Chapter 25

Aligning Potential & Passion for Promise: A Model for Educating Intellectually Talented Youth

Jonathan Wai, David Lubinski, & Camilla P. Benbow

For effective interventions and programs for the intellectually talented to be optimally developed and implemented, educators first need to realize what is important to understand for all students, namely, the nature and scope of their psychological diversity—or, their *Individuality*, the title of E. L. Thorndike's (1911) landmark essay, from which an appreciation of individual differences was ushered into American psychology (Dawis, 1992). In essence, program design should align opportunities to learn with each student's individual characteristics (Lubinski & Benbow, 2000, 2006). Or, stated another way, it should merge an individual's *potential* (abilities) and *passion* (preferences) with educational experiences tailored to each student's unique *promise* (readiness to learn). Personal promise for differential development emanating from constellations of contrasting ability/preference patterns is expressed in synthetic concepts such as "trait clusters" (Ackerman, 1996), "aptitude complexes" (Corno, et al., 2002; Snow, 1991), and "taxons" (Dawis & Lofquist, 1984). The basic idea is that knowing what a person can do (abilities or capabilities) is only one part of the equation; another important component is knowing what he/she will do or would like to do (viz., interests, needs, and values).

Although there is a rich psychological tradition for what follows (Achter & Lubinski, 2003), our focus is on the present as well as the future of intellectually precocious youth who have been, or who should be, identified. Our model is based on highly developed empirical, philosophical, and theoretical considerations from the study of human individuality (Lubinski, 1996, 2000; Paterson, 1957; Tyler, 1974; Williamson, 1965) and, hence, draws on fundamental insights about the role of cognitive abilities, preferences, and conative factors in learning readiness, the school to work transition, and work performance. How these determinants combine to engender the development of differential expertise and contrasting outcomes indicative of exceptional achievement and creativity in learning and work environments is the primary goal of our longitudinal research program (Lubinski & Benbow, 2000, 2006).

Study of Mathematically Precocious Youth: Uncovering Remarkable Learning Rates

The longitudinal data we will draw on to support our model stems primarily from the Study of Mathematically Precocious Youth (SMPY). SMPY was founded in 1971 by Julian C. Stanley (Keating & Stanley, 1972; Stanley, 1996), due to what he called a "serendipitous occurrence," with a young man who displayed astounding intellectual qualities that eventuated in a series of creative achievements later in life (Stanley, 1996). Stanley's discovery of this individual was the seed that led the talent search concept to fully blossom and, at present, over 200,000 youth are assessed annually using college entrance exams such as the SAT. Although administering college entrance exams to 12-year-olds was considered a radical idea initially, we now know that when such students score 500 or more on the SAT, they can routinely assimilate a full high school course in three weeks at summer residential programs for intellectually talented youth, and those scoring 700 or more can learn at least twice this amount within this time frame (Benbow & Stanley, 1996; Stanley, 2000). Of course, it is not test scores per se that are important, but the individual differences in learning rates that they reflect, and the prophecy they hold for differential development, that are important. Thus, selecting students based on their learning rate seemed to be an ideal way to conceptualize and build a longitudinal study. We are now in a position to examine how these well known individual differences in learning rates translate into achievement and creative production later in life.

Although SMPY was descriptively apt early on, now two letters (the M and Y) are misnomers, due to a wider focus on specific abilities and that all SMPY participants are intellectually talented adults. By the 1980s, for example, the initial mathematical (SAT-Mathematics) emphasis was widened to include verbal (SAT-Verbal) abilities. Nevertheless, we have chosen to retain SMPY as the title of our study to avoid confusion. SMPY now consists of more than 5,000 participants, grouped into five cohorts; and 20-year longitudinal data are available from three of these cohorts, which speak to the importance of taking the individuality of intellectually precocious youth into account for educational practice at an early age (Lubinski & Benbow, 2006). We now know categorically that intellectually precocious youths are anything but a categorical type.

Foundational Patterns: Individual Differences, Philosophy, and Theory

The historical and basic science underpinnings of our current model of talent development can be found in Lubinski (1996, 2000, 2004), the educational philosophy in Benbow and Stanley (1983, 1996; Benbow & Lubinski, 1996; Stanley, 2000), and the theory in Lubinski and Benbow (2000, 2006). Each of these foundational domains has led to what Lubinski and Benbow (2000) describe as "appropriate developmental placement," or giving students educational opportunities commensurate with their learning rates and preferences for subject matter content and growth. [For an excellent review of the importance of structuring the educational curriculum at a pace commensurate with students' rate of learning, see Colangelo, Assouline, and Gross (2004).]

The identification of talented youth has been facilitated through talent searches and the practice of group testing using college entrance exams, such the SAT, among talented youth whose intellectual capacity has extended beyond the ceilings of their age-appropriate measures (Lupkowski-Shoplik, Benbow, Assouline, & Brody, 2003). Unlike Hollingworth (1926, 1942) and Terman (1925), who, along with their coworkers, had to administer individual tests through a time consuming case by case basis, group testing using tests designed for older students efficiently differentiates or identifies the exceptionally able from the able. This practice is known as above level testing. (As we will argue below, however, talent searches could be doing a better job by incorporating other complementary measures.) In simple conceptual terms, what this means for intellectually talented populations is that you should not use a psychometric ruler to measure students' minds when you really need at least a psychometric yardstick. Otherwise, the perception of multipotentiality (Achter & Lubinski, 2005; Achter, Lubinski, & Benbow, 1996)—that students who have age or grade based scale scores clustered near the ceiling have the ability to do anything they wish—appears and then masks the full dimensionality and scope of their individuality. For example, their strengths and relative weaknesses, as revealed by appropriately difficult tests, are important to understand for personal appraisals of how one is likely to find different educational choices and learning environments (and anticipating how far one's individuality is likely to take them).

In a separate yet related vein, just as the term "educational acceleration" might be considered not quite as accurate as "appropriate developmental placement" (Benbow & Stanley, 1996) (because the student is really not being accelerated but rather placed in learning environments that present curriculum at a pace commensurate with his/her rate of growth), above-level testing also might be better seen as "appropriate-level testing" or assessing the student at the level at which he or she is functioning. Thus, appropriate-level testing might lead more readily to appropriate developmental placement, and then to an appropriate degree of educational and vocational achievement and enjoyment. Essentially, the best focus might not be so much on whether these students have "surpassed" a normatively based instrument's ceiling, should be "accelerated," or are achieving at "remarkable" levels in the eyes of the norm, but rather that, if given appropriate opportunities and counseling to fully develop the promise of their individuality (or personal constellation of salient psychological characteristics), can and will they capitalize upon these opportunities?

