in any given year.

Since UTeach graduates stay in teaching longer, the average cost per year of teaching is much lower

Teach for America —Dallas–Fort Worth area

To compute the cost per year of teaching for TFA–DFW, we divided the operating budget by the active STEM teachers: $\$3,570,000/142 = \$25,141$.

UTeach in Texas

To compute the cost per year of teaching for UTeach in Texas, we divided the operating budget by the active STEM teachers: $\$2,000,000/350 = \$5,714$.

References for “UTeach programs prepare STEM teachers for less”

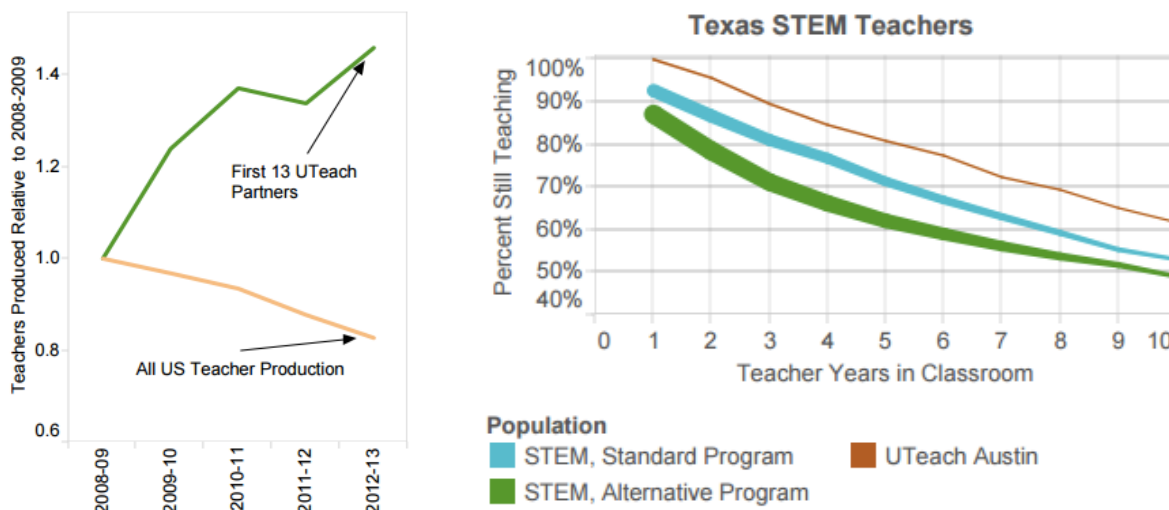
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Teach for America. (2016). 10 questions people ask us. TFA on the record. <https://www.teachforamerica.org/tfa-on-the-record> [Accessed March 31, 2017.]

UTeach graduates increase student learning

During the 20 years UTeach has prepared teachers, many have asked for evidence that high school students learn more if their teachers come from UTeach. Two recent studies from Texas show that students of UTeach graduates do learn more.

UTeach raises the number of math and science teachers coming from the universities where it has been established. UTeach graduates stay in teaching longer than those prepared by alternative certification programs. But for many thoughtful observers, the most important question has been whether students of UTeach graduates learn more. Now we can answer the question. The answer is yes.



Study 1: Conducted by UTeach Austin

The first study, from UTeach, examines the differences in student outcomes of university prepared and alternatively certified teachers in Texas, using scores in Algebra I and Biology from the 2011–2012 academic year compared with math and science scores in 2010–2011. We looked at the general question of whether graduates of standard university or alternative certification programs produce more student learning because rapid growth of for-profit teacher certification may be the most significant change taking place now in the way teachers are prepared in the United States.

We concluded that students of university-prepared teachers in Texas gain around one more month of schooling than comparable alternatively certified teachers in ninth-grade Algebra I and 0.7 months in ninth-grade Biology.

Focusing specifically on UTeach-prepared teachers, we found significant advantages of around 9 months of schooling in both Algebra I and Biology for Gifted students, and 5 months of schooling in Biology for Economically Disadvantaged and Hispanic students. There were no subgroups of students for whom alternatively certified teachers obtained significantly better student learning.

Study 2: Conducted by the American Institutes for Research

Another study, by the American Institutes for Research, made use of all the math and science tests given in public secondary schools in Texas from 2011–2012 to 2014–2015. They found that, relative to non-UTeach teachers in the state, graduates of both the UTeach founding program at UT Austin and six other UTeach programs in Texas universities are more effective than comparison teachers as measured by their ability to raise student test scores in math and science.

