Experimental Evidence on the Effect of Childhood Investments on Postsecondary Attainment and Degree Completion

Susan Dynarski and Joshua Hyman
University of Michigan

Diane Whitmore Schanzenbach
Northwestern University

March 9, 2012
The goal of educational interventions is to improve long-run outcomes, e.g.
- Educational attainment
- Earnings
- Health

Due to data limitations (and time-horizon) most evaluations of educational interventions look only at test scores.

It is unclear to what degree short-run gains in test scores translate into long-term impacts.
Several educational interventions have shown large test score effects that fade out:

- Abecedarian, Perry Preschool and Head Start (Anderson, 2008; Currie and Thomas, 1995)

These same programs appear to have large impacts on crime, educational attainment, earnings and health (Anderson, 2008; Deming, 2009)

Charter schools are shown to have large impacts on test scores (Abdulkadiroglu, et al., 2011; Dobbie and Fryer, 2011).

- Critical to understand whether these effects will persist.
Research Questions:
- What is the effect of class size during early elementary school on postsecondary attainment and choice?
- Can we predict the impacts on postsecondary attainment from the effects on test scores?

Using data from Project STAR we evaluate the impact of randomly assigned class size on:
- College entry and persistence
- Degree completion
- Field of degree

Advantages of Project STAR
- Big, old and well designed
- Manipulates single parameter in education production function
- Replicable
Project STAR

- STAR randomly assigned kindergarten students and their teachers to:
  - A small class (target size 13-17 students) or
  - A regular size class (22-25 students)
- Randomization was conducted within 79 schools in Tennessee.
- Students remained in their assigned class type through 3rd grade, then returned to regular classes in 4th grade.
- An eventual 11,571 students were involved in the experiment.
Related Literature

- Krueger (1999); Krueger & Whitmore (2002)
  - Contemporaneous scores rise 0.2 sd
  - Fades out by middle school
- Chetty, et al. (2011) examine STAR long-term outcomes using income tax return data
  - Effect of kindergarten classroom assignment:
    - Large effects on earnings, savings, home ownership, college quality
    - Driven by variation in teacher quality, peer quality
  - Effect of class size:
    - Small increase in college attendance at age 20, insignificant by age 27
    - No detectable impact on college quality or earnings.
Summary of Results

- Assignment to a small class increases:
  - College enrollment by 2.7 percentage points (pp).
    - Effects larger for blacks (6pp) and poor students (4pp).
    - Increase of 11pp among students with lowest ex-ante probability of enrolling.
  - Degree receipt by increases by 1.6pp.
    - Increase of 4.2pp among students with lowest ex-ante probability of completing.
    - Shifts students toward high earning fields (STEM, business and economics).

- Early test score gains completely predict long-term benefits.

- After comparing costs and impacts we conclude that early interventions are no more cost effective than later ones.
Estimating Equation

\[ Y_{isg} = \beta_0 + \beta_1 SMALL_{is} + \beta_2 X_{is} + \alpha_{sg} + \epsilon_{isg} \]  (1)

- \( Y_{isg} \) is outcome of student \( i \), who entered the STAR experiment in school \( s \) and in grade \( g \).
- \( SMALL_{is} \) is a dummy for whether the student initially attended a small class.
- \( X_{is} \) is a vector of demographics.
- \( \alpha_{sg} \) is set of school-by-entry-wave fixed effects.
Data on Educational Attainment

- National Student Clearinghouse (NSC)
  - Administrative data on \( \approx 92\% \) of enrollment
    - Name and state of college
    - School type (2/4 year, public/private)
    - Start and end date of semesters enrolled
    - Enrollment status
    - Whether a student graduates
    - Field of degree and major
  - Economists have begun to use data for research purposes.
  - States and districts use data to track educational attainment of HS graduates
## Treatment Evolution

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Scores, by Grade</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K (n=5,868)</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>3 (n=6,057)</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>4 (n=6,995)</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>8 (n=7,636)</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td><strong>Demographics</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- **Dependent Variable:**
  - Test Scores, by Grade
  - Demographics