The Radex, the RIASEC, and a Theory of Person-Environment Fit for Learning and Work Environments

The nature and organization of cognitive abilities (Carroll, 1993; Snow & Lohman, 1989) and educational-vocational preferences (Day & Rounds, 1998; Holland, 1996) are the two primary individual differences that SMPY uses in its framework for modeling differential learning rates, preferences for contrasting content, and anticipating future accomplishments and creative achievements among the intellectually precocious as a function of their individuality. This approach may be traced back to Parsons' (1909) three-step approach to vocational guidance, wherein he emphasized an understanding of one's individuality, knowledge of what the work or learning environment required, and honest reasoning between these two sets of information. This mirrors the underlying logic of the Theory of Work Adjustment (Lofquist & Dawis, 1991; TWA; Dawis & Lofquist, 1984), which Katzell (1994) generalized to industrial psychology and which was earlier extended to talent development in educational contexts for intellectually precocious youth (Lubinski & Benbow, 1992; Lubinski & Humphreys, 1990). TWA is a psychological approach predicated on a person-environment fit (Rounds & Tracey, 1990). Given the complexity of the development of talent, TWA was drawn upon to help inform practice, organize empirical findings, and structure SMPY's program of longitudinal research (Lubinski & Benbow, 2000, 2006). From our point of view, educational, counseling, and industrial psychology are each applied disciplines that are predicated on the scientific study of interventions or opportunities, based on individual differences, for enhancing positive psychological growth in learning and work settings (each specialty developed from a somewhat different focus or stage of development: School, the transition from school to work, and the world of work). We now turn to the two major classes of person-variables for our model (illustrated in Figure 1), which place equal emphasis on assessing the environment and the individual.

Cognitive abilities. How should cognitive abilities be conceptualized? Cognitive abilities are well characterized by Snow's radex model (Snow, Kyllonen, & Marshalek, 1984; Snow & Lohman, 1989). Within this framework, the general factor is ringed by the three major specific abilities: Spatial/mechanical, verbal/linguistic, and mathematical/numerical (see Figure 1). It is essentially another way to represent Carroll's hierarchical model of human abilities more parsimoniously.

Preferences. How should preferences be conceptualized? The most widely used framework for educational-vocational preferences is Holland's (1996) hexagon of six general interest themes (known as RIASEC, see Figure 1): Realistic (interest in working with things or outdoors and need for structure), Investigative (interest in sciences, in particular math and physics, and a preference for independent work), Artistic (interest in art, writing, or other types of creative expression with little need for structure), Social

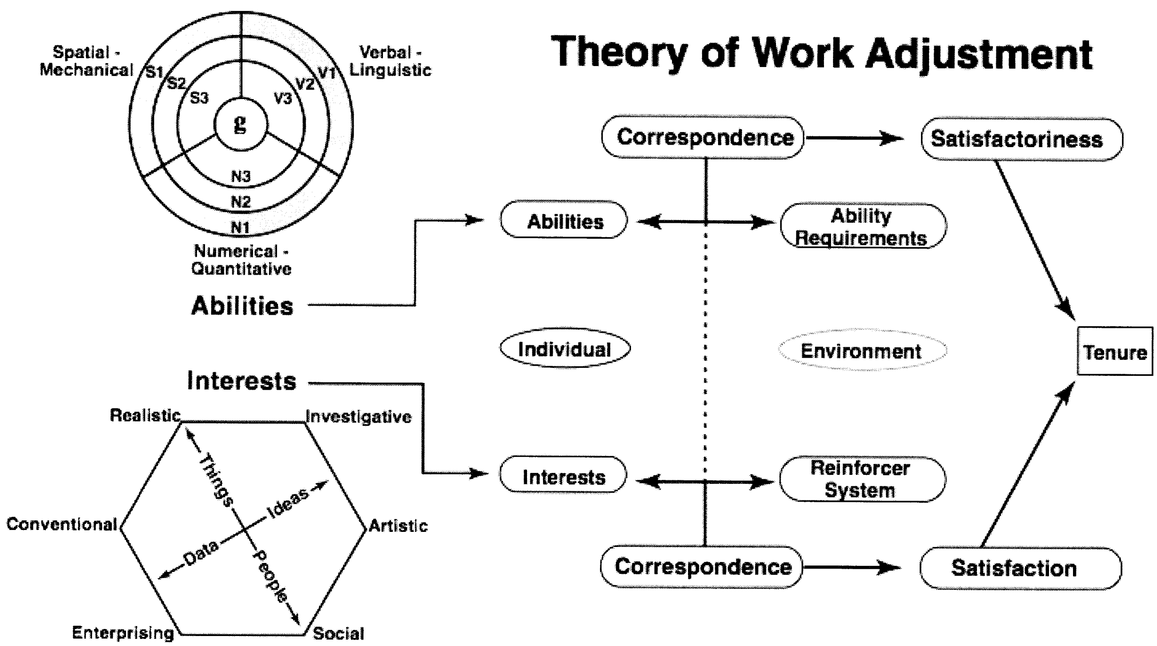

Figure 1. The Theory of Work Adjustment (right side) alongside the radex of cognitive abilities (top left) and RIASEC hexagonal pattern of interests (bottom left), used in combination to understand personal antecedents important to education and vocation (Lubinski & Benbow, 2000). The letters inside the radex pertain to a specific ability, whereas the numbers rise with sophistication. The two lines inside the hexagon are two reduced dimensions (Prediger, 1982), data/ideas and people/things that are central to the RIASEC. The dotted line in the individual and environment sections of TWA delineates the equivalence put on assessing personal attributes (abilities and interests) and environmental attributes (abilities requirements and reward architecture).

(interest in people and the helping professions), Enterprising (interest in leadership, particularly if it leads to economic achievement), and Conventional (interest in structured environments such as a well delineated command chain, and office activities). Important to describe for later summary of fresh empirical findings is the people versus things dimension within Holland's hexagon (Lippa, 1998; Lubinski, 2000), which runs from Social (contact with people) to Realistic (contact with things).

For comprehensiveness, it is also informative to introduce the Study of Values (SOV; Allport, Vernon, & Lindzey, 1970), another broad preference inventory that has been used extensively in longitudinal research programs (Dawis, 1991), including our own with gifted youth (Achter et al., 1996; Achter, Lubinski, Benbow, & Eftekhari-Sanjani, 1999; Lubinski & Benbow, 1992; Lubinski, Schmidt, & Benbow, 1996; Schmidt, Lubinski, & Benbow, 1998; Wai, Lubinski, & Benbow, 2005; Webb, Lubinski, & Benbow, 2007). The primary dimensions of the SOV include Theoretical (values discovery of truth, interest in the empirical, critical, and rational), Economic (values usefulness and practicality, sees as a waste knowledge unapplied), Political (values and desires power, influence, and status), Aesthetic (values harmony and form, and the artistic facets of life), Social (values altruistic and philanthropic love of others, is unselfish and has sympathy), and Religious (values unity, and attempts to find the relation between the cosmos and self).

