What the Critical Thinking Data Tell Us
# What the Critical Thinking Data Tell Us

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What the Critical Thinking Data Tell Us About Our Reasoning

Peter A. Facione, Noreen C. Facione, Carol Ann Gittens

Anything that is valued is measured. Over the past three decades building critical thinking skills and a thinking mindset has moved from a theoretical academic discussion to a global concern for employers, educators, and those seeking to advance truth-seeking for the sake of democracy and the reasoned pursuit of our common good. This white paper supplies an overview of empirical research on efforts to improve critical thinking in educational and employment settings. The unifying factor in these papers is the data provided by scholars measuring critical thinking using instruments developed and validated by our research team, often in collaboration with international scholar colleagues and professional sector experts.

Findings are organized under four broad questions: How do the critical thinking skills of today’s college students compare with earlier decades? How helpful is an assessment of critical thinking for graduate and professional program admissions and for prediction of transition to the workplace? What do the K-12 data tell us about the relationship between critical thinking and optimal childhood development? What is the business advantage of testing and training critical thinking?

Mining Mountains of Data

In the thirty years since the first forms of our critical thinking assessments appeared, subsequent tailored and calibrated instruments have made it possible for researchers around the world to collect data on critical thinking skills and mindset attributes. Translation and validation studies, and independent research and assessment projects, produced data on the distribution of critical thinking skills and mindset attributes for students at every level of development (K-12 through the doctorate), and for employees from support staff to top level leadership. Studies, like the examples referenced here, primarily report on the effectiveness of particular training techniques to build critical thinking skills or a critical thinking mindset, and/or examine the value of critical thinking scores as a component of admissions, curriculum effectiveness, or as a predictor of degree completion and professional licensure. Published research can be found in the health sciences, business, STEM, military science, and education journals and dissertation abstracts, internationally.


Observable differences have been documented in business, science and engineering, law, education, and health care delivery populations. Our hope in preparing this summary is one shared by educators, researchers, and truth-seekers the world over – advancing thinking worldwide. This paper offers a perspective on the state of the science by sharing what is known about the strength of reasoning skills and mindset attributes in four broad sectors:

- **College students:** How do the critical thinking skills of today's students compare with skills demonstrated in earlier decades?
- **Professional Programs:** How helpful is an assessment of critical thinking for graduate and professional program admissions and for prediction of transition to the workplace?
- **Advancements in the Assessment of K-12 Students’ Critical Thinking:** What do the data tell us about the relationship between critical thinking and optimal childhood development?
- **The Value of a Critical Thinking Assessment in the Workplace:** What is the business advantage of testing and training for critical thinking?

These four paradigmatic questions give voice to four concerns. Generalizing, the first question expresses the natural curiosity every group has for knowing how it compares to its peers or its rivals. The second question asks whether we can predict future success based on raw critical thinking ability considered apart from content knowledge? The third question focuses on human development and explores possible relationships among various skills and mindset attributes. And the fourth, what employers want to know, asks “So What?”

We have data and insights to share about each of these questions. But we are fully aware that no single paper can fully address any of these four topics. We hope this discussion will inspire other scientists to explore, evaluate, and refine these observations more fully.

### Are College Students’ Critical Thinking Skills Improving?

To answer this question, we need valid and reliable measures that have continuity over time. The snapshots of college students’ critical thinking, first taken in the 1990's, need to be comparable to the data being collected today. The reliable measures used to answer this question are CCTST and CCTDI because they have been kept psychometrically equivalent over the past three decades. This enables the comparison of critical thinking skills (CCTST Overall score) over time, and comparison of scores on the seven mindset attributes identified as essential to a strong critical thinker (CCTDI scale scores).

To remain valid and reliable, an assessment of critical thinking must also be kept culturally relevant. To capture the world population, the assessment must function well across languages and cultures, in a wide variety

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of educational contexts. Over the years, in response to these requirements, CCTST and CTDI have become large item pools that support psychometrically equivalent forms developed by our research team in collaboration with a long list of international translation partners [https://www.insightassessment.com/article/international-translation-partners]. Scores students recorded on these instruments can be aggregated and examined for possible changes in performance over time.

We will begin by dividing the college student population into three meaningful groups, students pursuing associate level, baccalaureate, and graduate level degrees. Are there differences in these three populations? Looking first at critical thinking skills, using the Overall score on the CCTST we find clear differences between these three student groups. While there are students with scores across the range of possible scores at all three levels, the mean CCTST Overall score in 2019 for associate degree students was 14.0 (72.0). The 2019 baccalaureate students averaged 16.3 (75.3), and the graduate student mean was 20 (80.4). These differences in mean scores for these three student populations are significant both statistically and educationally.

Selection probably is one key factor. We should expect graduate students to be stronger in critical thinking. As admissions gets more competitive, mean scores for selected groups increase. The same for the baccalaureate level. Student selectivity can explain much of the differences in population means. For example, the 2019 mean CCTST Overall score for the whole baccalaureate student population, which includes top tier institutions, was 16.3 (75.3). Yet, the mean at regional, open-enrollment universities was 14.8 (73.2). These universities admit some students who have weaker critical thinking skills and perhaps other educational gaps than do highly selective universities. In contrast, the mean CCTST Overall score for baccalaureate students at Research I universities was 18.0 (77.6), indicating that their admissions criteria result in the selection of students with higher critical thinking skills on average.

