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Do School Curricula Matter to Students in the Long Run?

The Case of Teaching the Theory of Evolution or Creationism in the United States*

Since Charles Darwin's publication of "On the Origin of Species" in 1859, US policy-makers have engaged in heated debates as to whether evolution theory should be taught in public schools. At the beginning of the 20th century, teachers covering evolution in US schools faced strong opposition (Beale 1941). Some states, such as Tennessee, banned the coverage of evolution in public schools entirely. A famous example of this was the Scopes trial of 1925, in which John T. Scopes, a biology teacher from Tennessee, was convicted under the Butler Act for teaching evolution in the classroom (Numbers 1982). Throughout the second half of the 20th century, legislative decisions gradually paved the way towards more evolution teaching. In 1967, the Butler Act was revoked by Tennessee's state legislators. Although this and further decisions gradually allowed for a more comprehensive teaching of evolution, even today there is substantial variation in the way that evolution is covered in education standards, both across US states and within states over time.

But does the teaching of evolution actually make any difference to students? About 65 percent of the US population agree that humans have evolved over time (Pew Research Center 2015). While the literature has identified such factors as parents (Bisin and Verdier 2001; Guiso et al. 2008; Tabellini 2008) and social networks (Sacerdote 2001; Bailey et al. 2020) as determinants of attitudes, I ask whether schools play a role in shaping scientific attitudes. More specifically, does the coverage of evolution in US education go on to affect students' attitudes towards evolution in adulthood? And what role does it play in students' high stakes life choices?

In a new paper (Arold 2022), I show that evolution teaching has lasting effects on students. Greater exposure to evolution teaching not only improves students' knowledge of evolution by the time they graduate from high school, but it also enhances their belief in evolution in adulthood. What is more, the reforms affect high-stakes life decisions, namely the probability of choosing a career in life sciences.

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KEY MESSAGES

- **The teaching of evolution theory in school has a lasting impact on students**
- **Reforms of the coverage of evolution in US education standards have a positive effect on students' knowledge of evolution by the end of high school**
- **These reforms translate into a greater belief in evolution in adulthood, without crowding out religiosity or affecting political attitudes**
- **They also affect high-stakes life decisions, such as the probability of choosing a career in life sciences**
- **These findings imply that science education is an effective tool for fostering scientific attitudes and tackling the shortage of STEM workers**

US REFORMS OF EVOLUTION TEACHING

Estimating the causal effects of school curricula is generally challenging, as they are not randomly attributed to students but largely reflect the population's attitudes and beliefs. Therefore, simply matching students' exposure to evolution teaching with their belief in evolution once they reach adulthood will likely not yield the causal effect of interest. To isolate the causal effect of evolution teaching, I exploit staggered state-level reforms of evolution-related content in the US State Science Education Standards. The predetermined timing of gubernatorial elections, in combination with the tenure of members of State Boards of Education, creates idiosyncrasies in the determination of the exact years of a reform. Furthermore, my two-way fixed effects approach explicitly accounts for a wide range of endogeneity concerns, by com-

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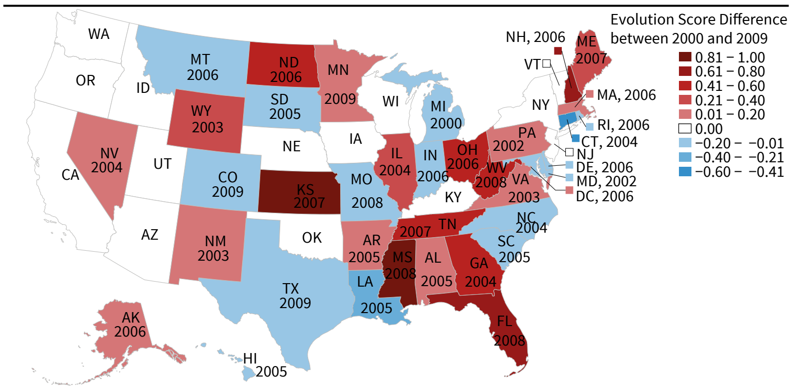
Figure 1

US Map Showing Differences in Evolution Scores between 2000 and 2009



Note: The map depicts the evolution score difference, which is defined as the evolution score for 2009 minus the evolution score for 2000. A positive (negative) difference implies an increase (decrease) in the score between 2000 and 2009, as indicated by the blue (orange) coloring. White coloring indicates that there was no change in an evolution score between 2000 and 2009. The years reported below the two-letter state codes are the years of the respective reform.
Source: Arold (2022), Lerner (2000), Mead and Mates (2009).

paring adjacent cohorts around sharp reforms in education standards.

To conduct my analyses, I link state-level data on the coverage of evolution in Science Standards with three individual-level datasets. Evolution coverage is measured by the so-called “evolution score”, constructed by Lerner (2000) and Mead and Mates (2009). The scores range from 0 to 1, with a higher score indicating a more comprehensive coverage of evolution. Over the study period of 2000 to 2009, 22 states increased the coverage of evolution in their education standards, while 15 states reduced it (Figure 1).

