Panel Presentation: Assessing Learning and Innovation Skills

At the May 2013 quarterly Governing Board meeting, members engaged in a "blue sky" brainstorming session to explore topics the Board and NAEP might pursue. Among the ideas presented was one that focused on whether NAEP should examine how to measure 21st Century Skills, which are sometimes referred to as learning and innovation skills, work readiness skills, and other titles.

In August 2013, Board members discussed several of the "blue sky" ideas in more depth. To provide additional background information on measuring 21st century skills, it was suggested that a panel of experts present information on the latest research and work in this area.

On Friday December 6, Chairman Driscoll will moderate a panel discussion on the assessment of learning and innovation skills (a.k.a. 21st Century Skills). The panel members are listed below. Biographical information and background materials are included on the following pages.

- Steven Paine, Partnership for 21st Century Skills

- Martin West, Harvard Graduate School of Education

- Deirdre Knapp, Human Resources Research Organization (HumRRO)

- James Pellegrino, University of Illinois at Chicago

Steven Paine

Dr. Steven Paine is President of the Partnership for 21st Century Skills. A consummate life-long educator, Dr. Paine has held numerous positions of leadership in the private and public sectors. Prior to joining P21, he served as Senior Advisor to the McGraw-Hill Education Research Foundation and as Senior level Vice President for CTB/McGraw-Hill, the assessment company within McGraw-Hill Education.

From July, 2005 to January, 2011, he served as West Virginia's 25th state superintendent of schools. Under his leadership, West Virginia was internationally and nationally recognized for its 21st century learning program entitled Global21: Students deserve it. The world demands it. Led by Paine, West Virginia transformed the rigor and relevance of its public school instructional program with the goal of providing all West Virginia children the skills that would enable them to excel in a fiercely competitive global world. West Virginia's Global21 program specifically focused on the development of internationally rigorous and relevant curriculum standards; a balanced assessment strategy; research and performance based instructional practices; an accountability system based on multiple measures of student performance; aligned teacher preparation and professional development programs; establishment of a 21st century leadership development continuum; emphasis on high quality pre-K programs; and integration of technology tools and skills in every classroom.

While state superintendent, Dr. Paine was active in national education policy discussions as past president and board member of the Council of Chief State School Officers, as a member of the National Commission on Teaching and America's Future (NCTAF) Board of Directors and as a member of the National Assessment Governing Board and High School Readiness Commission.

He joined the West Virginia Department of Education in 2003 as the Deputy State Superintendent of Schools after serving as Superintendent of Morgan County Schools in West Virginia. He has also served as principal, assistant principal, teacher, and curriculum director in Upshur and Harrison County School Systems. As a result of his work as principal, he was named a recipient of the prestigious Milken Family Foundation National Educator Award. Dr. Paine is concurrently serving as the Chief Academic Officer for Engrade, an education technology company based in Santa Monica, California.

Dr. Paine earned his undergraduate degree from Fairmont State University, in Fairmont, West Virginia. He furthered his education by attending West Virginia University in Morgantown, West Virginia, where he received his master's degree in educational administration and his doctorate in educational leadership and curriculum and instruction.

Key P21 Resources

- P21 Common Core Toolkit
  www.P21.org/P21Toolkit
- Assessment of 21st Century Skills
  http://www.p21.org/storage/documents/Assessment092806.pdf
- P21 Mile Guide: Milestones for Improving Learning & Education
  http://www.p21.org/our-work/resources/for-educators/800

Executive Summaries of P21 Surveys

- AMA 2012 Critical Skills Survey
  http://www.amanet.org/uploaded/2012-Critical-Skills-Survey.pdf

- Key Findings: Are They Really Ready To Work? 2006 Survey
  http://www.p21.org/storage/documents/key_findings_joint.pdf

- Voter Attitudes on 21st Century Skills
  http://www.p21.org/storage/documents/P21_pollreport_singlepg.pdf

Martin West

Martin West is Associate Professor of Education at the Harvard Graduate School of Education, Deputy Director of the Harvard Kennedy School's Program on Education Policy and Governance, and Executive Editor of Education Next, a journal of opinion and research on education policy.

His research examines the effects of education policy choices on student achievement and non-cognitive skills, as well as the politics of American education. His current projects include a federally-funded randomized trial of the use of interim assessment data to improve instruction and studies of the causal effect of grade retention on educational attainment, charter school impacts on cognitive and non-cognitive skills, and the views of teachers and the general public on education policy.

West is currently on leave to work as Senior Education Policy Advisor to the ranking member of the Senate Committee on Health, Education, Labor, and Pensions. He has also taught at Brown University and served as a research fellow in Governance Studies at the Brookings Institution, where he is now a Non-resident Senior Fellow. A 1998 graduate of Williams College, he received his M.Phil. in Economic and Social History from Oxford University in 2000 and his Ph.D. in Government and Social Policy from Harvard in 2006.

Promise and Paradox:

Measuring Non-Cognitive Traits of Students and the Impact of Schooling

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November 2013

Abstract

We used surveys to gather information on a broad set of non-cognitive traits from 1,368 8th-grade students attending Boston public schools and linked this information to administrative data on their demographics and test scores. Scales measuring students' Conscientiousness, Self-control and Grit are positively correlated with test-score growth between 4th- and 8th-grade. Yet students who attend over-subscribed charter schools with higher test-score growth score lower, on average, on these scales than students attending district schools. Exploiting admissions lotteries, we replicate previous findings indicating positive impacts of charter school attendance on math achievement but find negative impacts on these non-cognitive traits. We provide suggestive evidence that this paradoxical result is an artifact of reference bias, or the tendency for survey responses to be influenced by social context. Our results therefore highlight the importance of improved measurement of non-cognitive traits in order to capitalize on their promise as a tool for informing education practice and policy.

Introduction

Recent evidence from economics and psychology highlights the importance of traits other than general intelligence for success in school and in life (Almlund et al. 2011; Borghans et al. 2008; Moffitt et al. 2011). Disparities in so-called non-cognitive skills appear to contribute to the academic achievement gap separating wealthy from disadvantaged students (Evans and Rosenbaum, 2008). Further, non-cognitive skills may be more malleable than cognitive ability, particularly beyond infancy and early childhood (Borghans et al. 2008; Cunha and Heckman 2009). Understandably, popular interest in measuring and developing students' non-cognitive skills has escalated (see, e.g., Tough 2012).

Non-cognitive is, of course, a misnomer. Every psychological process is cognitive in the sense of relying on the processing of information of some kind. Characteristic patterns of attending to and interpreting information underlie many if not most personality traits (Bandura 1999; Mischel and Shoda 1999). Moreover, emotion and personality certainly influence the quality of one's thinking (Baron 1982) and how much a child learns in school (Duckworth and Seligman 2005).

Why, then, does the term *non-cognitive* persist? *Cognitive* in this context is shorthand for cognitive ability and knowledge, constructs that can be validly measured by standardized intelligence and achievement tests. Non-cognitive, therefore, has become a catchall term for skills and traits not captured by assessments of cognitive ability and knowledge. Many educators prefer the umbrella term "social and emotional learning," whereas some psychologists and philosophers embrace the moral connotations of "character" and "virtue."

Educators are increasingly interested in developing students' non-cognitive skills in support of academic success and long-term life outcomes. For example, several high-performing

charter management organizations have implemented comprehensive discipline systems aimed at molding student behavior in school and beyond (e.g. homework completion) in pro-social and pro-academic directions (Lake et al. 2012). KIPP Academies goes so far as to issue a regular "Character Report Card" for each student that tracks the development of various non-cognitive skills. Related efforts include the movement to address social and emotional learning needs of students alongside traditional academic goals (Durlak et al. 2011). One indication of this movement's growing policy influence is the U.S. Department of Education's August 2013 approval of waiver of federal accountability requirements requested by a consortium of eight school districts known as the California Office to Reform Education (CORE). The CORE districts, which collectively serve more than one million students, proposed a new school accountability metric that weights achievement test outcomes as only 60 percent of overall performance, with the balance assigned evenly to measures of school climate and student social-emotional development.

As practice and policy race forward, however, research on the measurement of non-cognitive traits remains in its infancy. There is little agreement on which non-cognitive traits are most important and limited evidence on their relative malleability. There are neither widely accepted standards for the application of extant measures nor evidence on their susceptibility to gaming if used for high-stakes purposes. Absent consensus on these points, educators cannot rely on available measures of non-cognitive traits or their underlying theories of personal development to assess and support individual students or to evaluate the success of schools, teachers, or interventions. As if to illustrate this dilemma, the CORE waiver request noted only that the specific social-emotional measures to be incorporated into school evaluations would be determined at a later time.