Institutions of different kinds find it meaningful to benchmark their scores against their peers. For this purpose, several sets of up-to-date comparison percentiles for the CCTST Overall score are maintained:

- Research I Universities -- Baccalaureate Students
- US Regional Open-Admissions Universities -- Baccalaureate Students
- Globally Ranked Universities -- Baccalaureate Students
- Globally Ranked Universities -- Graduate Students
- Health Sciences Undergraduate Students
- Health Science Graduate Students
- STEM Undergraduate Students
- Graduate Students and Professionals
- Undergraduate Students at Four-Year Colleges and Universities
- Undergraduate Students at Two-Year Colleges

Selectivity of admission is only one variable to consider when examining data for possible evidence of improvement in students’ critical thinking. The actual algorithm for modeling student populations for our comparison samples is proprietary, but many of the variables that we have used can be anticipated: geographic

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6 The original forms of the CCTST report scores from 0-34, newer forms range in score from 50-100. Here both equivalent scores are provided.
location, size of student body, rural/urban, public/private, online/residential, and socioeconomic descriptors are among those used to model these populations.

We used population modeling and sampling techniques to compare the mean CCTST Overall scores for associate degree students, baccalaureate students, and graduate students over time. Table 1 displays the mean CCTST Overall scores for these groups at three time points spaced seven years apart.

Table 1. Comparison of CCTST overall mean scores by student population over time. Scores for original 34-point scale and in parentheses for (100-point scale) introduced in 2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>Associate Degree (2YR) Students</th>
<th>Baccalaureate Students</th>
<th>Graduate Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>13.3 (71.0)</td>
<td>15.0 (73.4)</td>
<td>19.0 (79.0)</td>
</tr>
<tr>
<td>2012</td>
<td>13.7 (71.3)</td>
<td>16.5 (75.5)</td>
<td>19.0 (79.0)</td>
</tr>
<tr>
<td>2019</td>
<td>14.0 (72.0)</td>
<td>16.3 (75.3)</td>
<td>20.0 (80.4)</td>
</tr>
</tbody>
</table>

These cross-sectional data, although uncontrolled by the many changes that have occurred in higher education over the past decade and a half, provide evidence of gains in the overall critical thinking skills in the college student population (undergraduate and graduate) over the past 15 years. This evidence is very modest. And yet, it is encouraging when we consider the still uncontrolled influences on this analysis. Today, educational institutions enroll a higher percentage of high school graduates, and they offer a wider variety of programs to an ever more diverse student population as compared to 2005 (e.g. working vs. not / full-time vs. part-time / caring for children vs. not, FTC vs re-entry, etc.). Since 2012, student enrollment at for-profit institutions has disproportionately increased, and this variable’s influence is still undetermined at the time of this writing. Online programs are increasingly prevalent. So, although the news is positive about potential gains in critical thinking skills in the college student population, we need a deeper look into whether students are improving over time.

And one other important difference: Educators have focused considerable attention on the development of critical thinking. Does teaching for thinking make a difference at the macro level? Publications on ways to teach for critical thinking in different disciplines abound today, as compared to twenty or thirty years ago. Meta-analyses, like those conducted by Abrami and colleagues7 (2008, and 2015), provide a wealth of support for the claim that students gain strength in critical thinking after an effective training program. Our discussions with researchers, dissertation students, and employee development professionals lead us to conclude that initiatives to

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improve critical thinking are occurring all over the world and in at least 50 countries. And, as publication of peer reviewed papers studying the effectiveness of case-based learning, using human simulators, reflective journaling, concept mapping, and various other learning approaches indicates, studies conducted in many countries document critical thinking gains in various national populations.⁸

Is all this attention to critical thinking having a measurable overall impact? One way to approach this question is to look at specific populations over time. The null hypothesis would be that scores of like-groups of students today would not be significantly different than scores from decades ago. We selected a random, proportionate sample of CCTST scores collected at a set of undergraduate institutions of varying types to see how scores from 2012 compared to scores for 2019. In this sample there are 2,000 cases for each time period. To be clear, this is not a comparison of scores for the very same individuals seven years apart. These two samples of 2,000 students are randomly selected to be representative of the college student population at the two time periods in question.

Randomization helps assure that our analysis sample accurately represents the population of college students over time. To see this, consider the many reasons that critical thinking is assessed, and the effects that these reasons may have on our analysis sample, were it not carefully selected to represent the whole student population. E.g., the CCTST may have been used to assess students at risk, to select students for impacted programs, to study the effectiveness of an educational approach, to respond to state funding mandates, or for an accreditation self-study of learning outcomes. Some institutions may have had well-designed quality improvement programs in place during this period, but others certainly were only collecting data to minimally satisfy externally imposed obligations. Randomization is the best way to effectively control the many variables that could introduce measurement bias.