- **Treatment Evolution Table**
  - Grades: K, 3, 4, 8
  - Observations:
    - K: 5,868
    - 3: 6,057
    - 4: 6,995
    - 8: 7,636
Fraction Ever Attended College Over Time

Raw Means

Difference Between Small and Regular

- Small Class
- Regular Class

- Difference
- 95% Confidence Interval
Controlling for FEs and Demographics

Controlling for SxW Effects and Demographics

Difference Between Small and Regular

- Small Class
- Regular Class

- Difference
- 95% Confidence Interval
Controlling for FEs and Demographics

Controlling for SxW Effects and Demographics

Difference Between Small and Regular

<table>
<thead>
<tr>
<th>Year</th>
<th>Small Class</th>
<th>Regular Class</th>
<th>Difference 95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ever Attend College 0.028 0.027 (0.012) (0.011)
Demographics No Yes
Control Mean 0.385
Sample Size 11,269
## Postsecondary Attainment Over the Lifecycle

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>β</th>
<th>(Std Error)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever Attend College</td>
<td>0.027</td>
<td>(0.011)</td>
<td>0.385</td>
</tr>
<tr>
<td>Enrolled On-Time</td>
<td>0.024</td>
<td>(0.011)</td>
<td>0.274</td>
</tr>
</tbody>
</table>

- 89% of class size effect operates through on-time attendance, while 71% of students who enroll do so on time.
Timing of College Attendance

**Ever Attend College**

- **Fraction Ever Attended College**
- **Age**
- **Year**
- **Small Class**
- **Regular Class**

**Currently Attending College**

- **Fraction Currently Attending College**
- **Age**
- **Year**
- **Small Class**
- **Regular Class**
College Completion

- College completion rates declining in recent decades (Bound et al., 2009; Bailey and Dynarski, 2010)

- Important question: Do gains we see in college entry translate into increased persistence and completion?
Cumulative Number of Semesters Attended Over Time

- # of Semesters: 0.22 (0.13)
- Control Mean: 3.07
- Sample Size: 11,269
## Effect of Class Size on Degree Receipt

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any degree</td>
<td>0.016</td>
<td>(0.009)</td>
<td>0.151</td>
</tr>
<tr>
<td>Highest Degree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associates</td>
<td>0.007</td>
<td>(0.004)</td>
<td>0.027</td>
</tr>
<tr>
<td>Bachelors or higher</td>
<td>0.009</td>
<td>(0.008)</td>
<td>0.124</td>
</tr>
</tbody>
</table>

Sample Size 11,269
Timing of Degree Receipt

Ever Receive a Degree

Receive a Degree in Current Year

Small Class
Regular Class
Timing of Degree Receipt - By Degree Type

**Associates**

- Fraction Receiving a Degree in Current Year
- Age
- Year
- Small Class
- Regular Class

**Bachelors or Higher**

- Fraction Receiving a Degree in Current Year
- Age
- Year
- Small Class
- Regular Class
Timing of Highest Degree Earned - By Degree Type

**Associates**

- Age: 16, 18, 20, 22, 24, 26, 28, 30

- Fraction Ever Received a Degree

**Bachelors or Higher**

- Age: 16, 18, 20, 22, 24, 26, 28, 30

- Fraction Ever Received a Degree

Legend:
- Small Class
- Regular Class
### Effect of Class Size on Field of Degree

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Any degree</td>
<td>0.016</td>
<td>0.151</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM, business or economics field</td>
<td>0.013</td>
<td>0.044</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All other fields</td>
<td>0.003</td>
<td>0.085</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Size</td>
<td>11,269</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Inequality in postsecondary education has been increasing in recent decades (Bound, et al., 200; Bailey and Dynarski, 2010).