The difference was 2–3 months of schooling for UTeach graduates overall in Texas and 4–6 months of schooling for Austin UTeach graduates, similar to the difference between novice teachers and those with 10 or more years of experience.

Teasing conclusions out of small effects from exams not designed for the purpose requires lots of data, patience to remove errors from the data, and complicated methods of analysis. That is why it is so important that UTeach and AIR carried out the analyses independent of each other, that AIR conducted this study without any funding from or communication with UTeach, and that the analyses, done in somewhat different ways, are consistent with each other on all points where they overlap.

References for “UTeach graduates increase student learning”

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Marder, M., & Hamrock, C. (2016, working paper). Math and science outcomes for students of teachers from standard and alternative pathways in Texas. Available at <https://uteach.utexas.edu/uteach-blog/students-uteach-graduates-learn-more>

UTeach provides a high return on investment

The UTeach ROI was calculated using the same data as those used for the “UTeach produces STEM teachers for less” section, along with additional external data sources.

UTeach graduates inspire their students and influence them to go into STEM fields

Here we make an assumption that is based on anecdotes and reasoning. If we have 350 UTeach teachers in a given year, and each UTeach teacher can influence just one additional student who comes through their classroom per year to pursue a STEM career versus a non-STEM career, then 350 additional future STEM workers would be created each year. This is just 0.67% of the students taught by the UTeach teachers. As a side note, if students are exposed to subjects that they would not have otherwise been exposed to by having a UTeach teacher, such as physics and computer science, then we would expect effects up to as much as 20 times larger.

This projected increase of 350 additional STEM workers will increase state taxes paid—see the next section.

Median STEM vs. non-STEM annual earnings in Texas

We used the Institute on Taxation and Economic Policy to find the average Texas state taxes as a percentage of salary. We used Change the Equation’s Vital Signs to determine median job earnings in Texas for STEM and non-STEM workers.

If the average STEM worker in Texas has a salary of \$77,147 and the average non-STEM worker has a salary of \$36,566, then STEM workers make an average of \$40,580.80 more than non-STEM workers.

Cumulative lifetime earnings and minimum ROI to the state of Texas

Given that in one year the median salary in STEM is \$40,580.80 more, then over a 20-year career the cumulative lifetime earnings will be \$811,616 more in a STEM career vs. non-STEM career (20 years * \$40,580.80 more per year = \$811,616).

At a 7.4% average Texas state tax rate, there will be an increase of \$3,002.98 in annual state revenue for a STEM worker. Over a 20-year career, the additional state income tax revenue from 350 additional STEM workers is \$21,020,854.40 (350 STEM workers * \$3,002.98 tax revenue increase * 20 years = \$21,020,854.40).

If we assume that the number of UTeach graduates is around 70 per year, the cost per graduate is around \$30,000 (rounded from \$28,571; see the first section, “UTeach graduates prepare STEM teachers for less”).

Of the \$28,571, approximately 40% each year is from private sources, which include endowment interest income, gifts, and grants or contracts; 60%, or \$17,143 per teacher produced comes from university sources such as funding for instructors and student tuition and fees.

Therefore, there is a 1651.74% return on investment using the ROI formula (Gains - Cost)/Cost: (Increased revenue - (#grads per year*cost/grad))/(# grads per year * cost/grad).

At the rate of return we calculated, it will take just 1.14 years to break even on the university investment: Years to break even = ((Number of UTeach graduates/year*Cost per UTeach graduate produced (cost to University))/Increased government revenue/year (\$1,200,000/\$1,051,042.72 = 1.14).

Note on university investment

The amount that a Texas university spends per UTeach graduate is estimated at \$17,143, but that does not take into account university revenues from student tuition. The University of Texas at Austin, for example, is *not* primarily funded with public dollars. Tuition paid by students funds a significant portion of the cost of their education and teacher certification. Students in the UTeach program receive both a STEM bachelor's degree AND a teaching certificate upon graduation for the cost of their tuition, which leverages both their time at the university as well as the financial investment in their education.

References for “UTeach provides a high return on investment”

Change the Equation. (2015). *Vital signs*. United States. STEM demand.