Table 2. Comparison of CCTST overall score distribution in college undergraduates.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Year</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCTST Overall</td>
<td>2012</td>
<td>2000</td>
<td>15.3</td>
<td>5.0</td>
<td>1</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td>CCTST Overall</td>
<td>2019</td>
<td>2000</td>
<td>16.7</td>
<td>5.0</td>
<td>4</td>
<td>13</td>
<td>16</td>
<td>20</td>
<td>33</td>
</tr>
</tbody>
</table>

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Table 2 compares the groups, and the accompanying graphic verifies that the samples were normally distributed. The change in CCTST Overall score demonstrates an average gain of 1.4 points. This gain is statistically significant (t = 9.10, p<.001). More important, it is educationally significant, demonstrating that those in the 2019 sample were better able to reason to an accurate response and not fall prey to the common human reasoning errors. This supports the assertion that the educational emphasis on training reasoning skills is paying off. Figure 1 illustrates the positive shift of scores over this time frame.

![CCTST OVERALL Scores – 2012 and 2019](image)

Figure 1. CCTST overall scores for 2012 and 2019.

These findings provide some basis for confidence that improvements are occurring in the critical thinking skills of baccalaureate students. Going deeper than the CCTST Overall score, we found statistically significant growth in all the cognitive skill metrics the original versions of the CCTST assessed: Analysis (t = 7.84, p<.001), Inference (t = 7.96, p<.001), Evaluation (t = 5.66, p<.001), Induction (t = 11.78, p<.001), and Deduction (t = 5.55, p<.001).

Recent forms of the CCTST have expanded the score package to include Interpretation, Explanation, and Numeracy. Differences are commonly observed in relation to particular skill areas. Stronger scores are more typically seen for Analysis, Inference, Explanation, and Induction. Weaker scores are more common for Interpretation (identifying the critical details of the problem), Evaluation (determining the quality of an analysis, inference, judgment, etc.), Deduction (reasoning in logically precise contexts), and Numeracy (reasoning in contexts that involve numbers, proportions, probability, flow rates and other quantitative conditions).
The next step for scholars would be to examine college curricula to see how these skills are approached in different disciplines. Are all the skills comprehensively addressed? Are they all demanded as a component of course performance?

What about college students’ critical thinking mindset? A search of publications using CCTDI data shows that evidence for the improvement of the attributes associated with a positive disposition toward critical thinking is plentiful in specific cross-sectional and matched-pairs samples, collected under controlled conditions. Over several decades, many baccalaureate institutions working on SACS regional accreditation have focused on improving student’s thinking mindset and used the CCTDI to assess progress. Following our previous plan of comparing data from two random but comparable samples, we collected data from SACS institutions gathered before 2012 and compared these data with data collected in 2017-2019 to see if there were significant gains for any of the seven thinking mindset attributes. Mean scores for three of the seven mindset attributes were significantly higher in the data collected in 2019: Truth-seeking, Open-mindedness, and Maturity of Judgment. Scores above 40 on the CCTDI scales indicate a consistent affirmation and positive endorsement of the specific mindset attribute. Scores under 30 show consistent disinclination and rejection of the attribute. Scores in the 30’s indicate ambivalence about the attribute. Table 3 shows the difference in scores for three of the seven mindset attributes showing evidence of improvement over time.

**Table 3. Growth in three thinking mindset attributes over time.**

<table>
<thead>
<tr>
<th>Mindset Attribute</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Mean Gain</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truth-seeking 2012</td>
<td>450</td>
<td>32.79</td>
<td>6.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truth-seeking 2019</td>
<td>450</td>
<td>34.80</td>
<td>6.9</td>
<td>2.01</td>
<td>4.33</td>
<td>p&lt;.001</td>
</tr>
<tr>
<td>Open-mindedness 2012</td>
<td>450</td>
<td>39.67</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open-mindedness 2019</td>
<td>450</td>
<td>41.31</td>
<td>6.3</td>
<td>1.64</td>
<td>4.01</td>
<td>p&lt;.001</td>
</tr>
<tr>
<td>Maturity of Judgment 2012</td>
<td>450</td>
<td>37.94</td>
<td>8.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maturity of Judgment 2019</td>
<td>450</td>
<td>38.87</td>
<td>7.5</td>
<td>0.93</td>
<td>1.72</td>
<td>p&lt;.09</td>
</tr>
</tbody>
</table>

Scores for Analyticity (Foresight), Inquisitiveness, and Confidence in Reasoning did not improve significantly over time in these randomly selected samples; but all three averaged above 40 (Positive scores) at
both time periods. Keeping in mind that a person may express strong confidence in reasoning and yet not demonstrate the skill to warrant that confidence, this scale is most meaningful when examined at the individual level in the context of a reasoning skills score. A change in scores for Confidence in Reasoning after a training session in reasoning skills represents a more accurate self-assessment of reasoning skill. Scores for Maturity of Judgment and Systematicity were least strong at pretest and did not gain significantly at posttest, making these mindset attributes foci for curriculum improvement.