How abilities and preferences operate in the context of TWA is illustrated in Figure 1. Two primary concepts (which mimic the personal components of Parson's two sets of facts), abilities and preferences, parse the environment in commensurate terms—ability requirements and reward systems—and from two dimensions of correspondence—*satisfactoriness* and *satisfaction*. Satisfactoriness refers to the alignment between abilities of the individual and the ability requirements of the environment, whereas satisfaction is the correspondence between personal preferences and congruence with the reward structure of the environment. TWA stresses both abilities and interests, as do others (Gottfredson, 2003; Strong, 1943; Super, 1949), and the match between the person and the environment. When satisfactoriness and satisfaction are both in place, the predicted outcome is tenure (when the person and environment are mutually satisfied with one another, contribute to each other's growth, and are both motivated to maintain contact or an extended relationship). The latter occurs in a school setting when intellectually talented students are placed in environments with their intellectual peers, and positive social and emotional growth co-occurs with their educational development. Students who are learning at the same rate enable teachers to present the curriculum at an appropriate pace for optimal learning for all students (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000; Benbow & Stanley, 1996; Muratori et al., 2006), and talented students do notice and find it frustrating when the pace of the curriculum slows down to a non-optimal rate (Bleske-Rechek, Lubinski, & Benbow, 2004). If students share passion, the effectiveness of the learning environment is even further advanced.

Structural Relations: Empirical Findings

Now that our model has been outlined, we will review recent empirical findings supporting its verisimilitude. First, we focus upon the level and pattern of cognitive abilities and, then, move to a larger view that embraces preferences or interests and values. Under each topic, we will summarize up-to-date 20-year longitudinal findings that speak to the relevance of taking these dimensions of individuality into account. As Ivan Pavlov wrote (cf. Pressey, 1955, p. 129): "Perfect as the wing of a bird may be, it will never enable the bird to fly if unsupported by the air. Facts are the air of science." Without muscular empirical facts to support our model, our framework would be a mere skeleton incapable of scientific ambulation.

Cognitive abilities: Level and pattern. Both ability level and pattern manifested at an early age have practical value. Assessing mathematical and verbal reasoning abilities among intellectually precocious youth with appropriate level tests provide helpful guideposts for educational counseling and tailoring educational planning. To set the stage for the appreciation of ability level, consider the following: The top 1% of ability contains over one third of the ability range. While this statement can initially give one pause, consider the following example. Our model and the field of gifted education more generally has moved beyond IQ, but to use IQ as a familiar standard, IQs within the top 1% cover over one third of the ability range, from approximately 137 to over 200. An important issue to address is whether these intellectual differences make a difference in education and the world of work. There is a widespread supposition of an "ability threshold," or that beyond a certain ability level, more cognitive ability doesn't matter (Getzels & Jackson, 1962; Howe, 2001). Yet, data available for over 15 years has suggested otherwise.

Ability level. An early study conducted by Benbow (1992) that focused on educational outcomes examined the top and bottom quartiles (upper and lower 25% respectively) of the top 1% of mathematical reasoning ability (as assessed by SAT-M) across 10 years. This study found that on 62 of the 67 criteria examined (e.g., ranging from prizes and awards to standardized test scores) statistically and substantively different effect sizes were uncovered that all favored the top quartile. More recent studies have built upon this finding by using more longitudinally remote criteria in occupational settings. More specifically, Wai et al. (2005) examined the top and bottom quartiles, by sex, of those scoring in the top 1% in ability on the SAT-M and documented that the upper quartile in comparison to the lower quartile earned more doctorates (JD, MD, PhD, or EdD), STEM PhDs (Science, Technology, Engineering and Mathematics), income, patents, and tenure at top 50 U.S. universities (see Figure 2). The panel in the upper left corner of the figure includes both the percent earning a doctorate (total segment of each bar) and percent earning a STEM doctorate (bottom black segment of each bar). The remaining panels examine one variable each, with the mean SAT-M for Q1 and Q4 being 455 and 620, respectively (achieved before age 13). This difference is important. The top quartile of the top 1% exceeded the bottom quartile on each of these criteria, showing that even within the top 1% of the ability range, ability differences between the top and bottom quartiles uncovered by a one-hour test taken two decades prior, at age 13, can make important life differences.

Lubinski, Webb, Morelock, and Benbow (2001) studied 320 individuals who manifested profound intellectual abilities (in the top 1 in 10,000 for their age group: SAT-M $\geq$ 700 or SAT-V $\geq$ 630) before age 13. By their 10-year follow-up, 93% had attained a Bachelor's, and 31% and 50% were working on a Master's and Doctorate degree, respectively. The latter statistic is over 50-times base rate expectations according to the 1% statistic in the adult population for

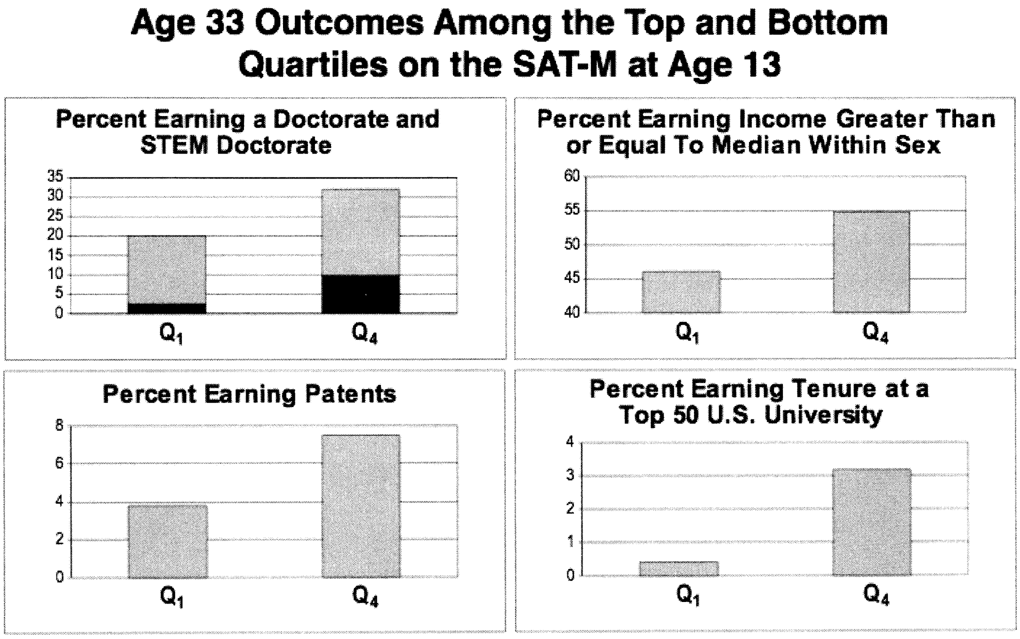

Figure 2. These four panels represent the overall (combined across cohort and sex) proportion of participants in the bottom and lower quartiles on the SAT-Mathematics earning a Doctorate, a STEM Doctorate, income ≥ the median within sex, and tenure at a top 50 U.S. University (adapted from Wai et al., 2005, Table 1, p. 486). The upper left panel includes both the percent earning a Doctorate (bottom segment of each bar) and percent earning a STEM Doctorate (top segment of each bar). The remaining panels examine one variable each, with the mean SAT-M for Q1 and Q4 being 455 and 620, respectively (achieved before age 13). The percentages illustrated in the figures for all Doctorates is 20.1% and 32.1% for Q1 and Q4, respectively, for STEM Doctorates (2.5% and 9.8%), for income (46.1% and 54.9%), and for tenure at a top university (0.4% and 3.2%).