<http://vitalsigns.changetheequation.org/state/United-States/demand> [Accessed March 31, 2017.]

Institute on Taxation and Economic Policy. (2015). *Who pays? A distributional analysis of the tax systems in all 50 states* (5th edition). Washington, DC: Author. <http://www.itep.org/pdf/whopaysreport.pdf>

UTeach is scalable

The UTeach Institute was established in 2006 in response to national concerns about the quality of K–12 STEM education and growing interest in the innovative and successful secondary STEM teacher preparation program, UTeach, started in 1997 at The University of Texas at Austin (UT Austin).¹

The Institute currently supports UTeach program implementation at 45 universities in 21 U.S. states and the District of Columbia.²

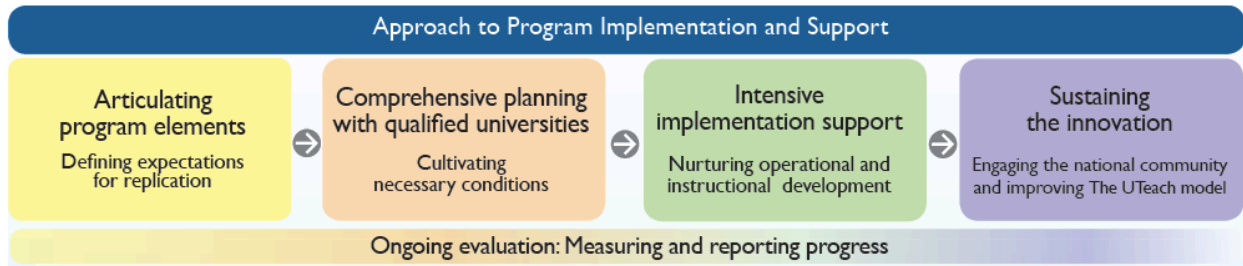
As of Spring 2016, there are nearly 7,000 students are enrolled in UTeach programs across the U.S. Nearly 3,300 UTeach graduates have been produced since 2000, and approximately 600 new graduates are produced annually. UTeach raises the number of math and science teachers coming from the universities where it has been established (see the graph in the first section, “UTeach graduates prepare STEM teachers for less”).

To promote the dual goals of fidelity to the UTeach model and long-term sustainability, the UTeach Institute developed a comprehensive approach to replication aligned with recommendations from the research literature on fidelity of implementation and program replication and expansion (e.g., Century, Rudnick, & Freeman, 2010; Glennan, Bodilly, Galegher, & Kerr, 2004; Hall & Hord, 2010; Hill, Maucione, & Hood, 2007).

The Institute’s approach emphasizes (1) clear articulation of program elements and expectations for replication, (2) comprehensive planning with qualified sites, (3) intensive implementation support, (4) ongoing evaluations of progress, and (5) sustaining the innovation.

¹ A discussion of the elements unique to UTeach and its success is beyond the scope of this document. See <https://institute.uteach.utexas.edu/uteach-model> for more information.

² The UTeach Institute’s work is supported through a variety of strategic partnerships at the national, state, and local levels. The UTeach Institute partners with the National Math + Science Initiative and the states of Arkansas, Florida, Georgia, Maryland, Massachusetts, Tennessee, and Texas. For a complete list of strategic partners, see <https://institute.uteach.utexas.edu/support-uteach-expansion>. For a complete list of UTeach programs, see <https://institute.uteach.utexas.edu/uteach-programs-across-nation>.



As the partner UTeach programs have matured, the UTeach Institute’s work has evolved from its initial focus on fidelity of implementation to building a robust networked community that currently engages more than 700 STEM and STEM education faculty, master teachers, university leaders, and program staff. This community collaborates to address the common aim of strengthening university-based, secondary STEM teacher preparation and production. Serving as the network hub, the UTeach Institute provides critical infrastructure to coordinate and sustain the activities of the community (Bryk, Gomez, & Grunow, 2011), including the collection and reporting of a common set of measures of program implementation and outcomes, investigation of variations in performance across the network to identify areas for improvement, provision of program implementation support across a variety of higher education contexts, and facilitation of the collection and sharing of adaptations and innovations to the program model throughout the network.