Does class size reduction attenuate or exacerbate race and income gaps in postsecondary attainment?
Effect of Class Size on the Race Gap in College Attendance

Regular Class

Small Class

- Whites
- Blacks
Effect of Class Size on the Income Gap in College Attendance

![Graphs showing fraction of students ever attended college by age and year for Regular Class and Small Class, differentiated by whether they are eligible for free lunch.](image-url)
## Heterogeneity by Propensity to Attend College

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Quintile of Ex-Ante Probability of Attending College</th>
<th>P-value: 1st vs. 2nd-5th</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>1st</td>
</tr>
<tr>
<td>College Attendance</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Ever attend</td>
<td>0.027</td>
<td>0.114</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.024)</td>
</tr>
<tr>
<td></td>
<td>0.385</td>
<td>0.152</td>
</tr>
<tr>
<td>Number of Semesters</td>
<td>0.22</td>
<td>0.54</td>
</tr>
<tr>
<td>Attempted</td>
<td>(0.13)</td>
<td>(0.17)</td>
</tr>
<tr>
<td></td>
<td>3.07</td>
<td>0.96</td>
</tr>
<tr>
<td>Sample Size</td>
<td>11,269</td>
<td>2,268</td>
</tr>
</tbody>
</table>
# Heterogeneity by Propensity to Receive a Degree

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Quintile of Ex-Ante Probability of Receiving a Degree</th>
<th>P-value: 1st vs. 2nd-5th</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>1st</td>
</tr>
<tr>
<td>Receive Any Degree</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>0.016</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.011)</td>
</tr>
<tr>
<td></td>
<td>0.151</td>
<td>0.016</td>
</tr>
<tr>
<td>Sample Size</td>
<td>11,269</td>
<td>2,268</td>
</tr>
</tbody>
</table>
Heterogeneity in Treatment Effect or Dosage?

\[ \text{YEARS}_{is} = \delta_0 + \delta_1 Z_{is} + \delta_{sg} + \psi_{isg} \]  
\[ \text{COLL}_{isg} = \alpha_0 + \alpha_1 \text{YEARS}_{is} + \alpha_{sg} + \epsilon_{isg} \]

- \( \text{COLL}_{isg} \) is a dummy for whether student \( i \), who entered the STAR experiment in school \( s \) and in grade \( g \) enrolls in college.
- \( \text{YEARS} \) is the number of years spent in a small class.
- \( Z \) is the potential number of years the student can be in a small class multiplied by an indicator for whether the student was assigned to a small class.
- \( \alpha_{sg} \) and \( \delta_{sg} \) are school-by-entry-wave fixed effects.
### Effect of Class Size on Enrollment Using Potential Years Instrument

<table>
<thead>
<tr>
<th></th>
<th>First Stage</th>
<th>Reduced Form</th>
<th>2SLS</th>
<th>Control Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Everyone</strong></td>
<td>0.643</td>
<td>0.006</td>
<td>0.009</td>
<td>0.385</td>
</tr>
<tr>
<td>(n=11,269)</td>
<td>(0.016)</td>
<td>(0.003)</td>
<td>(0.005)</td>
<td></td>
</tr>
<tr>
<td><strong>Black</strong></td>
<td>0.589</td>
<td>0.014</td>
<td>0.024</td>
<td>0.308</td>
</tr>
<tr>
<td>(n=4,109)</td>
<td>(0.019)</td>
<td>(0.006)</td>
<td>(0.010)</td>
<td></td>
</tr>
<tr>
<td><strong>White</strong></td>
<td>0.669</td>
<td>0.003</td>
<td>0.004</td>
<td>0.432</td>
</tr>
<tr>
<td>(n=7,160)</td>
<td>(0.019)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td></td>
</tr>
</tbody>
</table>
Do Short-Term Effects Predict Long-Term Effects?

Could effects we find have been predicted based on short-term impacts?
- We guess effect on college enrollment based on relationship between test-scores and educational attainment.

Use NLSY79 Mother-Child Supplement:
- One SD increase in scores associated with 16pp increase in college enrollment.
- Same as in STAR data.