doctorates earned (U.S. Department of Education, 1997). This, along with the findings that in the top 1 in 100 group the percentage is 25% (Benbow et al., 2000), and that the top and bottom quartiles of the top 1% in the Wai et al. study were 32% and 20%, respectively, gives us a nice sequence of proportions that rise as a function of ability level (i.e., bottom quartile: 20%, top 1 in 100: 25%, top quartile: 32%, and top 1 in 10,000: 50%). In addition, Lubinski, Webb, et al. found that for those seeking Doctorates in the top 1 in 100 group, 21% were doing so in top 10 ranked U.S. universities, whereas for the top 1 in 10,000 group this percentage rose to 42%, again a doubling effect. [Additional percentages taken from other databanks (the Terman study, and a subset of Project Talent) of intellectually talented youth in the top 1% serve as benchmarks that reinforce this trend (cf. Holahan, Sears, & Cronbach, 1995; Lubinski & Humphreys, 1990).]

Finally, a recent study by Lubinski, Benbow, Webb, and Bleske-Rechek (2006) examined the same criteria as Wai et al. (2005), and these findings are summarized in Figure 3. This diagram depicts data from both the 20-year follow-up of the top 1 in 10,000 group alongside 10-year follow up data from a cohort composed of beginning graduate students pursuing Doctorates in the top 15 U.S. STEM programs (Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001). Figure 3 reports on whether participants secured a tenure track position at a top

U.S. university (at three increasing rank gradations: Universities ranked higher than 51, 26-50, and top 25) or a high income (at three increasing income gradations: 100-249K, 250-499K, and greater than 500K), exhibiting, again, the importance of ability throughout the ability range.

Epidemiologists (and social scientists in general) are impressed when base rates are multiplied by a minimum factor of 2 (Lubinski & Humphreys, 1997) and, for these intellectually able youth spanning the range of the top 1%, these findings are quite astonishing, especially since for both Doctorates and patents, the base rate in the U.S. population is 1% (Huber, personal communication, October 2004).

J. C. Huber (1999) stated that in regards to documenting intellectual property that constitutes a patent, "It would be hard to find a field of study where so much effort has been expended in establishing a definition. Perhaps the definition of invention is the most solid definition in the field of creativity" (p. 61). From the Wai et al. study, the percentage of patents for bottom and top quartiles on the SAT-M were 3.8% and 7.5%, respectively, whereas talent search participants who scored above the top 1 in 10,000 level on the SAT-M from the Lubinski, Benbow, et al. study secured patents at a much higher rate in line with their ability level (males: 20.1%; females: 9.1%). Again, we can see a positively accelerating trend, this time corresponding to an objective indicator of creativity.

Society has moved well beyond the industrial revolution and we are now deep into the information age; the world is becoming "flat" with knowledge

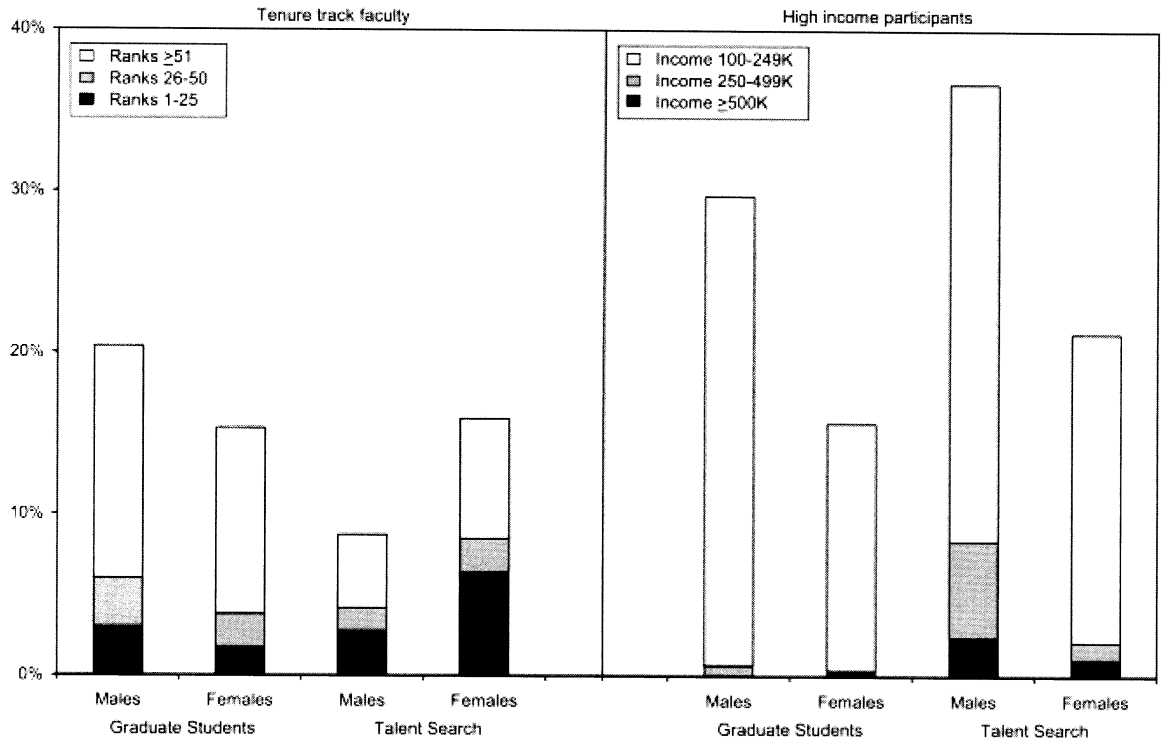

Figure 3. Twenty-year longitudinal follow up at age 33 of talent search (TS) participants scoring in the top 1 in 10,000 on the SAT-M or SAT-V before age 13, and a 10-year follow up graduate students (GS) at top U.S. STEM programs in their mid-30s, first identified in their first or second year as a graduate student. Percent of GS and TS participants who held tenure track or tenured positions (left) and annual incomes of more than 100K (right). Data are based on GS (299 males, 287 females) and TS (286 males, 94 females) participants. From Lubinski, Benbow, et al. (2006).

available everywhere a computer and the Internet can be (Friedman, 2005). The medium within which creativity is likely to occur in the future is changing as well. But some clear cut examples are likely to remain constant for an extended period of time. First of all, without question, earning tenure at a top university requires internal and external evaluation by experts within the same field and is a genuine measure of creativity. However, earning a high income appears to capture an aspect of creativity as well. In upper administration, finance, business, and law, huge salaries are granted for the capacity to respond to novel problems in instrumentally effective ways—essentially, creative problem solving, or being thrown into situations for which one has not practiced. And, specifically, PhDs are granted because of a genuine creative contribution to the field, showing that getting a PhD also adds a nuance to the way we conceptualize creativity. Thus securing a patent, a tenure track position at a top university, a high income, and a PhD all require aspects of what constitutes creative production.