References for “UTeach is scalable”

- Bryk, A. S., Gomez, L. M., & Grunow, A. (2011). Getting ideas into action: Building networked improvement communities in education. In M. T. Hallinan (Ed.), *Frontiers in sociology of education*. Berlin: Springer.
- Century, J., Rudnick, M., & Freeman, C. (2010). A framework for measuring fidelity of implementation: A foundation for shared language and accumulation of knowledge. *American Journal of Evaluation*, *31*, 199–218.
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- Hall, G. E., & Hord, S. M. (2010). *Implementing change: Patterns, principles, and potholes*. Upper Saddle River, NJ: Prentice Hall.
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Average years in teaching

Michael Marder
(Dated: 2/20/2017)

Consider a population of teachers where $N_{y,e}$ is the number of teachers in year Y with e years of experience. Assume the population is in steady state, and more specifically

1. That the total number of teachers is not changing over time
2. The average years of experience is not changing over time

Then the average number of years teachers stay in the classroom is the ratio of the total number of teachers actively teaching to the number produced each year.

To demonstrate this, let P be the number of teachers produced each year (for simplicity take this to be a constant), and let $L_{y,e}$ be the number of teachers who leave at the end of year y with e years of experience. Again for simplicity ignore teachers who re-enter teaching after absence.

The continuity equation for teachers with one or more years of experience is

$$N_{y+1,e+1} = N_{y,e} - L_{y,e}. \quad (1)$$

This says that the number of teachers with a certain number of years experience is the number there the year before minus the number who leave. This equation does not necessarily hold when $e = -1$, except we can define

$$N_{y,-1} = P \quad L_{y,-1} = 0, \quad (2)$$

in which case it applies then as well; the number of teachers with zero years of experience is the number produced the year before. With this understanding, return to Eq (1).

The total number of teachers teaching is

$$N_y = \sum_{e=0}^{\infty} N_{y,e}. \quad (3)$$

The number of leavers is

$$L_y = \sum_{e=0}^{\infty} L_{y,e}.$$

A first observation is that if the number of teachers is not changing, the number who leave equals the number who enter. To see this formally, sum both sides of Eq. (1) over e to obtain

$$\begin{aligned} \sum_{e=-1} N_{y+1,e+1} &= \sum_{e=-1} N_{y,e} - L_{y,e} \\ \Rightarrow N_{y+1} &= N_y + P - \sum_{e=-1} L_{y,e}. \end{aligned} \quad (4)$$

Since the number of teachers is not varying, using Eq (2) gives

$$P = \sum_{e=0} L_{y,e} = L_y; \quad (5)$$

the number of leavers equals the number produced. Now suppose that the average years of experience is not changing (the first moment of the distribution is in steady state). To see what this implies, multiply both sides of Equation (1) by e and sum. Now one has

$$\sum_{e=0}^{\infty} e N_{y+1,e+1} = \sum_{e=0}^{\infty} e N_y - \sum_{e=0}^{\infty} e L_{y,e} \quad (6)$$

$$\Rightarrow \sum_{e=1}^{\infty} (e-1) N_{y+1,e} = \sum_{e=0}^{\infty} e N_y - \sum_{e=0}^{\infty} e L_{y,e} \quad (7)$$

$$\Rightarrow \sum_{e=1}^{\infty} e (N_{y+1} - N_y) = \sum_{e=0}^{\infty} e N_{y+1,e} - \sum_{e=0}^{\infty} e L_{y,e}. \quad (8)$$

The left hand side of Eq (8) vanishes because the average number of years of experience is not changing. This means

$$\begin{aligned} \sum_{e=0}^{\infty} e N_{y+1,e} &= \sum_{e=0}^{\infty} e L_{y,e} \\ \Rightarrow \frac{\sum_{e=0}^{\infty} e N_{y+1,e}}{L_y} &= \frac{\sum_{e=0}^{\infty} e L_{y,e}}{L_y} \\ \Rightarrow \frac{N_{y+1}}{P} &= \langle e \rangle. \end{aligned} \quad (9)$$

For the left hand side of the final relation I used Eq. (5) and for the right hand side I have used the definition of an expected or mean value of any distribution to find the average number of years of experience at which teachers leave (the number who leave at e years times e divided by the total number who leave). This is the relation that was to be demonstrated.

The number teaching divided by the number produced equals the average number of years of experience at which teachers leave.

Note that because N_y and P are easy to measure, they should be viewed as primary quantities, while $\langle e \rangle$ should be viewed as derived.