In this paper, we draw on cross-sectional data from an unusually large sample of students in the city of Boston to examine the strengths and limitations of extant survey-based measures of four prominent non-cognitive traits as tools for practice and policy. We used survey instruments to gather self-reported information on non-cognitive traits from a sample of more than 1,300 8th-grade students across a wide range of the city's public schools and linked this information to administrative data on the students' demographics and test score performance. The schools attended by students in our sample included both open-enrollment public schools operated by the local school district and over-subscribed charter schools that have been shown to have large positive impacts on student achievement as measured by state math and English language arts tests (Abdulkadiroglu et al. 2011; Angrist et al. 2013).

The non-cognitive traits we measured and focus on in this paper include Conscientiousness, Self-Control, Grit, and Implicit Theory of Intelligence (ITI). Of the many non-cognitive traits that psychologists have studied, Conscientiousness and Self-Control have arguably the strongest evidence of predictive power over long-term outcomes even when controlling for cognitive skills and demographics (Almlund et al. 2011). We also consider two newer measures, Grit and ITI, because of their current salience among educators seeking to influence non-cognitive traits to support immediate academic success and long-term life outcomes. Grit refers to the tendency to sustain interest in and effort toward very long-term goals (Duckworth et al. 2007), while ITI is a measure of students' academic mindset – in particular the extent to which they believe that their academic ability can improve with effort, rather than being fixed by factors outside of their control (Blackwell et al. 2007).

Our results highlight both the potential value of these measures in explaining the proximate outcome of academic success and a less discussed paradox that may be inherent to

many available measures of non-cognitive traits. The promise is illustrated by the fact that the non-cognitive traits we measure through student self-reports are generally correlated with both the level at which students perform on standardized tests and the growth in their test scores over the previous four years. The paradox is illustrated by the fact that differences in the mean levels of three of the four non-cognitive traits between district and charter schools are in the opposite direction of what would be expected based on these student-level correlations. Students who attend over-subscribed charter schools score lower, on average, on measures of Conscientiousness, Self-Control, and Grit than students attending open-enrollment district schools. Exploiting data from the admissions lotteries for these schools, we replicate previous findings indicating positive impacts of charter school attendance on math achievement within the students in our sample but find large and statistically significant negative impacts on these non-cognitive traits. This pattern is especially puzzling in light of the emphasis the over-subscribed charter schools in our study place on behavior management and character development as a means to foster academic success (Angrist et al. 2013; Seider 2012).[1]

Two competing hypotheses could explain this paradox. One is that the measures of non-cognitive traits are accurate and that the charter schools, contrary to their goals, and despite their success in raising test scores, reduce students' non-cognitive abilities along crucial dimensions such as Conscientiousness and Self-Control. An alternative hypothesis is that the measures, all self-reported by students, are misleading because they are prone to reference bias – the tendency for survey responses to be influenced by the context in which the survey is administered. We find suggestive evidence supporting this alternative hypothesis, highlighting the importance of

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[1] In contrast with these outcomes, we find that students in over-subscribed charter schools score higher on ITI. Our lottery-based analysis, however, shows no effect of charter school attendance on ITI.

improved measurement of non-cognitive traits in order to capitalize on their promise as a tool for informing education practice and policy.

Measurement of Non-Cognitive Traits and the Perils of Reference Bias

Recognition of the importance of non-cognitive traits has, with few exceptions, preceded the development of valid and reliable measures thereof. Whereas performance tasks to assess how well children can read, write, and cipher are widely available, non-cognitive skills are typically assessed using self-report and, less frequently, informant-report questionnaires. Like standardized achievement tests, questionnaires have the advantage of quick, cheap, and easy administration.

Like all measures, questionnaires have limitations. Most obviously, questionnaires are subject to social desirability bias (to seem more attractive to observers or to oneself) and faking. When endorsing a survey item such as "I am a hard worker" a child (or her teacher or parent) might be inclined to choose higher ratings. To the extent that social desirability bias is uniform within a population under study, it can alter the absolute level of individual responses but not their rank order. If some individuals are more influenced by social pressure than others, however, their relative placement within the overall distribution of responses can change.

Less obvious but possibly more pernicious is reference bias, or the extent to which responses are influenced by implicitly held standards of comparison. When considering whether "I am a hard worker" should be marked "very much like me," a child must conjure up mental image of "a hard worker" to which she can then compare her own habits. A child with very high standards might consider a hard worker to be someone who does all of her homework, well before bedtime and, in addition, organizes and reviews all of her notes from the day's classes.

Another child may consider a hard worker to be someone who attempts to bring home her assignments, even if most of them remain unfinished by the next day.

Reference bias was first documented in cross-cultural psychology, and, indeed, culturally shared standards are a primary influence on implicit standards of comparison. In studies of distinct ethnic groups, cultural experts have often drawn conclusions which were not borne out by self-report questionnaires. For instance, self-report questionnaires of values (e.g., living an exciting life, honoring parents and elders, respect for tradition) by Chinese and Americans hardly converge with judgments by cultural experts (Peng, Nisbett, & Wong, 1997). Likewise, among 56 nations in a cross-cultural study of self-reported personality, East Asian countries including Japan, China, and Korea rated far lower in conscientiousness than any other region (Schmitt et al., 2007). In a separate cross-cultural study by Heine et al. (2008), self-reported conscientiousness at the country level (i.e., the average self-reported conscientiousness rating for citizens of a particular country) was inversely correlated with several objective proxies for conscientiousness, including postal workers' speed, accuracy of clocks, walking speed, and longevity.

The cultural heterogeneity of the United States allows similar reference bias effects to operate within the same country. In fact, some evidence for reference group bias among American students already exists. Naumann and John (2013) found that European-American undergraduates at UC Berkeley rated themselves higher in conscientiousness than did their Asian-American classmates, despite earning lower GPAs. The paradoxical finding disappeared when both groups are asked to complete the same questions with an explicit referent group of "typical Asian-American Berkeley student."

Other than ethnicity, what are likely influences on implicit frames of reference? Because children (like adults) are far from omniscient, unable to see the full distribution of human functioning, their peer groups and other aspects of their social context are likely to shape how they evaluate themselves when considering statements such as "I am a hard worker." It follows that the environment of the school in which they spend much of their waking lives could exert a powerful influence on students' perspectives on their own attributes. At a low-performing school, where the implicit standard for "hard worker" may be considerably more lax than at a high-performing school, reference bias might even be so severe as to reverse the expected pattern of student responses.

Data and Measures

Sample

To shed light on the extent to which survey-based measures of key non-cognitive traits are subject to reference bias in a policy-relevant setting, we collected data from a large sample of 8th-grade students attending 32 of the 49 public schools in the city of Boston with an 8th-grade cohort in the spring semester of the 2010-11 school year. The schools that agreed to participate in the study included 22 open-enrollment district schools, 5 over-subscribed charter schools, 2 test-in exam schools, and 3 charter schools which were not over-subscribed at the time the students in our study entered middle school. Within those schools, we sampled all students for whom we were able to obtain parental consent to participate in the study and who were in attendance on the day we collected our data.

We obtained school enrollment and demographic information, data on attendance and suspensions, and math and ELA test scores on the Massachusetts Comprehensive Assessment

System (MCAS) for the students in our sample from databases maintained by the Massachusetts Department of Elementary and Secondary Education. MCAS scores were standardized to have mean zero and unit variance by grade, subject, and year across all tested students in Massachusetts. We limit our analysis to the 1,368 of a total of 1,852 students who participated in the non-cognitive data collection for whom a MCAS math and ELA scores were available in 2007 (when most students were in 4th grade) and 2011, making it possible to track their academic progress and school enrollment since they entered middle school.

Table 1 compares the demographic characteristics and academic indicators of students in our analytic sample to those of all 8th-grade students attending public schools in Boston, as well as to those of 8th-graders attending schools participating in the study. The demographic characteristics of sampled students are quite similar to those of all 8th-grade students attending public schools in the city and to those of 8th-graders attending the same schools. However, the 8th-grade test scores of sampled students are 0.26 standard deviations and 0.19 standard deviations higher in math and ELA, respectively. Comparing the test scores of the sampled students to those of 8th-graders attending the same schools reveals that more than half of this difference reflects positive selection into the study sample within participating schools.

Much of our analysis focuses on comparisons between sampled students attending open-enrollment district and over-subscribed charter schools. Looking separately at these two groups of schools, we see that this positive selection with respect to academic indicators is somewhat more pronounced within the district schools. Specifically, the 8th-grade test scores of sampled students in district schools exceeded those of all students by 0.15 (math) and 0.11 (ELA) standard deviations, while the analogous differences in the over-subscribed charter schools were 0.05 (math) and 0.01 (ELA). This difference does not appear to stem from substantially higher

rates of participation in the study within the charter schools: the share of all 8th-graders

participating in the study was 63 percent in the over-subscribed charter schools, as compared

with 61 percent in the open-enrollment district schools.