Nevertheless, the importance of valid measures of individual differences in ability has been voiced repeatedly and recently called into question. For example, a recent letter published in *Science*, and signed by 79 academic administrators and researchers (Muller et al., 2005), read: "[T]here is little evidence that those scoring at the very top of the range in standardized tests are likely to have more successful careers in the sciences. Too many other factors are involved" (p. 1043). Other factors are obviously important; however, when other variables are held constant (or all other things are equal), more ability is definitely an advantage. Yet, in the flagship journal of the American Psychological Association, Vasquez and Jones (2006,) write: "Standardized tests are thus not sufficiently predictive of future performance. Individuals are not necessarily more meritorious if they obtain the highest scores on standardized tests, thus rendering invalid the argument that students with the highest scores should have priority in admissions" (p. 138).

This is simply not true.

Ability pattern. While ability level factors heavily into level of achievement, ability pattern is needed to predict the type of achievement. Spatial, quantitative, and verbal abilities all add something relative to each other in the prediction of the types of educational and occupational pursuits that individuals are likely to pursue (Gottfredson, 2003; Lubinski, Webb, et al., 2001). This can be seen in Figure 4, a sequence of four life outcomes that track intellectually talented youth, assessed on mathematical, spatial, and verbal abilities by age 13 and tracked over 20 years (Shea, Lubinski, & Benbow, 2001). All participants were in the top 1% in general intellectual ability. Yet, as a group, they manifested much diversity in terms of their intellectual strengths.

At 5, 10, and 20 years after initial assessment, individual differences in the profile of these three abilities, assessed in early adolescence, formed a consistent pattern of longitudinal outcomes. Panels A and B, respectively, indicate whether at age 18 if participants' favorite and least favorite high school course resided in math/science or the humanities/social sciences as a function of all three abilities. Panels C and D represent college major at age 23 and occupation at age 33. Over all four panels, these life outcomes reveal in three-dimensional space how mathematical (X), verbal (Y) and spatial (Z) ability factor into educational-vocational preferences and outcomes. Each of the abilities is represented in z-score or standard deviation units (A and B within sex, C and D aggregated across sex). Within each

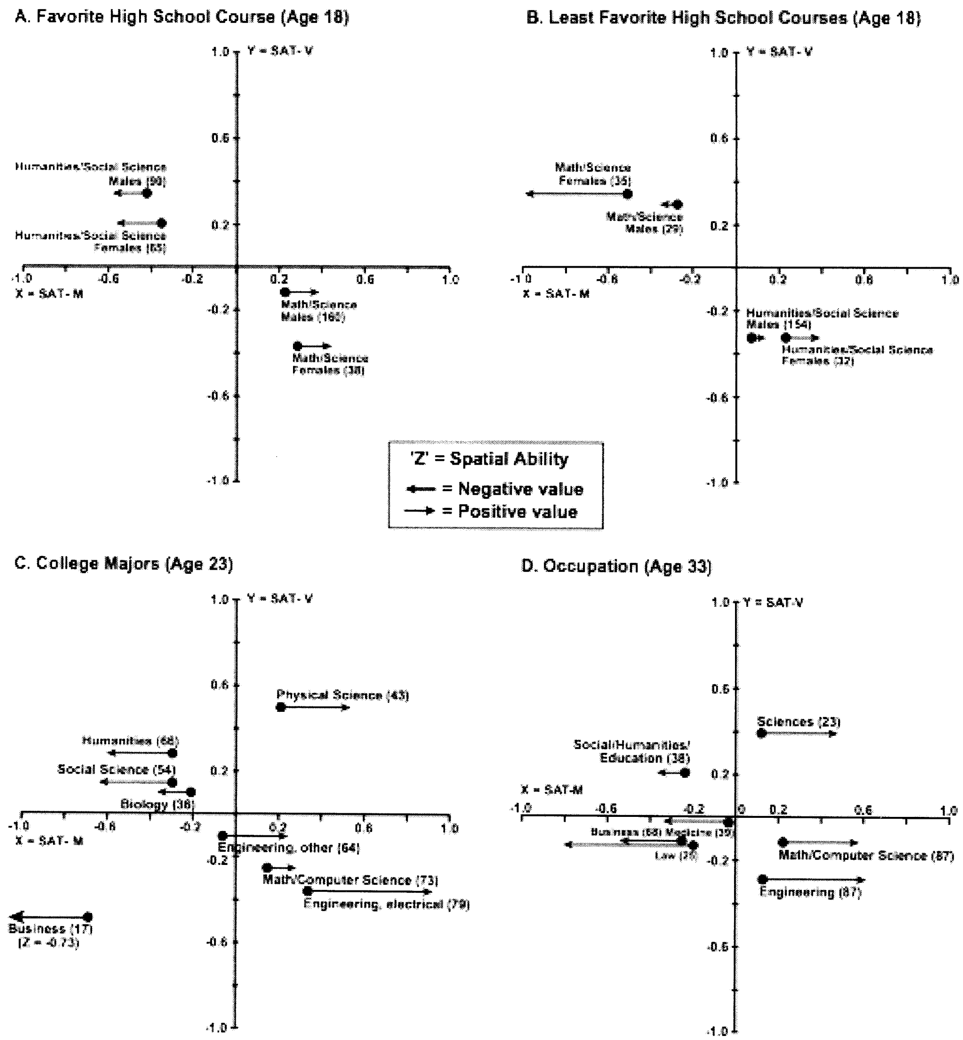

Figure 4. Trivariate means for (Panel A) favorite and (B) least favorite high school course at age 18, (C) earned a Bachelor's at age 23, and (D) occupation at age 33. SAT-V and SAT-M from the Scholastic Assessment Test; DAT-C is a composite of space relations (SR) + mechanical reasoning (MR) from the Differential Aptitude Test. Panels A and B are standardized within sexes, C and D between sexes. The large arrowhead in (C) indicates that the length of the arrow is actually twice the displayed length. Adapted from Shea et al. (2001).

panel, and for every labeled group, the direction of the arrows (scaled in the same units as the verbal and math scores) shows whether spatial ability (Z) was higher (right) or lower (left) than the comprehensive mean for spatial ability. Thus, as a function of math, verbal, and space, marking one axis each, the spread of these groups in standard deviation units can be visualized. The replicated pattern across these panels is that high levels of math and spatial abilities relative to verbal abilities reflect group membership in engineering and math/computer science, whereas participants with high verbal abilities relative to math and spatial characterize group membership in the humanities and social sciences. Participants with appreciable verbal ability, particularly when combined with relatively less mathematical and spatial ability, will likely seek out development in areas distinct from engineering and math/computer science fields.

Importantly, across these three points in time, spatial, mathematical, and verbal abilities each manifest incremental validity relative to the other two in predicting these criteria.