Much the same picture emerges when we carry out this same analysis using randomized samples from associate level degree programs and graduate level programs. Graduate level samples, however, tend generally to have stronger mindset attribute scores than do undergraduate level samples. Again, this is to be expected because of selectivity and the added educational experience of the graduate sample.

We can conclude that there is evidence that college students on average are improving over time in critical thinking skills and mindset. However, it is too early to celebrate. Datasets continually reveal that some college students demonstrate very weak reasoning skills and display a mindset that rejects critical thinking. Those with one or more negative dispositions on mindset attributes may be intolerant of new ideas, unwilling to reconsider in light of new evidence, mistrustful of reason, lacking in intellectual integrity, or disorganized in their approach to problem-solving. Those with weak reasoning skills scores are often unable to analyze the details of a situation well enough to get the problem right. They do not correctly interpret information and/or they have difficulty drawing well-reasoned conclusions. They cannot explain the rationale for their evaluations or decisions. These gaps can pose problems not just for learning, but for all contexts where the person must judge what to believe or what to do. Weak critical thinking skills, particularly when accompanied by the disinclination toward using critical thinking to solve problems, put people at risk for making many truly unfortunate decisions.

**Predicting Success – Critical Thinking and Professional Programs**

For several decades, health science educators have been working to train critical thinking in students and clinicians. Today this effort to provide thinking clinicians starts with admission to each of the clinical specialty programs, many of which receive an extraordinary number of applicants for a limited number of training seats. Educating physical therapists, nurses, pharmacists, physicians, and all our other clinical specialists, requires years of course work and extensive clinical practice hours. The challenge for these programs is to admit students who will succeed in their training, pass their licensure examinations, and then transition well to jobs that immediately demand strength in problem analysis and decision making.

For many years researchers have been studying the power of critical thinking scores at admission to predict clinical ratings, degree completion and licensure rates. Studies in Dentistry, Family Medicine, Pharmacy, Nursing, Physical Therapy, Occupational Therapy, Audiology, Midwifery, Psychology, Dental Hygiene, and other health specialties demonstrate the added value of including a critical thinking assessment in the admission protocol. See https://www.insightassessment.com/article/admissions-retention-and-licensure. Most programs use the Health Sciences Reasoning Test (HSRT) or the CCTST as their assessment tool to benchmark students or applicants against national comparison percentiles for their specialty group, and the CCTDI as the measure of thinking mindset attributes.

Assessing the effectiveness of instructional approaches is a common research focus of health sciences educators. Different training techniques have been closely studied for their effectiveness in building critical
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thinking skills and a thinking mindset. Significant gains in critical thinking have been related to problem-based learning strategies, the use of patient simulators, cased-based seminars, concept-mapping strategies, experiential learning programs, peer questioning techniques, and reflective writing exercises. For detailed citations and summaries see https://www.insightassessment.com/article/evaluating-training-techniques.

Following student cohorts over time and collecting a second or third measure of critical thinking skills and mindset at program completion has informed researchers about which particular skills and mindset attributes are commonly seen in admissions cohorts, which are improved in relation to particular training techniques, and which require more attention in curriculum building. Exit scores provide a baseline comparison when new curriculum is introduced. https://www.insightassessment.com/article/training-critical-thinking-and-clinical-reasoning.

One thing is beyond doubt: assuring and improving students’ critical thinking requires explicit attention and educational effort. This is well documented by the Abrami and colleagues (2015) meta-analysis examining “available empirical evidence on the impact of instruction on the development and enhancement of critical thinking skills and dispositions and student achievement. The review includes quasi- or true-experimental studies that used standardized measures of CT as outcome variables.” The cases improve, but the controls either do not or they improve less. Abrami’s work reinforces sound practices, viz. that educators make learning objectives clear to students and that educational institutions provide preservice and in-service training for educators specifically as trainers of critical thinking. For more about these studies, go to the links above, and visit https://www.insightassessment.com/article/learning-outcomes-assessment.

Peer-reviewed studies from Hong Kong, Australia, Peoples Republic of China, Ireland, Canada, UAE, Turkey, Australia, Saudi Arabia, United Kingdom, Japan, The Netherlands, Malaysia, USA and many other areas have demonstrated the predictive power of critical thinking skills scores as indicators of an accomplished health science student and practicing clinician.10

In summary, consider the comments of another investigator, John Eigenauer, who reminds us that “measurable gains in critical thinking are obtainable by implementing proven methods and best practices, which always include explicit instruction in critical thinking.” 11

The changes in health care delivery over recent decades have increased the complexity of care delivery for all specialties. Clinician training is matching the challenge, but each seat is critical to accomplishing the goals of the program and the needs of the patient population. An increased focus on critical thinking in is helping health science education respond to these increasing demands as they continue to prepare clinicians who can reason well and maintain practice standards. Long concerned with training strength in clinical reasoning and evidence-based practice, health science educators are taking additional steps to assess critical newly admitted students to evaluate each student’s ability to engage a rigorous health science curriculum.