Table 1 also reveals that the 8th-grade test scores of sampled students are considerably

higher in the over-subscribed charter schools. The test scores of students in these schools

exceeded the statewide mean by 0.27 (math) and 0.37 (ELA) standard deviations, while students

in open-enrollment district schools trailed the statewide average by -0.69 (math) and -0.33 (ELA)

standard deviations. The students in our sample attending over-subscribed charter schools also

experienced larger gains in test scores (relative to the statewide average) between 4th and 8th

grade, especially in math. Charter students gained 0.72 standard deviations relative to the state

average over those four years, while their district peers lost 0.07 standard deviations. The

difference in ELA gains was less pronounced, with charter and district students making positive

gains of 0.92 and 0.72 standard deviations, respectively. Sampled students in over-subscribed

charter schools were also 10 percentage points more likely to be white, 16 percentage points less

likely to be Hispanic, and 21 percentage points less likely to be eligible for a free or reduced

price lunch than their counterparts in open-enrollment district schools.

Non-cognitive Measures

All students participating in our study completed a battery of surveys designed to

measure their cognitive and non-cognitive abilities along various dimensions. These surveys,

which were administered in the students' regular classrooms, included questionnaires probing

students' Conscientiousness, Self-Control, Grit, and ITI that have been validated for adolescents.

After scoring student responses to these questionnaires based on the appropriate rubrics, we then

standardized the scores to have a zero mean and unit variance within our analytic sample.

To assess students' Conscientiousness, we administered the Big Five Inventory (John and Srivastava 1999), a well-established 44-item questionnaire measuring the "Big Five" personality traists: Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. Students endorsed items (e.g., "I think I am someone who is a reliable worker") using a 5-category Likert scale, where 1= *strongly disagree* and 5 = *strongly agree*. Each student's Conscientiousness score is calculated as the average of their response the 9 items that comprise the Conscientiousness scale. Among the students in our data, this Conscientious scale had an internal reliability of 0.76.

Our Self-Control scale is based on an 8-item questionnaire developed to measure school-age students' impulsivity (its obverse), which is defined as "inability to regulate behavior, attention, and emotions in the service of valued goals, impulsivity" (Tsukayama et al. 2013). This questionnaire asked students to indicate how often during the past school year they exhibited each of a set of behaviors indicative of a lack of self-control, with 5 response options ranging from "almost never" to "at least once a day." Importantly, the use of response categories specifying objective, discrete time periods was motivated by a desire to "avoid reference bias" in students' responses (Tsukayama et al. 2013, p. 881). The questionnaire included 4 items measuring inter-personal self-control (e.g., "I interrupted other students while they were talking") and 4 items measuring intra-personal self-control (e.g., "I forgot something I needed for class"). We calculated an overall Self-Control score for each student as the average of their (reverse-coded) responses to all 8 items. This scale had an internal reliability of 0.83.

Students also completed the 8-item Short Grit Scale (Grit-S) developed by Duckworth and Quinn (2009) to measure trait-level persistence toward long-term goals.[2] Students endorsed

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[2] Duckworth and Quinn (2009) demonstrate that adolescents' Grit-S scores predict future GPA independently of IQ and are inversely related to the number of hours of television watched.

a series of items (e.g., "New ideas and projects sometimes distract me from old ones" and "I finish whatever I begin") using a 5-category Likert Scale, where 1 = *not like me at all* and 5 = *very much like me*. Student's Grit score was then calculated as their mean response across all 8 items. This scale had a somewhat lower internal reliability among the students in our sample than our Conscientiousness and Self-Control scales (0.64).

Finally, to probe students' Implicit Theory of Intelligence, we administered a set of 3 items measuring the extent to which students view intelligence as a fixed trait rather than one which can improved with effort (Dweck, 1999). For example, students were asked to rate their agreement with the claim that "You have a certain amount of intelligence, and you really can't do much to change it." Following Blackwell et al. (2007), we used a 6-category Likert scale, where 1 = *strongly disagree* and 6 = *strongly agree*. After reverse coding, we calculated each student's mean response across these three items to create a scale with an internal reliability of 0.86. Following recent work (see, e.g., Yeager et al. 2013), we refer to this scale as measuring the extent to which students have a Growth Mindset (as opposed to a Fixed Mindset).[3]

Student Perceptions of School Climate

The battery of surveys students completed also included a set of 10 items probing the disciplinary climate at their school. These items were drawn from a survey developed over the past decade by Ron Ferguson and the Tripod Project for School Improvement to measure various aspects of school or classroom climate. Each item asked students to respond to a descriptive statement about their school using a 5-category Likert scale, where 1 = *totally untrue* and 5 = *totally true*. The overall set included two items on each of five dimensions of school climate: High Expectations (e.g., "Teachers at this school demand that students work hard"); Teacher

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[3] Blackwell et al. (2007) show that adolescent students who exhibit a Growth Mindset have significantly higher rates of math test score growth than students who view intelligence as fixed.

Strictness (e.g., "Teachers are very strict here"); Clear Rules (e.g., "Students understand what will happen to them if they break a rule"); Negative Peer Effects (e.g., "In this school, some students try to keep others from working hard"); and Student Input (e.g., "Students in this school have a say in how things work"). We use the average of each student's responses to the two items within each pair as a measure of his or her perception of the relevant aspect of the school's climate.

Achievement Gains

We also used our administrative data to estimate measures of each student's test score growth in math and English language arts between 4th- and 8th-grade. Specifically, we regressed students' 8th-grade MCAS test scores in the relevant subject on a cubic polynomial of their 4th-grade test scores in both subjects and calculated the residual from that regression for each student. We use these residualized gain scores, which capture the extent to which a student's 8th-grade performance in math and English language arts exceeded expectations based on their performance four years earlier, to examine the relationship between non-cognitive traits and improvements in test score performance over time.

Results

Correlations of Non-cognitive Traits and Academic Indicators

Table 2 reports student-level Pearson product-moment correlations among the full set of non-cognitive traits and academic indicators included in our analysis. Given that Conscientiousness, Self-Control, and Grit are closely related constructs, it is unsurprising that they are highly inter-related, with correlations ranging from .43 to .66. Growth Mindset is also positively and significantly correlated with each of these measures, but at lower levels ranging from .08 (Conscientiousness) to .18 (Grit).

Among these four non-cognitive measures, Growth Mindset is most strongly related to test score levels in 8th grade ($r = 0.32$ in math; $r = .36$ in ELA). Self-Control is also significantly related to test scores, but the correlations are .13 in math and .10 in ELA. The correlations between both Conscientiousness and Grit and test score levels are positive but small and statistically insignificant.

Of greater interest are the relationships between the non-cognitive measures and residualized test score gains, which measure students' academic progress relative to expectations based on their performance in 4th grade. Each of the four non-cognitive measures is positively correlated with test score gains in both math and ELA; all of these correlations except that between Self-Control and ELA gains are statistically significant. The relationships are strongest for Growth Mindset, which has correlations with test score gains of .21 and .17 in math and ELA, respectively.

There is also some evidence that these non-cognitive measures are related to suspensions and absences, the two behavioral indicators available in our administrative data. All four non-cognitive measures are negatively correlated with the total number of suspensions or absences a student accumulated in 8th grade. Those correlations that are statistically significant include Self-Control with both suspensions (-.14) and absences (-.12), Grit with suspensions (-.12), and Growth Mindset with absences (-.10).

Mean Non-cognitive Traits and Academic Indicators by School Type

Table 3 compares the mean test-score gains and non-cognitive traits for students attending the 22 open-enrollment district and 5 over-subscribed charter schools included in our sample. Consistent with the descriptive statistics in Table 1, mean residualized test score gains between 4th and 8th grade are higher among students attending charter schools. The differences

are substantial, at 0.72 standard deviations in mathematics and 0.42 standard deviations in ELA, though it is important to note that they could reflect the selection of students into the application process for over-subscribed charter schools rather than differences in school quality.

Despite the fact that sampled students attending charter schools experienced larger test score gains than sampled students in district schools, the same students exhibit markedly lower levels of Self-Control as measured by student self-reports. This statistically significant difference of -0.23 standard deviations is in the opposite direction of that expected based on the positive student-level correlations between Self-Control and achievement gains evident in Table 2. The differences between the charter and district students in Conscientiousness (-0.09) and Grit (-0.13), although statistically insignificant, run in the same counter-intuitive direction. Interestingly, the difference in mean Growth Mindset between charter school and district school students follows a different pattern than the other three non-cognitive traits. Charter school students score 0.38 standard deviations higher, on average, which is consistent with the student-level correlation between Growth Mindset and test score gains within the sample as a whole.