Another study looked at the importance of ability pattern at an even greater level of ability—those individuals in the top 1 in 10,000 group (Lubinski, Webb, et al., 2001). Favorite high school courses were sifted into three groups: Sciences and Technology, Humanities and Arts, and Other. Correspondingly, three groups were formed regarding ability pattern: High-Math (SAT-M was one standard deviation above SAT-V), High-Verbal (SAT-V was one standard deviation above SAT-M), and High-Flat (SAT-M and SAT-V were within one standard deviation of each other). Table 1 parallels the quantitative profiles (found in the lower right corner) with comparable qualitative achievements. Contrasting high school and college course preferences matched quite well with the pattern of differing accomplishments at age 23, as those who were High-Math were more likely to have accomplishments in the Sciences and Technology, High-Verbal individuals in the Humanities and Arts, and High-Flat individuals exhibiting intermediate qualitative achievements. Table 1 also provides not only more evidence speaking to the role abilities play in creative achievements, but also how ability pattern is critical for understanding the domains intellectually precocious youths are likely to subsequently pursue based on the pattern of their

Table 1
Special Accomplishments and Awards

Sciences and technology

- Scientific publications (11)
- Software development (8)
- Inventions (4)
- National Science Foundation fellowship (2)
- Designed image correlation system for navigation for Mars Landing Program
- The American Physical Society's Apker Award
- Graduated from Massachusetts Institute of Technology in 3 years at age 19 (entered at 16) with perfect (5.0) grade point average and graduated from Harvard Medical School with MD at age 23
- Teaching award for "Order of Magnitude Physics"

Humanities and arts

- Creative writing (7)
- Creation of art or music (6)
- Fulbright award (2)
- Wrote proposal for a novel voting system for new South African Constitution
- Solo violin debut (age 13) Cincinnati Symphony Orchestra
- Mellon Fellow in the Humanities
- Presidential Scholar for Creative Writing
- Hopwood writing award
- Creative Anachronisms Award of Arms
- First place in midreal-medieval poetry
- Foreign language study fellowship
- International predissertation award

Other

- Phi Beta Kappa (71)
- Tau Beta Pi (30)
- Phi Kappa Phi (14)
- Entrepreneurial enterprises (2)
- Omicron Delta Kappa
- Olympiad silver medal
- Finished Bachelor's and Master's in 4 years
- Received private pilot's license in 1 month at age 17

Group	Science & technology	Humanities & arts
High-math	16	5
High-flat	6	6
High-verbal	7	13

individuality. The top 1 in 10,000 group is extraordinary indeed.

Teaming Abilities and Preferences: Toward a More Comprehensive Framework

As delineated in Figure 1 as part of the TWA model, person-variables, just like the environmental ones, can be parsed into two major categories. The first group relates to *satisfactoriness* (or whether the individual meets the ability requirements of the environment) and thus is captured well by abilities. However, the second cluster, preferences (as assessed by the RIASEC and SOV), is related to *satisfaction* (or whether an individual's needs are met by the environment). Even though abilities and preferences are slightly correlated (hence the existence of trait-complexes), this overlap is sufficiently small so that assessing abilities and preferences are both necessary for understanding students comprehensively (Dawis, 1992, 2001; Lubinski, 1996, 2001; Savickas & Spokane, 1999).

To determine whether preferences achieved incremental validity (Sechrest, 1963) beyond abilities in the forecasting of college majors, for example, Achter et al. (1999) analyzed data from 432 intellectually precocious youths who had been measured by both the SAT and SOV and who attained a college degree 10 years after their initial assessment (at age 23). Participants were grouped into three categories: Humanities, Math-Science, and Other.

A discriminant function analysis was executed, using the SAT-M, SAT-V, and five SOV themes, to determine the patterns (in this case two functions, F_1 and F_2) that separated each of the three groups from one another. Table 2 is the discriminant function structure matrix that shows the two functions (one per column) and their respective weights. The first function (F_1) characterized a math-science combination of weights, with positive weights for the SAT-M and SOV-Theoretical, and negative weights for Social and Religious values. Whereas, the second function (F_2) characterized a humanities weight combination, with high SAT-V scores and Aesthetic values. Incremental validity of preferences beyond abilities was demonstrated as the SAT-M and SAT-V accounted for 10% of the variance between the three groups, and the five SOV dimensions accounted for an additional 13%, for a total of 23% of the variance accounted for (which is impressive considering the 10-year gap and the diversity within each of the three broad degree groupings).

The visual complement to the discriminant functions in Table 2 is given in Figure 5, which includes the bivariate means plotted in this space for the three educational degree groups (Math-Science, Humanities, and Other). The data from Achter et al. (1999) are represented by the unshaded triangle in Figure 5, and dotted lines drawn from each bivariate mean through the midpoint of the other two create mutually exclusive and exhaustive categories specifically indicative of the three educational groupings used by Achter et al. In the Wai et al. (2005) study, an

Table 2
Discriminant Function Structure Matrix

Variable	Function 1	Function 2
SAT-Verbal	.09	.56
SAT-Math	.59	-.12
SOV-Theoretical	.87	-.03
SOV-Aesthetic	-.13	.81
SOV-Social	-.60	-.01
SOV-Religious	-.56	0.3
SOV-Economic	.47	-.29

Note: For the age 23 data examining college degrees, the group centroids were (F_1, F_2): math-science (.43, -.05), humanities (-.29, .60), and other (-.57, -.21). F_1 = Function 1, F_2 = Function 2, SAT = Scholastic Assessment Test, and SOV = Study of Values. From Achter et al. (1999, p. 783).