Reports of the success of that effort have begun to emerge in publications covering audiology, dentistry, dental hygiene, family medicine, health policy, nursing, optometry, pharmacology, physical therapy, and respiratory therapy education.12

Because common human reasoning errors have been well documented for several decades, 13 some health science innovators are working toward a future where machine intelligence will make key clinical judgments, not humans. Our preferred future would be one where humans with strength in critical thinking make clinical judgments aided by a machine intelligence. This would allow us to expect that clinical judgment will improve globally, ethically balancing economics, risk management, context, and quality of life.

**Advancements in the Assessment of K-12 Students’ Critical Thinking**

The promise of the American K-12 educational system is to develop strong numerically and scientifically literate critical thinkers who are ready for college and career in today’s Information Age (U.S. Department of Education, 2019). This pledge is grounded in the understanding that children and adolescents, just like adults, must reason through a perpetual tidal wave of information washing over them in school and beyond through television, social media, and the Internet. Achievement of this ambitious educational goal requires the cultivation of critical literacies including higher order thinking, scientific reasoning, information literacy, and numeracy. Research shows that mathematical reasoning, or numeracy, is as strong of a predictor of students’ school success as reading ability14 and that the development of early mathematical skills and literacy skills is highly interrelated.15 Wiest offers a stronger perspective suggesting that quantitative literacy is, in essence, a gatekeeper for effective functioning today.16 The development of quantitative literacy in all children is a matter of social justice in the Information Age.

In this era of Common Core State Standards, where depth of understanding, critical thinking, and real-world problem solving receive heightened attention as learning outcomes, educators are transitioning their practice to emphasize problem-based learning to provide creative learning opportunities for all students.17 The

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17 Cash, J. (2013). Transitioning teaching and learning to embrace common core. Leadership, 43(2), 22-25. (Leadership is a publication of the Association of California
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School administrators similarly must critically evaluate the impacts of an enriched thinking and problem-solving focused pedagogical approach to elementary and secondary education. Rigorous educational research into the characteristics, variations, and developmental trajectories of children’s and adolescents’ critical thinking is of upmost importance to best inform our children’s teachers as they strive to nurture critical thinking in tomorrow’s citizens and leaders.

Until recently a significant challenge has been the limited availability of valid and reliable standardized measurement tools to directly assess K-12 students’ critical thinking. However, with the introduction of the EDUCATE INSIGHT Reasoning Skills and Mindset Series, this assessment instrument gap is now closed. In this section we discuss the development and uses of the EDUCATE INSIGHT series with a special focus on data from assessments of reasoning skills and mindset among middle school and early elementary school students.

The EDUCATE INSIGHT Series was first introduced under titles that referenced their K-12 companion status with the original post-secondary California Critical Thinking Skills Test (CCTST), and the CCTDI related California Measure of Mental Motivation (CM3). The mindset assessments were introduced in 2005. That year saw the first skills test, the upper elementary which focused on grades 3-5. This was, followed in 2008 by the middle school skills version. These were later consolidated under the EDUCATE INSIGHT Series title with the publication of the secondary level skills test in 2014. With the introduction of the K-2 level skills test in 2017, the reasoning skills and mindset series was complete for all levels; early elementary, upper elementary, middle school, and secondary.

Like the CCTST and CCTDI, the EDUCATE INSIGHT series of K-12 instruments is based on the Delphi study sponsored by the American Philosophical Association (APA) that produced an expert consensus definition of critical thinking as the process of purposeful, self-regulatory judgment. The Delphi panelists described the characteristics of a strong thinking and included reference to both skills and dispositional mindset characteristics.

The EDUCATE INSIGHT (EI) reasoning skills questions increase in difficulty and complexity at each higher educational level. At all levels, the questions use developmentally appropriate and relevant everyday scenarios that are common and familiar to the target test takers. Reading and language issues are not significant barriers for the test taker. Upper elementary, middle school, and secondary levels of the EI instruments have Flesch-Kincaid reading levels well below the grade level of the intended test taker. For children in K-2, it is recommended that the instrument scenarios be read aloud to test takers by a trained proctor.

Reasoning skills questions require test takers to analyze the scenario information, draw appropriate inferences, and evaluate the claims and arguments presented. The response frame on all the skills tests is multiple choice format. Any specialized information needed to select the best option from among those offered is provided in the question itself. Together, the items provide a measure of overall critical thinking and a measure of five or more skill domains (see Table 4). The K-2 level includes the scale Categorization, considered a fundamental developmental thinking skill. Categorization is the cognitive process by which objects are identified, recognized, and grouped according to a perceived common characteristic. Categorization enables understanding language, predicting the behavior of, inferring the characteristics of, and deciding how to behave toward or how to interact with objects grouped into the same category.

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Critical thinking skill in early middle school (6th grade) has been found to be highly predictive of student mathematics achievement in later grades.\(^\text{19}\) In this three-year longitudinal study of students in California, scores on the EI Skills measure were strongly positive and significantly (p<.001) correlated with students’ math scores on the California Standardized Testing and Reporting (STAR) assessment program. In the first year of testing (6th grade), the correlation between students’ EI Skills and the California Standardized Test – Math (CST Math) overall scores was .635 (subscale correlations = .448-.601). This tells us that approximately 40% of the variance in 6th grade students’ mathematics achievement as measured by State mandated standardized test could be predicted by these students’ 6th grade EI Overall critical thinking skills scores – a very strongly predictive finding.