Lottery-Based Estimates of the Effect of Charter School Attendance

Simple comparisons of the outcomes of students attending charter and traditional public schools, such as those presented in Table 3, capture both any effects of attending a charter school on those outcomes and selection into charter schools based on characteristics correlated with the outcome. Although over-subscribed charter schools must admit students via lottery, applicants who seek to enroll in an academically demanding charter school are likely to differ from those who do not along both observed and unobserved dimensions. To better isolate the causal effect of attendance at the five over-subscribed charter schools represented in our sample, we exploit the lottery admissions process to these schools to restrict our analysis to students who entered the

admissions lottery of one or more of the over-subscribed charter schools and compare those students who were randomly offered admission to those who were not.

We acquired records from the lotteries used to admit the students in our sample directly from the charter schools and matched these records to state administrative data on all public school students using names, year, and grade of application. Of 702 verified lottery participants (481 of whom were offered a seat in one or more of the five schools), 497 appeared in the administrative data and had valid demographic data and test scores for both subjects in 2007 and 2011. A smaller subset of 200 students met those requirements and participated in the non-cognitive data collection. Although we can produce lottery-based estimates of charter school impacts on non-cognitive traits only in the latter sample, we present estimated impacts on test scores for both groups in order to be able to compare the results. To the extent that our estimated impacts on test scores are similar across the two groups, this should reduce concerns that our results are biased due to non-random sampling of successful and unsuccessful applicants.

Table 4 examines whether the demographic characteristics and 4th-grade test scores of students offered and not offered a seat in a charter school were balanced within these two subsamples of lottery participants. We first note that within both subsamples the share of applicants who were offered a seat (32 percent in the administrative data sample and 29 percent in the non-cognitive sample) is very similar to the share among all lottery applicants (31 percent). F-tests nonetheless reveal that students' observed characteristics are jointly significant predictors of whether they were offered a seat in a charter school in both subsamples.

In the larger sample of students matched to the administrative data, students receiving an offer are significantly more likely to be male and eligible for a free or reduced price lunch. The 4th-grade test scores of students offered a seat are also modestly lower in both math and ELA,

though these differences are not statistically significant. Within the smaller non-cognitive sample, the differences in 4th-grade test scores are substantial in both subjects and marginally statistically significant in math (p<0.09). These differences, which favor students not offered a charter school seat, may reflect the fact that positive selection into the non-cognitive sample was less pronounced in over-subscribed charter schools (see Table 1). Given the imbalances between students offered and not offered a seat in a charter in both samples, we control for students' observed characteristics throughout our lottery-based analysis of the effects of charter school attendance.

Following (Abdulkadiroglu et al. 2011), we implement the lottery-based analysis via a Two Stage Least Squares (2SLS) regression model in which we first predict charter attendance for each student based on whether they were offered admission and use those predictions to generate an estimate of the effect of charter attendance on our outcomes of interest. The first-stage model is:

$$YEARS_i = \gamma_c OFFER_{ic} + \theta A_{i,t-4} + \tau X_i + \sum_j \rho_j d_{ij} + \xi_{is}$$

where $YEARS_i$ measures the number of years between 5th and 8th grade student i attended an over-subscribed charter school and $OFFER_{ic}$ represents a vector of dummy variables indicating that the student was or was not offered a seat at over-subscribed charter school c. We include as controls a cubic polynomial of lagged 4th-grade scores in math and ELA ($A_{i,t-4}$) and a vector of student demographic characteristics (X_i,) including gender, race, age, free and reduced-priced lunch status, limited English proficiency, and special education status. The set of indicator variables d_{ij} controls for lottery "risk sets," or the unique combination of lotteries to which each student applied, indexed by j.

Within the administrative data sample, students offered a seat in at least one of the five over-subscribed charter schools spent 2.1 years between 5th and 8th grade in one of those schools, as compared with 0.39 years of charter attendance among students not initially offered a seat. Among students in the non-cognitive sample, students offered and not offered a seat spent 2.4 and 0.6 years in charter schools, respectively. Appendix Table A2, which presents the first-stage regression results, confirms that the $OFFER_{ic}$ indicators are relevant instruments for predicting variation in years of attendance, with joint F-test statistics of 35.5 and 16.0 for the administrative data and non-cognitive samples, respectively.

We implement the second stage of our 2SLS model as follows:

$$Y_{is} = \beta \widehat{Years}_i + \alpha A_{i,t-4} + \lambda X_i + \sum_j \delta_j d_{ij} + \epsilon_{is}$$

where Y_{is} represents a given test score or non-cognitive outcome for student *i* in school *s*, $\widehat{YEARS}_{is}$ captures each student's predicted years of charter attendance based on the first-stage regression, and all other variables are as above. Parameter β represents the quantity of interest: the effect of one year's attendance at one of the five over-subscribed charter schools.

Table 5 presents the results. Consistent with Abdulkadiroglu et al. (2011), the first two columns show that, among the students in the administrative data sample, each additional year of charter attendance is estimated to increase 8th-grade math scores by 0.14 standard deviations. The estimated effect for ELA scores is positive and of non-negligible magnitude, but too imprecisely estimated to achieve statistical significance. We replicate these analyses in our non-cognitive sample and find very similar point estimates in both math and ELA; the math effect is statistically significant at the $p < 0.1$ confidence level. The similarity of results across the two samples suggests that our lottery-based effect estimates on non-cognitive skills are unlikely to

suffer from substantial biased due to non-random sampling of students who participated in our non-cognitive data collection.

Within that sample, we estimate that one year's attendance at an over-subscribed charter school had a statistically significant negative effect on students' self-reported Conscientiousness, Self-Control, and Grit. The estimated effect sizes are in the opposite direction of the achievement effects and of similar or even larger magnitude, ranging between -0.117 (Grit) and -0.212 (Self-Control) standard deviations. These results are consistent with the descriptive patterns in Table 3, which show students in over-subscribed charter schools making larger achievement gains despite lower scores on these non-cognitive measures, and suggest that those patterns are not due merely to selection. Rather, it would appear that attending one of these charter schools adversely affects students' non-cognitive abilities along these dimensions as assessed by self-reports. We discuss our interpretation of this unexpected finding in detail below.

Intriguingly, we estimate a near zero effect of attending an over-subscribed charter schools on the degree to which a student in our non-cognitive sample has a Growth Mindset, despite the fact that Table 3 showed students in over-subscribed charter schools scoring notably higher on this measure. The null result for this outcome in the lottery analysis suggests that the descriptive difference favoring charter schools may be an artifact of selection. In other words, it may be that students who believe that their intelligence can be improved with effort are more likely to seek out a school with a demanding environment, but that attendance at such a school has no causal effect on their implicit theory of intelligence.

Longitudinal Trends in Non-Cognitive Traits

We supplement our lottery analysis with longitudinal measures of students' non-cognitive traits among a cohort of students who attended two over-subscribed charter schools and one

open-enrollment district school. Starting in fall 2009, we administered a similar battery of non-cognitive measures to the entering student cohorts at three middle schools. We then re-administered these batteries at the end of that school year and the two that followed. One of the charter schools and the district school are both included in our larger study sample, while the second charter school is located in another school district but shares a similar academic and disciplinary orientation to the over-subscribed charters in our sample.

In Table 6, we present average scores for the 2009 entering cohort of students in each school for whom we have complete data across four time points.[4] Consistent with our lottery-based estimates of the negative effects of attending a charter school on non-cognitive skills as assessed by self-reports, we observe a steady decline in students' Conscientiousness, Self-Control, and Grit. Among students attending the district school, scores on these scales decline at a more moderate pace; in two cases, the changes between the first and final time points are not statistically significant. Also consistent with our lottery-based estimates, we observe a gradual increase in Growth Mindset among oversubscribed charter school students which is mirrored by a similarly large increase among students at the district school.

Evidence of Reference Bias

The results presented thus far contain divergent evidence concerning the relationship between non-cognitive traits and achievement gains among the 8th-grade students in our sample, particularly with respect to the related constructs of Conscientiousness, Self-Control, and Grit. Student-level correlations indicate significant positive correlations between these non-cognitive traits and test score growth – a pattern consistent with a large body of research using the same or similar measures. However, we find that students in over-subscribed charter schools with large positive impacts on student test scores rate themselves more critically along each of these

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[4] Appendix Table A2 reports the same averages using all available data; the patterns are substantively identical.

dimensions. Our lottery-based analysis indicates that these same charter schools have large

negative "effects" on students' self-reported levels of Conscientiousness, Self-Control, and Grit,

suggesting the descriptive findings are not explained by the selection into charter schools of less

conscientious or more impulsive students. It is of course possible that the over-subscribed charter

schools in our sample improve student test scores at the expense of cultivating students' non-

cognitive capacities in these areas. Yet it is seems more likely that the apparent negative effects

of charter school attendance on these non-cognitive traits are an artifact of reference bias.