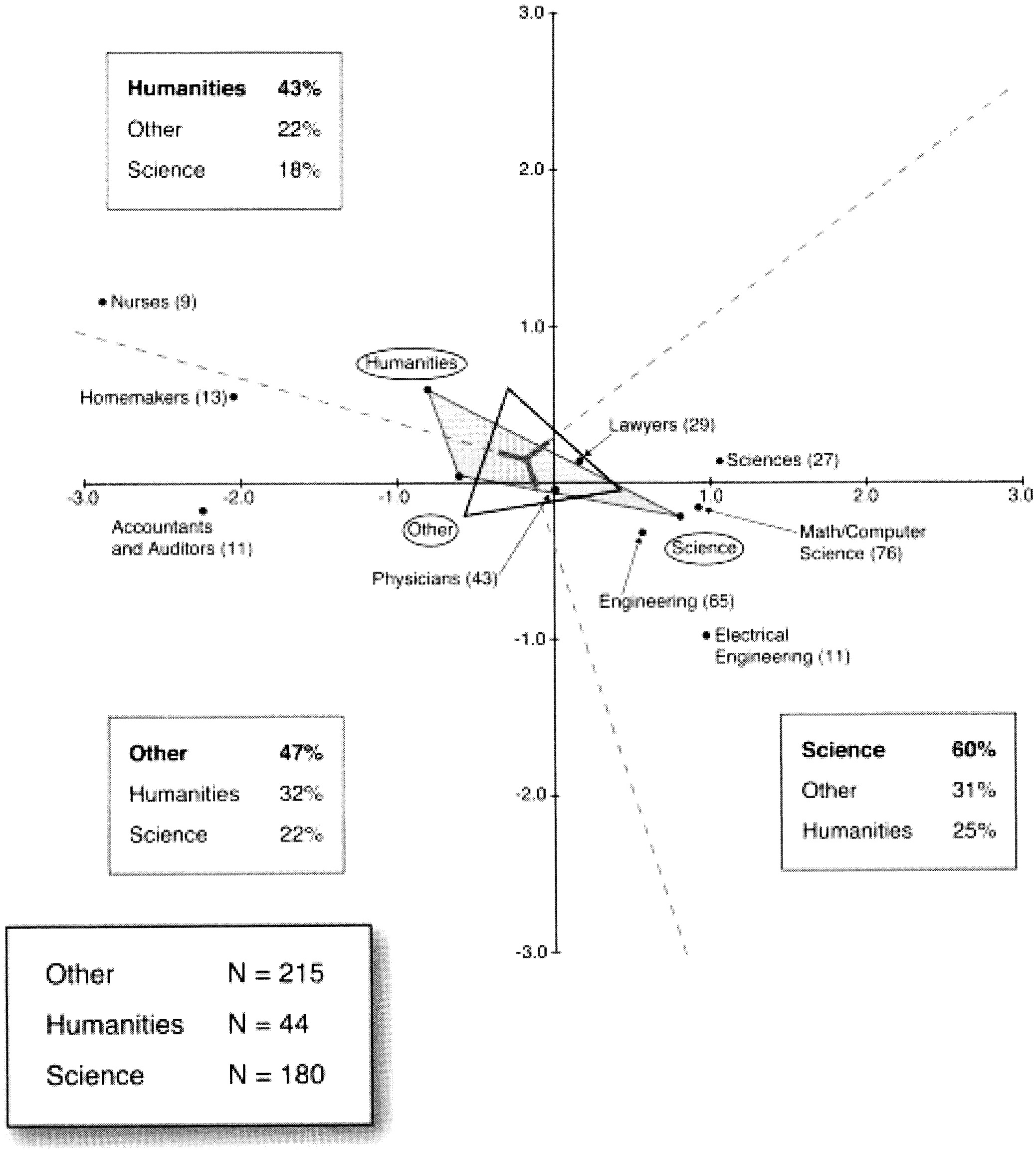

Figure 5. Bivariate group centroids (means) for occupations. The unshaded triangle is created by F_1 and F_2 group means for college majors at age 23, whereas the shaded triangle is defined by F_1 and F_2 group means for occupational groups at age 33. The group centroids for the data collected at age 33 were (F_1, F_2) humanities (-.80, .59), math-science (.80, -.21), and other (-.60, .04). Science = math-science occupations; F_1 = Function 1; F_2 = Function 2. Percentages were computed utilizing individual data points. Physicians, lawyers, and other occupations are placed in this space with sample sizes in parentheses. Taken from Wai et al. (2005).

analysis similar to Achter et al. was conducted, but this time using occupational group membership (20 years later at age 33) as the criteria for prediction. The logic of this analysis was that if age-13 SAT and SOV assessments could predict occupational attainment at age 33 using functions derived from age 23 educational criteria, this would constitute a successful generalization probe from educational-learning to occupational-work environments, and the two functions in Table 2 would accrue additional validity. And indeed they did.

Wai and his colleagues tracked 511 participants over 20 years who had relevant data for the analysis described above, and again the occupations were put into the same three broad groupings (Math-Science, Humanities, and Other), and the scores based on the Achter et al. discriminant functions were plotted in the same space as Achter et al. (Figure 5). The bivariate means of the occupational data for each group are represented by the shaded triangle. More circumscribed bivariate means for various occupational groupings were also placed in this two-function space (with sample sizes in parentheses), and the proportion of hits and misses for each broad grouping is given for each segment. Beyond the majority of each group falling into the predicted category (a convergent pattern), if a bivariate point is located in the math-science space then it is most likely that the individual is not employed in a humanities occupation, and vice versa (a discriminant pattern). This convergent-discriminant pattern captures empirically what C. P. Snow (1959, 1998) described as the two cultures, where the term "culture," according to Snow, is precisely meant in both meanings, that is (1998): "development of the mind" (p. 62) and "a group of persons living in the same environment, linked by common habits, common assumptions, a common way of life" (p. 64). Also interesting to note in Figure 4 is a people versus things (or organic versus inorganic) dimension that can be traced from slightly above the positive x-axis (around homemakers and nurses), through the origin, to slightly under the negative x-axis (near engineers and computer scientists). Based on both the Achter et al. and Wai et al. studies, there is no question that in the prediction of educational and occupational choice, both abilities and preferences contribute unique information relative to each other.

Although the studies reviewed so far in this section have included mathematical and verbal reasoning abilities, the radex of cognitive abilities (Figure 1) also includes spatial ability. A recent study by Webb et al. (2007) used all three specific abilities along with both the RIASEC and the SOV to forecast learning and work criteria at age 18. In this 5-year longitudinal study, five criterion variables were examined: Favorite (and least favorite) high school course, leisure activities, college major, and intended occupation. In summary, spatial ability was demonstrated to hold incremental validity for these predicted variables (2.4%) beyond the SAT combined with either the RIASEC or SOV. In parallel to the Achter et al. and Wai et al. first discriminant functions, for Webb et al., function one (F_1) for either the SOV or the RIASEC uncovered a noticeable math-science pattern of promise, both of which can be found in Table 3. That is, there were positive weights for mathematical and spatial ability, negative ones for verbal ability, linked with positive theoretical and negative social, aesthetic, and religious preference loadings. Although these results were derived from a 5-year study examining primarily intentions and not actual outcomes, the pattern found here has already been discovered in more mature groups (Austin & Hanisch, 1990; Gohm, Humphreys, & Yao, 1998; Humphreys, Lubinski, & Yao, 1993), suggesting that these findings hold reasonable promise, especially when placed alongside the words of Snow (1999): "There is good evidence that [visual-spatial reasoning] relates to specialized achievements in fields such as architecture, dentistry, engineering, and medicine.... Given this plus the longstanding anecdotal evidence on the role of visualization in scientific discovery ... it is incredible that there has been so little programmatic research on admissions testing in this domain" (p. 136). A comprehensive mapping of cognitive abilities requires mathematical, verbal, and spatial abilities, and so should modern talent searches (Lubinski, 2003). Our understanding of cognitive abilities,

Table 3

Two Sets of First Discriminant Functions (F_1), Utilizing the SOV and the RIASEC for Predicting Three Criterion Groups (Humanities, Math-Science, & Other)

Values and Abilities		**Interests and Abilities**	
	F_1		F_1
		Realistic	.11
Theoretical	.57	Investigative	-.04
Aesthetic	-.42	Artistic	-.69
Social	-.36	Social	-.51
Economic	.47	Enterprising	-.42
Religious	-.17	Conventional	.02
SAT-V	-.19	SAT-V	-.24
SAT-M	.39	SAT-M	.30
Spatial Ability	.70	Spatial Ability	.64

Note: Numbers reflect the average weights of two first discriminant functions (F_1), based on three abilities (verbal + math + space) and either the SOV or the RIASEC (reflecting values and interests, respectively) in predicting three criterion groups (humanities, math-science, and other). SAT-V = SAT-Verbal or verbal ability; SAT-M = SAT-Mathematics or math ability. Adapted from Webb et al. (under review).

preferences, and other relevant human attributes should be reflected in practice, otherwise providing optimal environments for intellectually precocious youth will necessarily be less than they could otherwise be (Benbow & Stanley, 1996; Colangelo et al., 2004). The Webb et al. study is currently the most complete step towards the comprehensive architectural mapping of the SMPY model.