When retested with EI Skills in 7th and 8th grade, strong and significant correlations with the CST Math persisted, as did an observable relationship between these scores and whether teachers’ recommended students to advance to Algebra as 8th graders. In this study, critical thinking skills in 6th grade powerfully predicted math course placement at 8th grade. But, more importantly, this demonstrated relationship between critical thinking and mathematics achievement in early middle school means that an assessment of critical thinking skills can identify students whose critical thinking skills need to be improved to support their future learning in mathematics.

Can middle school students improve their critical thinking skills? Evidence from another study, is more than reassuring. This evidence, gathered from struggling schools across the US, suggests that training critical thinking skills should be a fundamental focus of middle school.

Figure 2 plots the difference scores for EI Skills in a sample of 422 middle school students, most of which are demonstrating benefit from a grant funded educational enrichment program. Not all children in this educational program are demonstrating gains. Some may be failing to fully engage a retest that challenges them to analyze, evaluate, and explain why. But the students represented by the solid black bars are demonstrating gains in critical thinking skills that correspond to significantly improved performance when compared to the national distribution of critical thinking skills scores for children in these grade levels.

![XXX Middle School Sample Gains 2018-2019](image)

*Figure 2. XXX Middle School Sample gains 2018-2019. Numbers on the horizontal axis indicate, from left to right, points lost to points gained pre-to-post. Shading is not relevant.*
How early is too early to assess and train critical thinking? In our view, it is never too early to empower children with better thinking skills. And, with careful attention to their ability to participate in an assessment process, it is possible to capture valid and reliable data about their thinking skills. The EDUCATE INSIGHT series equips educators and researchers with tools to directly measure critical thinking among students as young as kindergarten. The conventional approach has been to indirectly approximate reasoning ability using standardized measures of student achievement typically administered at the state level. Those assessments of students’ achievement are not routinely administered before 3rd grade. International exams such as the NAEP and TIMMS are not administered younger than 4th grade.

What have we learned so far about critical thinking at the K-2 level? The EI Skills K-2 was administered to a sample of 100, male and female first and second graders from an economically and ethnically diverse public-school district in the southern region of California’s Bay Area. The instrument was read aloud as students followed along. A distribution of scores for the Overall critical thinking scale are presented in Figure 3.

The students’ scores array in a relatively normally distribution, the average score falling within the same value range as is observed with older students. While many of these scores indicate low levels of skills, others show children at the K-2 level manifesting high levels of critical thinking skills. Followed over time, studies such as this can help us learn how critical thinking is driving learning in other skill and knowledge domains.

![Figure 3. Critical thinking in our younger students.](image-url)
The reasoning skills tests grades 3 and higher include a numeracy metric. Numeracy, defined by Gittens as \textit{critical thinking in a quantitative context},\(^{20}\) emphasizes the use of analysis, inference, interpretation, explanation, evaluation, as well as reflection on one’s own reasoning process (metacognition and self-regulation). Much more than simply adding a column of numbers or solving for \(x\), numeracy is the ability to set up the problem in the first place, that is determining which mathematical operations to apply, and in what order, so that one might reason correctly about the quantitative information available and resolve the question at hand.

There is great synergy between a focus on numeracy as critical thinking applied to the context of mathematics, probability and numerical data analysis and the overarching educational goal of building students’ critical thinking in both the K-12 and postsecondary levels. Not surprisingly, the national standards reform movement in mathematics, as reflected by the Common Core State Standards Initiative (CCSI) draws heavily on the National Council of Teachers of Mathematics (NCTM) vision and recommendations and prioritizes numeracy.\(^{21}\) They emphasize number sense and problem solving, abstract and quantitative reasoning, argument construction and critique, structural analysis and strategic application of tools to solve math problems, and modeling with mathematics, as vital practice-based learning outcomes at all grade levels.\(^{22}\) In alignment with mathematics education, the centrality of quantitative reasoning and literacy manifesting in evidence-based explanations for science practice is emphasized in major science education documents including, the Next Generation Science Standards (NGSS).\(^{23}\) The Numeracy scale of the EI Reasoning Skills series provides a focused measure that is conceptually aligned with the reasoning and problem-solving skills endorsed by NCTM, NGSS, and reflected in the language of the Common Core Standards.

\(^{20}\) Gittens, 2015, op. cit.


More than training skills only, education for critical thinking demands nurturing a critical thinking mindset in children of all ages. The mindset portion of the EI assessments addresses this vital dimension -- a person’s consistent internal motivation to think critically when faced with problems to solve, ideas to evaluate, or decisions to make. These attitudes, inclinations, or habits of mind are dimensions of one’s personality and motivational style which relate to how likely a person is to approach decision-making contexts or problem-solving situations by engaging their reasoning skills.