     We present two additional analyses intended to establish the plausibility of reference bias

as an explanation for these counter-intuitive findings. First, we compare students' perceptions of

the academic and disciplinary climate in open-enrollment district and over-subscribed charter

schools to see whether those perceptions differ in a way that could influence students' self-

ratings of their non-cognitive capacities. It could be that students are more likely to use a higher

bar when assessing their own Conscientiousness, Self-Control, and Grit when they attend schools

that establish high expectations for student effort and a "no-excuses" disciplinary culture.

Second, we examine how the strength of the relationship between our non-cognitive measures

and achievement growth changes if we use school fixed effects to limit the analysis to variation

occurring within specific schools. If the environment of the school students attended and in

which they completed our survey influenced their responses so as to produce the counter-

intuitive findings concerning the effects of charter school attendance, the within-school

correlations between non-cognitive measures and achievement growth should be stronger than

the analogous correlations that capture both between- and within-school variation.

     Table 7 confirms that students attending over-subscribed charter schools perceive their

schools as having very different academic and disciplinary climates than students attending

open-enrollment district schools. Students in over-subscribed charter schools rate the work ethic expected of students, teacher strictness, and the clarity of rules in their school substantially higher do students in district schools. For example, charter students' ratings of High Expectations exceed those of their district counterparts by 0.57 on the 5-point scale used for these items, or 63 percent of a standard deviation of district students' responses. The analogous differences observed for Teacher Strictness and Clear Rules are of comparable magnitude. Students in the over-subscribed charter schools also reported substantially lower levels of Negative Peer Effects and modestly lower levels of Student Input in their schools.

Table 8 in turn confirms that the relationships between Conscientiousness, Self-Control, and Grit and test score growth among students attending the same school are consistently stronger than the same relationships across the sample as a whole. For example, the magnitude of the relationship between Self-Control and test score growth increases by 61 percent in math and 93 percent in ELA. Importantly, the same pattern is not evident for Growth Mindset, the one non-cognitive measure in which we did not find counter-intuitive evidence of adverse effects of attending an over-subscribed charter school. The relationship between Growth Mindset and test score growth is essentially unchanged in ELA and becomes weaker in math when between-school variation is excluded.

Discussion

Generations of parents have sought to instill in their children the virtues of self-discipline, diligence, and perseverance, and self-discipline. These qualities are at the core of legends and fables that societies around the world have developed to cultivate the traits most essential for human flourishing. In recent decades, scholars have begun to confirm this common wisdom by

developing measures for these non-cognitive traits and examining their relationship with children's success in school and in life. We add to this literature evidence that four prominent and widely used measures of non-cognitive traits are positively correlated with achievement gains on standardized tests among a large and diverse sample of 8th-grade students attending distinctly different types of schools. Measures of Conscientiousness, Self-Control, Grit, and Growth Mindset were all correlated with math and ELA test score gains from 4th to 8th grade. Higher non-cognitive ability along the dimensions captured by these measures therefore may help explain why 8th-grade students score higher or lower than predicted by their 4th-grade achievement levels.

However, a paradox emerges when we juxtapose these results with two additional findings: 1) that students in a set of over-subscribed charter schools, where students are experience large test score gains, report lower average levels of Conscientiousness, Self-Control, Grit than students in open-enrollment district schools; and 2) that lottery-based analyses of the causal impact of attending these charter schools indicate negative "effects" on these non-cognitive traits. How can non-cognitive skills that are positively correlated with test score gains within our sample have deteriorated among students in schools where they were simultaneously achieving large test score improvements?

Two competing hypotheses could explain the paradox. One is that these measures are accurate and that the charter schools' actions actually reduce students' non-cognitive abilities along crucial dimensions such as conscientiousness and self-control. In that case, the academic gains posted by these schools occur in spite of their negative effects on these non-cognitive measures.

An alternative hypothesis is that these measures, all based on student self-reports, are misleading because they are prone to reference bias—the tendency for individuals responding to questionnaires to rate themselves based on the varying localized sample of people with whom they are familiar, not the broad sample of all respondents to whom their responses are being compared. Put specifically for these circumstances, students attending academically intense charter schools may redefine upward their notion of what it means to demonstrate strong self-control or a conscientious work ethic and thus rate themselves more critically, even if they are in fact improving on the underlying behavior. In theory, such reference bias could be so severe as to distort the magnitude of any changes in the underlying traits and even to invert their sign.

We find support for this alternative hypothesis not only in our data set, but also in other recent evaluations of high-performing charter middle schools. In their recent evaluation of KIPP Academy middle schools, Tuttle et al. (2013) find large positive effects of attending a KIPP school on student test scores and time spent on homework, but find no effects on student-reported measures of self-control and effort or persistence in school and negative effects on student-reported measures of undesirable behavior. Similarly, Dobbie and Fryer's (2013) find that attending the Harlem Promise Academy reduced student-reported Grit despite having positive effects on test scores college enrollment and negative effects on teenage pregnancy (for females) and incarceration (for males).[5] These parallel findings from research in similar settings strengthen our conclusion that reference bias provides the most likely explanation for the unexpected patterns we document.

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[5] Reference bias also may help explain seemingly paradoxical results in other areas of education research. For example, Robbins et al. (2006), report that first-year students at two-year colleges rate themselves higher in an ACT-developed measure of academic self-discipline that is predictive of college GPA and persistence than do seniors bound for four-year colleges, despite having lower ACT scores, high school GPAs, and subsequent rates of persistence.

Conclusion

Our results suggest three things: (1) that existing measures of non-cognitive traits based on self-reports help to explain important, proximate academic outcomes – test score gains over the middle school years – beyond what previous test scores predict and therefore show promise as traits for schools to learn to measure and influence; (2) that schools can have significant, even if initially surprising, impacts on these measures; and (3) that conclusions about the nature of those impacts may be misleading due to reference bias. The challenges posed by reference bias may grow more severe to the extent that schools explicitly work to change students' traits and thereby change their reference frames.

Our study has important limitations. First, our evidence of the importance of reference bias is circumstantial rather than direct. Second, we have documented the potential problem posed by reference bias without providing a solution to overcome it. In particular, we have not examined whether teacher or parent ratings of students' non-cognitive traits may be less prone to reference bias. Alternative solutions could include the use of anchoring vignettes within surveys to establish consistent reference points (King et al. 2004) or the development of behavioral indicators of non-cognitive traits that render reference points irrelevant (Jackson et al. 2010). Additional research that documents the conditions under which reference bias exists and validates strategies to address it is critical.

The current policy environment demands accountability, and accountability requires assessment. In the rush to embrace non-cognitive skills as the missing piece in American education, policymakers may overlook limitations of extant measures of non-cognitive skills. Our results raise important questions about the practice of assessing students' non-cognitive traits based on the existing instruments that rely on student self-reported data. In particular,

studies of the effects of teacher, school, and family influences on non-cognitive skills could lead to false conclusions if the assessments used are biased by distinct frames of reference. Biased measures could similarly misguide scientific investigation of non-cognitive skills.

If we are correct that these measures show both promise and peril, it is imperative that the nascent field of measuring and seeking to improve non-cognitive traits through schooling develop new, better measures that are less susceptible to reference bias and therefore more likely to be robust enough to play a constructive role in managing and evaluating students, programs, and schools. We can and should measure students' non-cognitive traits, but we should do so in full recognition of the flaws in our measures.