STAR increased K-3 test scores by 0.17 SD’s.
- 0.17*16 = 2.72 percentage points - identical to effect we find.
Estimating Equations

\[ Coll_{isg} = \alpha_0 + \alpha_2 TEST_{is} + \alpha_4 X_{is} + \alpha_{sg} + \epsilon_{isg} \quad (4) \]
\[ Coll_{isg} = \beta_0 + \beta_1 SMALL_{is} + \beta_2 TEST_{is} + \beta_3 SMALL \ast TEST_{is} + \beta_4 X_{is} + \beta_{sg} + \epsilon_{isg} \quad (5) \]

- \( TEST_{is} \) is the average of student \( i \)'s K-3 math and english test scores, normalized to mean zero and SD of one.
## Effect of Class Size on College Attendance Conditional on K-3 Test Scores

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test score</td>
<td>0.169</td>
<td>0.169</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>Small class * test score</td>
<td>-0.008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td></td>
</tr>
<tr>
<td>Small class</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td></td>
</tr>
<tr>
<td>Control Mean</td>
<td>0.385</td>
<td>0.385</td>
</tr>
<tr>
<td>Sample Size</td>
<td>11,269</td>
<td>11,269</td>
</tr>
</tbody>
</table>
Effect of Class Size on College Attendance Conditional on Grade 6-8 Test Scores

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test score</td>
<td>0.229</td>
<td>0.230</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Small class * test score</td>
<td>-0.014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td></td>
</tr>
<tr>
<td>Small class</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td></td>
</tr>
<tr>
<td>Control Mean</td>
<td>0.385</td>
<td>0.385</td>
</tr>
<tr>
<td>Sample Size</td>
<td>11,269</td>
<td>11,269</td>
</tr>
</tbody>
</table>
Test scores during K-3 predict college attendance to the same degree for students in small and regular-size classes.

This suggests that short-term gains in test scores actually predict long-run impacts quite well.

The fact that test-score impacts fade-out but human capital persists implies effects working through another channel.
Do Early Interventions Pay off More Than Late Ones?

- Theory popularized by James Heckman and coauthors:
  - Students more plastic when young so as they age, interventions are less effective.

- In this section we compare costs and benefits of interventions from throughout life-cycle.
Figure 2.6
(a) Rates of return to human capital investment initially setting investment to be equal across all ages

Rates of return to human capital investment initially setting investment to be equal across all ages
Preschool Interventions: Effect on College Entry Rate

- **Abecedarian** (Anderson, 2008)
  - Effect: +22 pp
  - Cost per child: $90,000
  - Cost per child induced into college: $410,000

- **Head Start** +6 pp (Deming, 2009)
  - Effect: +6 pp
  - Cost per child: $8,000
  - Cost per child induced into college: $133,000
K-12 Interventions: Effect on College Entry Rate

- **Upward Bound** (Seftor, et al., 2009)
  - Effect: +6 pp (among students with low educational aspirations)
  - Cost per child: $5,620
  - Cost per child induced into college: $94,000

- **STAR** (Dynarski, et al., 2011)
  - Effect: +3/+11 pp (total/lowest ex ante probability of attendance)
  - Cost per child: $12,000
  - Cost per child induced into college: $400,000 to $109,000
Postsecondary Interventions: Effect on College Entry Rate

- **Simple Aid Programs** (Dynarski, 2003 & 2008; Deming and Dynarski, 2011))
  - Cost per high school student induced into college: $21,000
- **FAFSA Simplification** (Bettinger, et al., forthcoming)
  - Effect: +7 pp
  - Cost per applicant: $88
  - Cost per applicant induced into college: $1,300
Effects on College Entry Rate, by Age at Intervention

- Abcedarian
- Head Start
- STAR
- Upward Bound
- Student aid
- FAFSA experiment

Effect on college enrollment

Quadratic fitted line

Percentage Points

Preschool Primary/Secondary School College

Age
Cost per Student Induced to Enter College, by Age at Intervention

- Abcedarian
- Head Start
- STAR
- Upward Bound
- Student aid
- FAFSA experiment

Cost/student induced to attend college

Quadratic fitted line
Summary of Results

- We find impacts of class size on college attendance, persistence, and completion, particularly for disadvantaged students.
  - Degree receipt effects driven by increases in STEM and business/econ fields.
- Attending a small class cuts black-white college attendance gap in half and reduces SES gap by 12%.
- Early test-score gains completely predict long-term benefits.
Our results suggest that fade-out of test score gains does not imply a policy or program is ineffective.

- Contemporaneous test score gains seem to be a good predictor of long-run improvements.

Given declining college graduation rates and lack of effective interventions addressing this problem, it is particularly encouraging that we see impacts of class size on postsecondary completion.