REFORMS AFFECT EVOLUTION KNOWLEDGE IN SCHOOL

To test whether the evolution coverage in the Science Standards affects what students learn about evolution in school, I use data from the National Assessment for Educational Progress (NAEP). This is a standardized student achievement test that assesses US students’ knowledge of a variety of subjects and issues. The NAEP test for science in grade 12 contains questions on evolution. I link the share of questions on evolution answered correctly by a given student to the evolution score that was in force in the state and year of his or her high school entry.

I find that students exposed to more comprehensive evolution coverage in high school are more likely to be able to correctly answer questions on evolution by the end of high school, conditional on the fixed effects of state and year as well as individuallevel controls. More specifically, a change in evolution score from 0 to 1 increases the share of evolution questions answered correctly by 5.8 percentage points (18 percent of the sample mean). Given that scientific knowledge positively impacts earnings and economic growth (Lucas 1988; Barro 2001; Hanushek and Woessmann 2008, 2012), this finding is of direct economic significance.

In summary: The more students are taught about evolution in high school, the more they know about evolution. Two additional findings from this analysis strengthen its causal claim: First, an increase in evolution coverage is not linked to students’ non-evolution-related scientific knowledge, which can be interpreted as a placebo test to detect general scientific confounders. Second, the reforms have no effect on private school students’ knowledge of evolution, for whom the Science Standards have never been binding.

EFFECTS TRANSLATE INTO BELIEF IN EVOLUTION IN ADULTHOOD

I also examine whether the reforms evaluated have any lasting effect on evolution beliefs in adulthood. I use data from the General Social Survey, which asked a representative sample of US adults about their belief in evolution. This elicited a wide range of further scientific, religious, and political attitudes. As the data also records the respondents’ year of birth and state of residence at the age of 16, I can approximate the year and state of high school entry and merge it with the corresponding evolution score.

I find that students’ exposure to evolution teaching in school affects the probability of their believing in the concept of evolution in adulthood. Compared with no coverage at all, extensive coverage of evolution increases the probability that a student will believe in evolution in adulthood by 33.3 percentage points (57 percent of sample mean).

In contrast, I find that evolution coverage has no effect on non-evolution-related scientific, religious, and political attitudes, lending empirical support to the interpretation that a reform’s timing is not affected by scientific, religious, or political shocks. This finding complements studies of the effects of school curricula on economic and political attitudes in China (Cantoni et al. 2014) as well as on religious attitudes in Germany (Arold et al. 2022).

REFORMS ALSO AFFECT HIGH-STAKES OCCUPATIONAL CHOICES

Finally, I analyze whether the evaluated reforms of teaching evolution theory affect high-stakes choices, in particular career choices. I hypothesize that learning about evolution, the fundamental theory of life sciences, increases the probability that a student will choose to work in life sciences in adulthood. To measure how evolution teaching impacts occupational choice, I use data from the IPUMS American Community Survey (Ruggles et al. 2020), which contains detailed information on respondents’ fields of occupation as well as their state and year of birth.

I demonstrate that compared to having had no evolution coverage at all, exposure to comprehensive evolution coverage increases the probability of a student working in life sciences in adulthood by 23 percent of the sample mean. This effect comes predominantly from the subfield of biology, the subject in which evolution is typically taught. Supporting the empirical strategy, evolution teaching does not affect the probability of a student working in a non-scientific occupational field.

POLICY IMPLICATIONS

More generally, this study suggests that science education can be used to foster scientific knowledge and beliefs and to attract future STEM workers, these being central policy goals in both the United States and Europe (National Science and Technology Council 2018; European Commission 2020). Having more scientific knowledge and people working in STEM not only raises wages at the individual level (Hastings et al. 2013; Kirkeboen et al. 2016; Deming and Noray 2020) but also fosters innovation, enhances labor productivity, and stimulates economic growth (Griliches 1992; Jones 1995; Kerr and Lincoln 2010; Peri et al. 2015).

Furthermore, the findings of this study challenge the notion that reforms in education standards have no meaningful impact on students, as prevalent in the academic and political debate. It has been argued that, in reality, there is limited scope for education standards to affect teaching, due to the dominance of other factors, such as the teachers' personal ideologies regarding curriculum designs in school (Moore et al. 2003; Loveless 2021). Still, legal pressures on school districts to follow education standards, the reflection of the content of such standards in textbooks, as well as the gradual expansion of standardized testing covering the content of these standards have arguably incentivized teachers to follow them.

The implications of the findings reach beyond evolution teaching in the United States. First, the fact that education standards lastingly shape students' beliefs even on a highly charged topic like evolution suggests that the effects on less controversial topics might be even larger. Second, the findings may also have a bearing on other countries where the teaching of evolution is controversial, such as most countries in the Middle East. Overall, fostering scientific attitudes and attracting STEM workers through education may enhance the technological progress that is required to overcome some of the great challenges of our time such as energy transition, combating climate change, and digitalization.