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Table 1: Mean student demographic characteristics and academic indicators by school type among all public schools in Boston, sampled schools, and sampled students

	Public Schools in Boston			Open-enrollment District Schools		Over-subscribed Charter Schools	
	All Students	All Students in Sampled Schools	Sampled Students	All Students in Sampled Schools	Sampled Students	All Students in Sampled Schools	Sampled Students
Male	0.52	0.51	0.47	0.53	0.49	0.43	0.43
African-American	0.41	0.40	0.38	0.41	0.39	0.53	0.50
White	0.12	0.12	0.13	0.08	0.08	0.17	0.18
Asian	0.09	0.07	0.09	0.03	0.05	0.02	0.01
Hispanic	0.37	0.39	0.39	0.46	0.46	0.27	0.30
Free/Reduced Price Lunch	0.79	0.78	0.77	0.86	0.87	0.66	0.66
Limited English Proficient	0.12	0.12	0.11	0.17	0.16	0.00	0.00
Special Education	0.22	0.22	0.19	0.27	0.23	0.16	0.18
8th-Grade Math	-0.52	-0.42	-0.26	-0.84	-0.69	0.22	0.27
8th-Grade ELA	-0.23	-0.15	-0.04	-0.44	-0.33	0.37	0.38
4th-Grade Math	-0.45	-0.45	-0.35	-0.70	-0.62	-0.41	-0.37
4th-Grade ELA	-0.82	-0.80	-0.71	-1.10	-1.05	-0.68	-0.66
Suspensions	0.25	0.22	0.19	0.19	0.16	0.39	0.31
Absences	11.85	11.03	9.00	12.95	10.61	7.88	7.14
Number of schools	49	32	32	22	22	5	5
Number of students	3151	2121	1368	1483	906	234	148

Note: All samples are restricted to students with valid 2011 and 2007 MCAS scores. Sampled schools are schools participating in non-cognitive trait data collection; sampled students are those with valid data on at least one non-cognitive trait. Math and ELA test scores are standardized to have a mean zero and unit variance statewide.

Table 2: Correlation matrix of non-cognitive traits and academic indicators

	Consc.	Self-Cont.	Grit	Growth Mindset	8th-Grade Math	8th-Grade ELA	4th-8th Math Gain	4th-8th ELA Gain	Susp.	Abs.
Conscientiousness	1.00									
Self-Control	**0.47**	1.00								
Grit	**0.66**	**0.43**	1.00							
Growth Mindset	**0.08**	**0.10**	**0.18**	1.00						
8th-Grade MCAS Math	0.05	**0.13**	0.03	**0.32**	1.00					
8th-Grade MCAS ELA	0.05	**0.10**	0.04	**0.36**	**0.69**	1.00				
4th-8th Grade Math Gain	**0.10**	0.08	**0.12**	**0.21**	**0.63**	**0.38**	1.00			
4th-8th Grade ELA Gain	**0.09**	0.04	**0.08**	**0.17**	**0.26**	**0.62**	**0.44**	1.00		
Suspensions	-0.06	**-0.14**	**-0.12**	-0.04	**-0.10**	**-0.11**	-0.01	-0.03	1.00	
Absences	-0.06	**-0.12**	-0.03	**-0.10**	**-0.29**	**-0.25**	**-0.17**	**-0.11**	**0.13**	1.00

Note: Sample restricted to students with complete data on each indicator (N=1,340); bolded entries are statistically significant at $p<0.1$.

Table 3: Mean test-score gains and non-cognitive traits by school type

	Open-enrollment District School	Over-subscribed Charter School	Difference
MCAS Math Gain (4th-8th)	-0.015	0.708	0.723**
	(0.712)	(0.699)	(0.122)
	[906]	[148]	
MCAS ELA Gain (4th-8th)	-0.017	0.407	0.424**
	(0.684)	(0.697)	(0.120)
	[906]	[148]	
Conscientiousness	0.022	-0.069	-0.091
	(0.994)	(0.981)	(0.078)
	[890]	[145]	
Self-ontrol	0.001	-0.225	-0.226*
	(1.017)	(0.969)	(0.116)
	[891]	[145]	
Grit	0.034	-0.099	-0.133
	(0.986)	(1.009)	(0.093)
	[888]	[145]	
Growth Mindset	-0.121	0.260	0.381**
	(1.016)	(0.95)	(0.104)
	[887]	[144]	

Note: +$p<0.1$, *$p<0.05$, ** $p<0.01$; statistical significance is for difference in mean for over-subscribed charter schools and traditional public schools. In the first two columns, standard deviations are reported in parentheses and sample sizes in brackets. Standard errors reported in parentheses in the third column are adjusted for clustering by school. MCAS scores are standardized to have mean zero and unit variance statewide; non-cognitive traits are standardized to have mean zero and unit variance in the study sample.

Table 4: Balance of observed characteristics in admissions lotteries for over-subscribed charter schools

	Administrative Data Sample				Non-cognitive Sample			
	Offer	No Offer	Regression-Adjusted Difference	P-value	Offer	No Offer	Regression-Adjusted Difference	P-value
Male	0.501	0.437	0.100	0.099	0.420	0.368	0.054	0.532
African-American	0.590	0.513	0.013	0.779	0.517	0.544	-0.124	0.145
White	0.100	0.171	0.008	0.828	0.112	0.211	0.001	0.980
Asian	0.009	0.025	-0.016	0.312	0.014	0.018	0.007	0.691
Hispanic	0.277	0.278	-0.016	0.760	0.350	0.228	0.107	0.140
Free/Reduced Price Lunch	0.687	0.563	0.107	0.022	0.657	0.579	0.007	0.926
Limited English Proficient	0.032	0.070	-0.049	0.129	0.021	0.035	-0.022	0.530
Special Education	0.195	0.209	-0.003	0.956	0.140	0.123	0.009	0.884
4th Grade MCAS Math	-0.498	-0.395	-0.074	0.310	-0.334	-0.100	-0.172	0.091
4th grade MCAS ELA	-0.784	-0.615	-0.134	0.220	-0.617	-0.178	-0.307	0.110
Joint F-test statistic				0.003				0.000
Observations	339	158			143	57		

Note: Administrative data sample includes all applicants to over-subscribed charter schools matched to valid 2011 and 2007 test scores in the Massachusetts Department of Elementary and Secondary Education state database. Study sample includes students in the administrative data sample with valid data on at least one non-cognitive outcome. The first two columns for each sample provide the mean of each variable for students receiving at least one and no offers of admission to an over-subscribed charter school. Regression-adjusted differences control for fixed effects for lottery applicant risk sets used to estimate charter attendance effects. P-values are for the regression-adjusted difference.

Table 5: Instrumental variables estimates of the effects of a year's attendance at an over-subscribed charter school

	Administrative Data Sample	Non-cognitive Sample
8th Grade MCAS Math	0.138**	0.118+
	(0.039)	(0.062)
8th Grade MCAS ELA	0.039	0.048
	(0.043)	(0.048)
		[497]	[200]
Conscientiousness		-0.153+
		(0.075)
		[196]
Self-Control		-0.212*
		(0.095)
		[196]
Grit		-0.117*
		(0.053)
		[195]
Growth Mindset		-0.03
		(0.092)
		[195]

Notes: +$p<0.1$, *$p<0.05$, ** $p<0.01$. Standard errors reported in parentheses are clustered by 8th-grade school. Sample sizes for each outcome are in brackets. Each cell presents results from a separate regression. Administrative data sample includes all applicants to over-subscribed charter schools matched to valid 2011 test scores in the Massachusetts Department of Elementary and Secondary Education state database. Study sample includes students in the administrative data sample with valid data on at least one non-cognitive outcome. All regressions control for student gender, race, age, LEP, SPED, and free/reduced price lunch, cubic polynomials in 4th-grade MCAS ELA and math scores, and fixed effects for lottery applicant risk sets.

Table 6: Mean student non-cognitive traits in three middle schools over time, stable sample

	Fall Y1	Spring Y1	Spring Y2	Spring Y3
		Time Point		
		Conscientiousness		
Charter School 1	3.83	3.69	3.55	3.40
Charter School 2	3.70	3.70	3.49	3.34
District School	3.79	3.67	3.64	3.68
		Self-Control		
Charter School 1	3.48	3.22	3.08	2.91
Charter School 2	3.42	3.31	3.12	2.96
District School	3.46	3.31	3.22	3.26
		Grit		
Charter School 1	3.62	3.41	3.31	3.23
Charter School 2	3.58	3.44	3.20	3.24
District School	3.42	3.42	3.32	3.36
		Growth Mindset		
Charter School 1	3.74	4.25	4.50	4.40
Charter School 2	3.71	4.67	4.42	4.42
District School	3.74	4.30	4.26	4.44

Note: Sample restricted to students with valid data in each year. N=61 for Charter School 1; N=43 for Charter School 2; N=65 for District School. See Appendix Table A2 for data on all sampled students. Conscientiousness, Self-Control, and Grit are measured on a 5-point scale; Growth Mindset is measured on a 6-point scale. Years 1-3 correspond to grades 5-7 in Charter School 1 and grades 6-8 in Charter School 2 and District School.