The EDUCATE INSIGHT Mindset instruments include assessments for kindergarten through 2nd (primary), grades 3-5 (upper elementary), and grades 6-12 for middle school and secondary students. At the K-2 level the instrument is a 25-item survey that employs a dichotomous response format, agree or disagree. The instruments

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for grades 3-5 and grades 6-12 employ a four-point Likert type scale ranging through agree strongly, agree, disagree or disagree strongly. The K-2 instrument reports scores on four dispositional dimensions: Learning Orientation, Creative Problem Solving, Mental Focus, and Cognitive Integrity. Scholarly Rigor is added as a fifth metric on the 3-5 and 6-12 grade instruments.26 (See Table 5.)

Scores in the upper half of the range (above 30) indicate evidence for the disposition being present and are desired. For example, Figure 4 shows the distribution of scores for a group of 168 children in the 4th grade. Most children in this sample had a positive Learning Orientation and demonstrated Cognitive Integrity. Creative Problem Solving and Mental Focus scores ranged across a broader continuum. Creative Problem Solving, as measured here, is the habit or tendency of approaching problem solving with innovative or original ideas and solutions; toward feeling imaginative, ingenious, original and able to solve difficult problems; toward engaging in activities such as puzzles, games of strategy; and toward striving to understand the underlying function of objects. Creative problem solving is highly desirable in today’s workforce. Many children in this very young group demonstrate this mindset attribute. If it diminishes over the course of their education, one will naturally wish to investigate why.

Now that the assessment instruments are available for the entire K-12 educational spectrum, research on the development of critical thinking and numeracy skills and mindset attributes can be studied in greater detail. We anticipate that, as happened at the college and graduate professional school levels, equipped with these assessments, educators will significantly advance our understandings of effective pedagogies and the interrelationships in children of thinking skills, mindset attributes, and educational achievement.

What Are We Learning about Critical Thinking in the Workplace?

Leaders in the health professions, business, and the military have called for greater attention to critical thinking at all levels of their organizations. Their focus is practical. They rightly believe that stronger critical thinking will result in better leadership, better decision-making, and better problem-solving. And these mean better business, healthcare, and military outcomes. This very practical, bottom line, attention to critical thinking creates demands of effective employee development programs, including accurate empirical assessments.

The accurate assessment of the reasoning skills and thinking mindset of working people in varying sectors required the development of tailored instruments addressing their varying levels of decision responsibility. Expertise developed through several decades of work in the measurement of critical thinking, and valuable input from working professionals and acknowledged leaders in each sector, made it possible to create instruments tailored specifically for people who work in Business, Health Care, Defense, Science and Engineering, Law, and as Educators and First Responders. This set of assessments, the INSIGHT Series of Business Assessments, are used by employers in hiring and for employee development. Today the INSIGHT Series directly targets the reasoning skills and mindset attributes relevant to executives, to professionals in different fields, and to specialized and general support staff.

Understanding the value of specifically training and evaluating critical thinking has been a gradual process in educational settings. This is true in business and government settings too, particularly in high-stakes situations where errors of judgment are costly events, and where poor thinking skills and an inconsistent thinking mindset directly threaten the success of projects and the goals of the organization. As with education, corporate and government leaders have discovered that expecting strong critical thinking of management and staff is inadequate. There must be an explicit organizational focus, and a commitment of resources, to developing this expertise in their workforce. Assessments coupled with training in critical thinking are becoming more common as a component of professional development programs seeking to strengthen an existing workforce. The result of effective programs is a transformation of the decision-making culture at all organizational levels. This is new territory for many businesses and agencies, but once data begins to accumulate, there is no further need to convince leadership that assessing and training critical thinking is worth the investment.

Including explicit assessments as part of the applicant screening process enables organizations to identify candidates for hire who demonstrate strong critical thinking. Having an assessment in hand at the time of a candidate interview is the preferred use of tools like the INSIGHT Business Professional. However, reasoning skills and mindset are not the only components of a candidate’s application, and at times a hiring agent will be inclined toward the candidate who interviews well, even if that candidate demonstrates weak reasoning skills, or a mindset that was averse to engaging difficult problems or is lacking in other key mindset attributes. In some cases, these observations are used to set goals in training programs for the new hire. Once the value of the assessment has become clear to a strong thinking HR director, perhaps because new hire test scores are seen as consistent with subsequent supervisor ratings and department head observations, the next step is a roll out of a critical thinking initiative for all employee groups. In recent years US government agency leaders have made strong improvements in their federal workforce groups using this approach.

Assessments of groups of employees can provide an organization with a picture of the critical thinking strengths and weaknesses of their workforce. In the next figure the reasoning skills mid-career professionals show strong and superior overall critical thinking skill in approximately two-thirds of the 3670 assessments. And yet that...
other third, those showing moderate and weak-moderate scores, can lead the organization’s leadership to have serious concerns. What quality of decision-making can the organization expect if so many of its mid-career professionals display only moderate or weak-moderate reasoning skill?

![Descriptive Information: OVERALL]

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<th>N</th>
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The OVERALL Reasoning Skills metric on the INSIGHT Professional represents the integration of thinking and reasoning skills needed to make operational decisions and to address concerns at the professional levels of an organization.