REFERENCES

Arold, B. W. (2022), "Evolution vs. Creationism in the Classroom: The Lasting Effects of Science Education", *Center for Law and Economics Working Paper Series*, ETH Zurich.

Arold, B. W., L. Woessmann and L. Zierow (2022), "Religious Education in School Affects Students' Lives in the Long Run", VoxEU.org, 3 March.

Bailey, M., D. M. Johnston, M. Koenen, T. Kuchler, D. Russel and J. Stroebel (2020), "Social Networks Shape Beliefs and Behavior: Evidence from Social Distancing During the COVID-19 Pandemic", *NBER Working Papers* 28234, National Bureau of Economic Research, Inc..

Barro, R. J. (2001), "Human Capital and Growth", *American Economic Review* 91 (2), 12–17.

Beale, H. K. (1941), *A History of the Freedom of Teaching in American Schools in Report of the Commission on the Social Studies*, Part 16, Charles Scribner & Sons, New York, Chicago.

Bisin, A. and T. Verdier (2001), "The Economics of Cultural Transmission and the Dynamics of Preferences", *Journal of Economic Theory* 97 (2), 298–319.

Cantoni, D., Y. Chen, D. Y. Yang, N. Yuchtman and J. Zhang (2014), "Curriculum and Ideology", VoxEU.org, 29 May.

Deming, D. J and K. Noray (2020), "Earnings Dynamics, Changing Job Skills, and STEM Careers", *Quarterly Journal of Economics* 135 (4), 1965–2005.

European Commission (2020). "European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience", Publications Office of the European Union Luxembourg.

Griliches, Z. (1992), "The Search for R&D Spillovers", *Scandinavian Journal of Economics* 94, 29–47.

Guiso, L., P. Sapienza and L. Zingales (2008), "Social Capital as Good Culture", *Journal of the European Economic Association* 6, 295–320.

Hanushek, E. A. and L. Woessmann (2008), "The Role of Cognitive Skills in Economic Development", *Journal of Economic Literature* 46 (3), 607–668.

Hanushek, E. A. and L. Woessmann (2012). "Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation", *Journal of Economic Growth* 17 (4), 267–321.

Hastings, J. S., C. A. Neilson and S. D. Zimmerman (2013), "Are Some Degrees Worth More than Others? Evidence from College Admission Cutoffs in Chile", *National Bureau of Economic Research Working Paper Series* 19241.

Jones, C. I. (1995), "R & D-Based Models of Economic Growth", *Journal of Political Economy* 103 (4), 759–784.

Kerr, W. R. and W. F. Lincoln (2010), "The Supply Side of Innovation: H-1B Visa Reforms and U.S. Ethnic Invention", *Journal of Labor Economics* 28 (3), 473–508.

Kirkeboen, L. J., E. Leuven and M. Mogstad (2016), "Field of Study, Earnings, and Self-Selection", *Quarterly Journal of Economics* 131 (3), 1057–1111.

Lerner, L. S. (2000), "Good and Bad Science in US Schools", *Nature* 407 (6802), 287–290.

Loveless, T. (2021), *Between the State and the Schoolhouse: Understanding the Failure of Common Core*, Harvard Education Press, Cambridge, Mass.

Lucas, R. E. (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics* 22 (1), 3–42.

Mead, L. and A. Mates (2009), "Why Science Standards are Important to a Strong Science Curriculum and How States Measure Up", *Evolution: Education and Outreach* 2, 359–371.

Moore, R., M. Jensen and J. Hatch (2003), "The Problems with State Educational Standards", *Science Education Review* 2 (3), 83.1-83.8.

National Science and Technology Council (2018), "Charting a Course for Success: America's Strategy for STEM Education", Report by the Committee on STEM Education of the National Science and Technology Council.

Numbers, R. L. (1982), "Creationism in 20th-Century America", *Science* 218 (4572), 538–544.

Peri, G., K. Shih and C. Sparber (2014), "How Highly Educated Immigrants Raise Native Wages", VoxEU.org, 29 May.

Pew Research Center (2015), "Public and Scientists' View on Science and Society", https://www.pewresearch.org/science/2015/01/29/public-and-scientists-views-on-science-and-society/.

Ruggles, S., S. Flood, R. Goeken, J. Grover, E. Meyer, J. Pacas and M. Sobek (2020), "Integrated Public Use Microdata Series USA: Version 10.0 [dataset]", Minneapolis, MN: IPUMS.

Sacerdote, B. (2001), "Peer Effects with Random Assignment: Results for Dartmouth Roommates", *Quarterly Journal of Economics* 116 (2), 681–704.

Tabellini, G. (2008), "The Scope of Cooperation: Values and Incentives", *Quarterly Journal of Economics* 123 (3), 905–950.