Table 7: Student perceptions of school climate by school type

	Open-enrollment District School	Over-subscribed Charter School	Difference	
High Expectations	3.929	4.496	0.567**	0.63
	(0.900)	(0.669)	(0.149)	
	[885]	[112]		
Teacher Strictness	3.526	4.107	0.581*	0.65428
	(0.888)	(0.904)	(0.211)	
	[878]	[112]		
Clear Rules	3.789	4.186	0.397*	0.42324
	(0.938)	(0.854)	(0.154)	
	[881]	[110]		
Negative Peer Effects	2.738	2.252	-0.486**	0.5052
	(0.962)	(0.796)	(0.122)	
	[878]	[112]		
Student Input	2.514	2.264	-0.250*	0.10065
	(0.924)	(0.851)	(0.093)	
	[882]	[111]		

Note: *p<0.05, ** p<0.01; statistical significance is of difference in mean for over-subsribed charter and traditional public schools. In the first two columns, standard deviations are reported in parentheses and sample sizes in brackets. Standard errors reported in parentheses in the third column are adjusted for clustering by school.

Table 8: Relations of non-cognitive traits and test-score gains, overall and within schools

	4th-8th MCAS Math Gains		4th-8th MCAS ELA Gains	
	Overall	Within Schools	Overall	Within Schools
Conscientiousness	.100**	.144**	.078**	.107**
	(0.028)	(0.032)	(0.025)	(0.027)
Self-Control	0.076*	0.122**	0.042	0.081**
	(0.034)	(0.029)	(0.025)	(0.025)
Grit	.110**	.155**	.073*	.096**
	(0.032)	(0.031)	(0.033)	(0.035)
Growth Mindset	0.198**	.155**	.151**	.148**
	(0.036)	(0.040)	(0.037)	(0.032)

Note: *$p<0.05$, ** $p<0.01$. Each cell presents results from a separate regression of math or ELA MCAS gains on the relevant non-cognitive trait. Within-school regressions include fixed effects for schools. Standard errors reported in parentheses are clustered by 8th-grade school. Non-cognitive traits are standardized to have mean zero and unit variance in the study sample

Table A1: First stage results for instrumental variable lottery analysis

	Administrative Data Sample	Non-cognitive Sample
Offer at Charter School A	1.576**	0.952*
	(0.370)	(0.441)
Offer at Charter School B	1.710**	2.039**
	(0.515)	(0.461)
Offer at Charter School C	1.183	1.467
	(0.874)	(1.561)
Offer at Charter School D	1.319*	1.682*
	(0.651)	(0.740)
Offer at Charter School E	1.600**	1.248*
	(0.374)	(0.524)
Joint F-test statistic	35.53	16.04
Observations	497	200

Note: *p<0.05, ** p<0.01. Standard errors reported in parentheses are clustered by 8th-grade school. The administrative data sample includes all applicants to over-subscribed charter schools matched to valid 2011 test scores in the Massachusetts Department of Elementary and Secondary Education state database. The study sample includes all students in the administrative data sample with valid data on at least one non-cognitive outcome. All regressions include controls for student gender, race, age, LEP, SPED, and free/reduced price lunch, cubic polynomials in 4th-grade MCAS ELA and math scores, and fixed effects for lottery applicant risk sets.

Table A2: Mean student non-cognitive traits in three middle schools over time, all sampled students

	Time Point					Time Point			
	Fall Y1	Spring Y1	Spring Y2	Spring Y3		Fall Y1	Spring Y1	Spring Y2	Spring Y3
		Conscientiousness					Self-Control		
Charter School 1	3.83	3.58	3.52	3.43		3.46	3.20	3.06	2.92
	[98]	[95]	[86]	[71]		[100]	[95]	[86]	[71]
Charter School 2	3.76	3.64	3.50	3.35		3.44	3.17	3.12	2.97
	[86]	[89]	[61]	[49]		[95]	[90]	[61]	[49]
District School	3.70	3.58	3.55	3.60		3.36	3.19	3.13	3.17
	[169]	[138]	[117]	[116]		[169]	[138]	[117]	[116]
		Grit					Growth Mindset		
Charter School 1	3.53	3.32	3.25	3.20		3.73	4.20	4.47	4.38
	[99]	[95]	[86]	[71]		[100]	[95]	[86]	[71]
Charter School 2	3.58	3.44	3.24	3.21		3.71	4.62	4.53	4.50
	[90]	[89]	[61]	[49]		[95]	[90]	[61]	[49]
District School	3.40	3.29	3.20	3.29		3.58	4.16	4.11	4.23
	[169]	[138]	[117]	[116]		[170]	[138]	[117]	[116]

Note: Brackets report sample size by outcome, year, and school. Conscientiousness, Self-Control, and Grit are measured on a 5-point scale; Growth Mindset is measured on a 6-point scale. Years 1-3 correspond to grades 5-7 in Charter School 1 and grades 6-8 in Charter School 2 and District School.

Deidre J. Knapp

Dr. Deirdre J. Knapp is Vice President of HumRRO's Research and Consulting Operations Division. She earned her doctorate in industrial-organizational psychology from Bowling Green State University in 1984 and has been at HumRRO since 1987. Dr. Knapp's primary area of expertise is in performance measurement. She has developed performance measures for use in professional certification programs and as outcome measures in large-scale criterion-related validation research studies in employment settings. Dr. Knapp has experience with a wide range of measurement methods, including selected response, oral interviews, live and computer-based simulations, experience records, and observer ratings.

Dr. Knapp served on the National Research Council (NRC) committee that evaluated the impact of the National Board of Professional Teaching Standards and helped organize and presented at an NRC workshop on the assessment of 21st century skills in K-12 educational settings. Dr. Knapp has authored multiple book chapters, technical reports, and articles on job analysis, performance measurement, and various professional practice topics.

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His research and development interests focus on children's and adult's thinking and learning and the implications of cognitive research and theory for assessment and instructional practice. He has published over 275 books, chapters and articles in the areas of cognition, instruction and assessment. His current research on learning, instruction, and assessment is funded by the U.S. National Science Foundation and the U.S. Institute of Education Sciences. He has served as the head of several U.S. National Academy of Sciences study committees, including co-chair of the Committee on Learning Research and Educational Practice, and co-chair of the Committee on the Foundations of Assessment which issued the report Knowing What Students Know: The Science and Design of Educational Assessment.

Most recently he served as a member of the Committee on Science Learning: Games, Simulations and Education, as chair of the Committee on Defining Deeper Learning and 21st Century Skills, and co-chair of the Committee on Developing Assessments of Science Proficiency in K-12. He is a past member of the Board on Testing and Assessment of the National Research Council and a lifetime member of the U.S. National Academy of Education. He currently serves on the Technical Advisory Committees (TAC) of several states as well as the TACs of multiple state consortia funded under the U.S. Department of Education's Race to the Top assessment initiative.

See *Education for Life and Work* at http://www.nap.edu/catalog.php?record_id=13398

EDUCATION FOR LIFE AND WORK
DEVELOPING TRANSFERABLE KNOWLEDGE AND SKILLS IN THE 21ST CENTURY
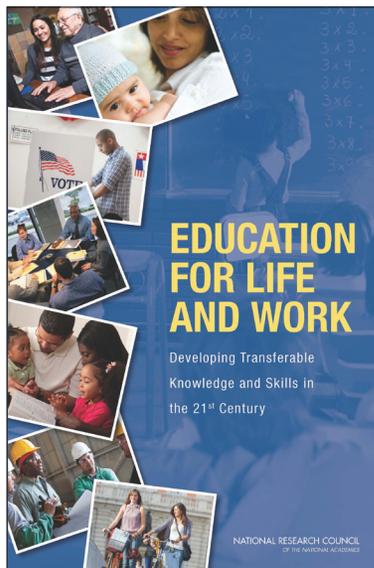
Business, political, and educational leaders are increasingly asking schools to integrate development of skills such as problem solving, critical thinking, and collaboration into the teaching and learning of academic subjects. These skills are often referred to as "21st century skills" or "deeper learning."

At the request of several foundations, the National Research Council appointed a committee of experts in education, psychology, and economics to more clearly define "deeper learning" and "21st century skills," consider these skills' importance for positive outcomes in education, work, and other areas of life, address how to teach them, and examine related issues.

The committee's findings and recommendations are detailed in its report *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century.*

FIRST STEPS TOWARD CLARIFYING TERMS

Deeper learning is the process through which a person becomes capable of taking what was learned in one situation and applying it to new situations – in other words, learning for "transfer." Through deeper learning, students develop expertise in a particular discipline or subject area.

Suppose a student learns about means, medians and modes in mathematics. Deeper learning would mean that the student would learn not only how to calculate these values, but also understand how and when each is best used. For example, if the student later worked at a store that tracked average daily sales each month, he or she would recognize that a special sale on the first day of a particular month could skew the mean and that an alternative measure like the median might be more representative of daily sales for that month.