**Figure 5 INSIGHT Professional Reasoning Skills Overall Score Sample of 3670 Assessments**

A deeper dive into the data produced by the INSIGHT Professional reasoning skills assessment used with this group of professionals shows that the areas needing professional development include problem analysis and reasoning in precise contexts. Getting the problem right in the first place is, of course, a fundamental of strong critical thinking and decision-making. And being able to reason with precision is an essential where applying regulations, laws, and quantitative information are elements in the job description.

The mindset to engage problems using strong reasoning skills is as important as having the skills themselves. Consider this distribution scores representing the mindset characteristic of being judicious in this group of employees. The vast majority display a positive or strongly positive inclination toward maturity of judgment and thoughtfulness in their approach to decision-making. But out of the more than 3800 cases reported, close to 200 of these employed professionals fail to manifest judiciousness. Their responses suggest disagreement with the idea that some problems are ill-structured. They indicate rejection of the notion that there may be more than one reasonable way to resolve problems. They generally disagree with the idea that there are times when a person should revisit and revise poor decisions dispassionately.
When it comes to assessing and training critical thinking in a current workforce, it is vitally important to design initiatives that encourage optimal employee buy-in and participation. Being “voluntold” to participate in a program that will assess one’s reasoning will likely raise anxiety in employees. Such an assessment might easily be perceived as a threat to continued employment or a potential impediment to future promotion. Solutions that consider privacy and which include focused options for personal development typically prove more successful, particularly when the entire organization including executives are participating and when employees come to appreciate the power of critical thinking to bring benefits not only at work but in other areas of their lives as well.

Evidence of explicit critical thinking training having a long-term benefit is beginning to be found. In one highly notable, longitudinal study of working professionals conducted by the US government in relation to a United States Airforce (USAF) training program, the effectiveness of a leadership program was studied over an eight-year period. Critical thinking skills were assessed using INSIGHT Health Professional, a form of the academic instrument that is the Health Sciences Reasoning Test (HSRT). The trainees were assessed at the beginning of the three-month training program (T1) and then again at the end of the training (T2). In this study, the nurses were provided their T1 scores at the beginning of the training to help them focus on areas where growth in their reasoning skill was most needed. The program was held at six training bases, each with a different training team and the same USAF training curriculum. A matched pairs comparison of the change in scores from T1 to T2 demonstrated that the training significantly improved critical thinking skills in the trainees as a group and many improved exceptionally. These gains were observable at all six training sites. This was true despite the observation that some portion of the trainees at each training site were dropping their scores at T2 due to insufficient focused effort. They also noted that nurses who did relatively well at T1 were more likely not to fully engage the retest. Although these false tests at T2 could be eliminated from program evaluation reports, the trainers worked hard in each subsequent annual cohort to stress the importance to seeking a second self-assessment to learn whether they were improving because of the importance of critical thinking for military leadership.
This USAF study is notable because it required a third assessment (T3) of these same personnel after one year of deployment at hospitals located on USAF bases around the world. Of great interest was the observation that scores at T3 continued to improve over T1 and T2. It has long been believed that the benefit of a training program focused on improving reasoning skills will have a continued impact as the learner integrates and practices what has been learned. Said differently, once someone begins to watch their reasoning and their attitudes about reasoning (becomes metacognitive about their reasoning skills and mindset), and they perceive a benefit from this type of reflection, they become instrumental in their own continued development. Most of us who train critical thinking believe this to be true, and this is why we believe that effective training of critical thinking will have enormous impact for an individual, perhaps more so when they are introduced to reflecting on their reasoning process as a young child.

Conclusion

If it is important to an organization, the organization measures it. And very often the organization – whether a school, business, health care agency, or military organization – soon begins to get what it is measuring. Whatever “it” is. The people in the organization know it is important because those in charge are measuring it. Employees attend to the metrics their supervisors use to evaluate workplace performance. If it is something my company values enough to measure, then I had better be doing it well. Students want to know what is going to be on the final because grades depend on it, and this is what they will try to master. The ever-increasing focus on measuring critical thinking, whether for of a Quality Enhancement Project (QEP) carried out by a SACS region college, or in a program to develop skills in government employees responsible for auditing defense contracts, or as the criterion set to document thinking skills in candidate screening, these action reveal an important global energy around critical thinking. We can draw several confident conclusions. First, strong thinkers are valued. Second, measuring critical thinking yields actionable results. And third, organizations will respond to perceived deficits, once objectively identified, by offering training. For example, colleges are responding to entry cohort assessment results with a view to improving student retention, graduation, and professional licensure rates. Employers are providing critical thinking focused development options as a component of on-boarding and employee advancement.

Published articles increasingly document the growing numbers of critical thinking-focused educational reports, research studies, corporate projects, and critical thinking focused initiative around the world. Naturally, we are honored that Insight Assessment clients have used our assessment instruments to create many of these documented results. We congratulate them on increasing the research knowledge about their own national educational and professional populations. Their findings suggest that training for critical thinking skills and for the critical thinking mindset is generally effective, and that strength in critical thinking is increasingly linked with key performance indicators in education and in the workplace.