Through the process of deeper learning, students develop **21st century competencies** – transferable knowledge and skills. In contrast to a view of "21st century skills" as general

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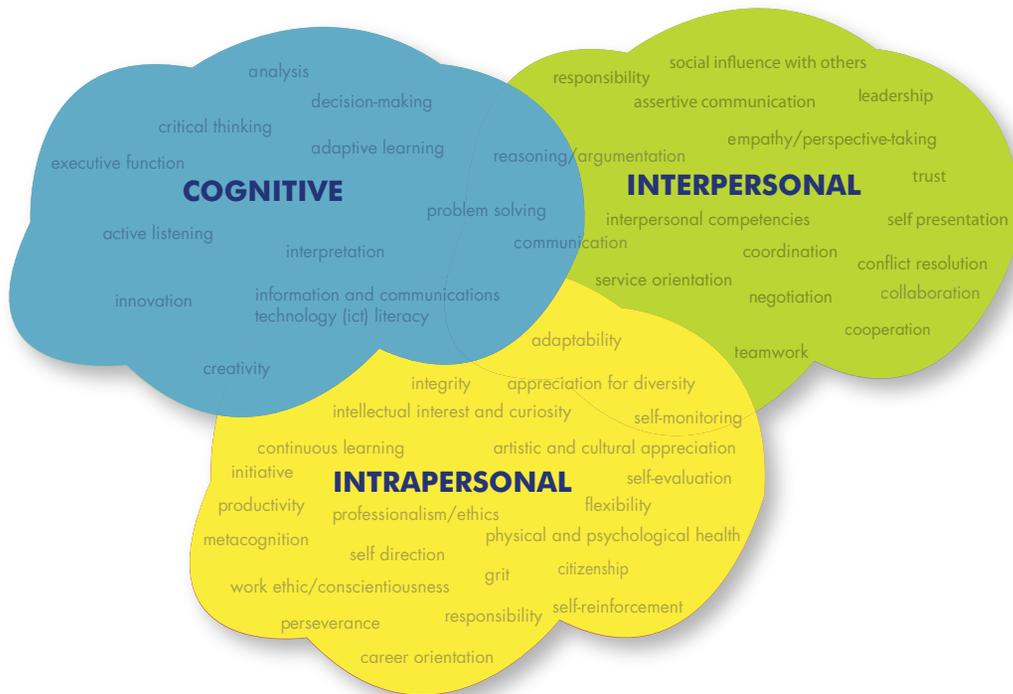
"21st century skills" grouped into three broad domains

skills that can be applied to a range of different tasks in various civic, workplace, or family contexts, the committee views these competencies as aspects of expertise that are specific to – and intertwined with – knowledge of a particular discipline or subject area. The committee uses the broader term "competencies" rather than "skills" to include both knowledge and skills.

Precise definitions of the many terms used for "21st century skills" are not possible at this time, in part because there is little research to support such definitions. However, as a preliminary way to organize the skills, the committee first identified three broad domains of competence:

- **the cognitive domain**, which includes thinking, reasoning, and related skills;

- **the intrapersonal domain**, which involves self-management, including the ability to regulate one's behavior and emotions to reach goals; and

- **the interpersonal domain**, which involves expressing information to others, as well as interpreting others' messages and responding appropriately.

The committee then took several existing lists of "21st century skills" and, based on a content analysis, grouped them within these three domains.

The figure above links similar competencies together, groupings that provide a starting point for further research on the competencies' meaning and value.

THE IMPORTANCE OF 21ST CENTURY COMPETENCIES

The committee examined evidence on the importance of 21st century competencies within the three domains for positive outcomes in education, work, health, and other areas. They reached the following conclusions:

- The available research is limited and primarily correlational in nature. To date, only a few studies have demonstrated a causal relationship between one or more 21st century competencies and adult outcomes.

- Cognitive competencies, which have been more extensively studied than interpersonal and intrapersonal competencies, show consistent, positive correlations of modest size with desirable outcomes in education, the workplace, and health.

- Among intrapersonal and interpersonal competencies, conscientiousness – being organized, responsible, and hardworking – shows the strongest correlation with desirable work and educational outcomes. Anti-social behavior, which has both intrapersonal and interpersonal aspects, is negatively correlated with these outcomes.

- Educational attainment – the total number of years a person spends in school – strongly predicts adult earnings, as well as health and civic engagement. It may be that schooling builds some mix of cognitive, interpersonal, and intrapersonal skills that are valued by the labor market.

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If so, making it possible for students to get more education may itself be a useful complementary way to develop 21st century competencies.

More research is needed to increase our understanding of the relationships between particular twenty-first century competencies and desired adult outcomes.

Over a century of research on transfer has yielded little evidence that teaching can develop general cognitive competencies that are transferable to any new discipline, problem or context, in or out of school. Much of the research has been carried out in the cognitive domain and it shows that transfer does occur but is limited in scope. Studies of interventions to teach social and emotional skills suggest that these also support transfer beyond the immediate context in which they were acquired, affecting students' behavior throughout the school day. More research is needed to illuminate whether, and to what extent, competencies learned in one discipline or context of application can generalize and transfer to other disciplines or contexts.

The committee found not only that deeper learning develops 21st century competencies, but also that the relationship flows both ways: 21st century competencies can aid the process of deeper learning in a discipline or subject area. For example, deeper learning to develop expertise in a discipline or subject area requires months of sustained, deliberate practice – a process supported by the intrapersonal competency of conscientiousness.

TEACHING FOR DEEPER LEARNING

Emerging evidence indicates that cognitive, intrapersonal, and interpersonal competencies can be taught and learned in ways that support transfer. Research in the cognitive domain has also identified features of instruction that are likely to support transfer within a given subject area. For example, transfer is supported when instruction helps learners understand the general principles underlying the specific examples included in their original learning. Teaching that emphasizes not only content knowledge, but also how, when, and why to apply this knowledge is essential to transfer. Instruction should follow these research-based teaching methods:

- **Use multiple and varied representations of concepts and tasks**, such as diagrams, numerical and mathematical representations, and simulations, along with support to help students interpret them.

- **Encourage elaboration, questioning, and explanation** – for example, by prompting students who are reading a history text to explain the material aloud to themselves or others as they read.

- **Engage learners in challenging tasks,** while also supporting them with guidance, feedback, and encouragement to reflect on their own learning processes.

- **Teach with examples and cases,** such as modeling step-by-step how students can carry out a procedure to solve a problem while explaining the reason for each step.

- **Prime student motivation** by connecting topics to students' personal lives and interests, engaging students in problem solving, and drawing attention to the knowledge and skills students are developing and their relevance, rather than grades or scores.

- **Use "formative" assessments,** which continuously monitor students' progress and provide feedback to teachers and students for use in adjusting their teaching and learning strategies.

DEEPER LEARNING IN STANDARDS DOCUMENTS

The committee found important areas where goals for deeper learning and 21st century competencies overlap with the new Common Core State Standards in English language arts and mathematics and the NRC Framework for K-12 Science Education. All three documents highlight the importance of helping students understand the general principles underlying specific content, a hallmark of deeper learning. A cluster of cognitive competencies—including critical thinking, nonroutine problem solving, and constructing and evaluating evidence-based arguments—is included in all three disciplines. Coverage of other competencies—especially those in the intrapersonal and interpersonal domains—is uneven. Developing the full range of 21st century competencies within the disciplines will require systematic instruction and sustained practice, a change from current practice that will require additional instructional time and resources.

MOVING FORWARD

Because 21st century competencies support deeper learning of school subjects, their widespread acquisition could potentially reduce disparities in educational attainment, preparing a broader swathe of

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young people for successful adult outcomes in work and other areas of life.

However, important challenges remain in two major areas. First, research and development is needed to create and evaluate new curricula based on the research-based instructional methods described above, and to find valid ways to assess cognitive, intrapersonal, and interpersonal skills. Second, at the level of education systems and policies, new approaches to teacher preparation and professional development will be needed to help instructors acquire a deep understanding of the role of 21st century competencies in learning core academic content and create environments that support students' learning of these competencies.

To help address these systemic issues, the states and the federal government should establish policies and programs – in the areas of assessment, accountability, curriculum and materials, and teacher education – to support students' acquisition of transferable knowledge and skills.

RESEARCH NEEDS

Far more research is needed to fill gaps in the evidence base on deeper learning and 21st century competencies. Foundations and federal agencies should support research aimed at:

- Establishing agreed-upon definitions of 21st century competencies and ways to measure and assess them.

- Better illuminating the relationships – particularly any causal relationships – between 21st century competencies and desired outcomes.

- Gaining a better understanding of whether, and to what extent, teaching for transfer within an academic discipline (such as mathematics) can facilitate the transfer of competencies across disciplines (for example, from mathematics to history).

COMMITTEE ON DEFINING DEEPER LEARNING AND 21ST CENTURY SKILLS

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