Other factors. Beyond the appropriate blend of specific abilities and preferences, other factors, such as work habits, make an important difference in life outcomes (Benbow et al., 2000; Lubinski & Benbow, 2006; Lubinski, Benbow, et al., 2006), however our focus here will be on the necessity for proper educational experiences to be in place for these talented adolescents, or what can be considered the combination of appropriate attributes and opportunities (Lubinski, Benbow, et al., 2001). For example, educational acceleration (or more properly termed appropriate developmental placement) has been documented to be effective in increasing achievement by hundreds of studies (Benbow, 1991; Benbow & Stanley, 1996; Colangelo et al., 2004; Cronbach, 1996; Swiatek & Benbow, 1991b). And Benbow (2006) recently presented results pertaining to math/science interventions implemented by SMPY, which revealed the trend reinforced by an earlier study (Swiatek & Benbow, 1991a, demonstrating the effectiveness of fast-paced math classes); for mathematically talented populations, being well challenged through appropriate opportunities to learn enhances the probability of being in a STEM career 2 decades later.

A study by Bleske-Rechek et al. (2004) assessed the importance of Advanced Placement (AP) courses for intellectually gifted students more generally. AP courses were noted by gifted students frequently as their favorite, and at age 33, 70% of individuals who had taken one or more AP courses during high school had obtained an advanced degree (Master's or higher), compared to 43% of those who had not taken an AP course. Taking an AP course accounted for

5% to 7% of incremental variance above the SAT-M in the prediction of the attainment of an advanced degree. Whether it is some personal factor or external determinant (related to the AP program itself), or both, being involved with an AP class is a positive predictor of both educational achievement and corresponding satisfaction with the high school experience for intellectually talented youth. For a review of subjective and objective longitudinal findings on educational acceleration from SMPY, see Lubinski (2004).

Issues in Educating Spatially Gifted Youth

Given that over half of the top 1% in spatial reasoning abilities are currently being missed by modern talent searches (cf. Shea et al., 2001; Webb et al., 2007), this likely constitutes the most underserved intellectually talented population in the U.S that is readily identifiable. Moreover, it is a critical resource of human capital. As Corno et al. (2002) state: "If spatial-mechanical reasoning ... is a component of achievement in some walks of science, then educators and program evaluators should be giving it direct attention" (p. 3). We also feel that it is important to further discuss some elements that might go into educating this currently underserved population. As numerous educational programs have been developed for those who are more mathematically and verbally talented (Colangelo & Davis, 2003; Colangelo et al., 2004; Heller, Mönks, Sternberg, & Subotnik, 2000; Silverman, 1998; VanTassel-Baska, 1998), it is import to ascertain key factors that would provide optimal learning environments for students gifted in nonverbal ideation. Moreover, all specific abilities covary with unique constellations of personal attributes and external criteria, so considering the role of spatial visualization plays an important part for all intellectually precocious youths.

For example, since spatial visualization is correlated lower with socioeconomic status (SES) in comparison to math and verbal abilities, using spatial ability measures will identify more talented students who are from lower SES levels (Austin & Hanisch, 1990). Moreover, following normal curve theory, selecting from the top 1% of math and verbal ability will result in the absence of greater than one half of the top 1% in spatial ability (Webb et al., 2007). If students who are already currently identified in talent searches (Lupkowski-Shoplik et al., 2003) using the SAT (or the parallel ACT subtests) are also assessed using spatial ability measures, this will help us map their non-truncated ability profile, but we will still be missing a large proportion of the spatially talented. One partial solution would be to encourage educators and counselors to be more aware of non-test signs of spatial talent, such as students exhibiting grade patterns that are tilted towards math and lab classes, or demonstrated success in hobbies that involve creating, building, and working with "things" rather than "ideas" or "people" (Gohm et al., 1998; Humphreys et al., 1993; Prediger, 1976), and then assess them on a spatial ability measure. Another solution is to include spatial ability measures in talent searches.

It is evident that spatial ability is involved in forecasting STEM related occupations, which draw on high levels of nonverbal ideation, but it is also critical in domains such as architecture, surgery, and many of the creative arts. Importantly, Webb et al. (2007) found that talent search participants who were high on spatial ability also tended to have similar ability + preference profiles as graduate students in top STEM programs. Both the high space talent search participants and STEM graduate students manifested a salient triadic cluster on the Strong Basic Interest Scales: Mathematics, Science, and Mechanical Activities. Given that spatial ability provides incremental information to assessments of mathematical and verbal reasoning abilities in forecasting the development of math-science expertise, what else might be done to identify and assist this neglected population?

Some spatially talented students could be frustrated by the density and exclusivity of verbal and quantitative content saturating our current school system, which has historically led to underachievement among spatially talented youth (Gohm et al., 1998). Some findings suggest that working in a "hands on" manner is quite important to this special population. In science classes, such as chemistry or physics, one possibility could be to increase time in the laboratory. When learning organic chemistry, students could be encouraged to create molecules in three dimensions during class using the standard kits. Robotics or architectural design courses might be introduced to encourage future engineers. Another research area suggests that increased reasoning with figures and shapes might help the spatially gifted learn subject matter. Therefore, for example, when teaching a topic such as multivariate statistics to the gifted, the matrix algebra or geometric method might be used instead of traditional algebraic ones. And in mathematics, emphasis in understanding certain topics certainly could be presented in a geometric, rather than algebraic fashion, as there is even a group of mathematicians known as "geometers," Field's Medalist Shiing Shen Chern being one of the greatest still living today. And to possibly develop a greater appreciation for literature and writing, students might be encouraged to read about the lives of famous inventors and scientists and how they developed intellectually and personally as well as how they made their important discoveries, some through nonverbal ideation or spatial visualization (Lohman, 1994; Shepard, 1978; West, 1991). Perhaps these youths need to develop the appropriate passion, and they need to be encouraged to find individuals they can relate to (and thus hope to emulate) among past and current STEM professionals and leaders. Possibly what will matter most is the degree that instructors can include as many aspects of nonverbal ideation into their teaching methodologies. For example, teaching with imagery might be an avenue to investigate, as Lohman has written (1994): "Thought without imagery would be like prose without metaphor" (p. 6). Other possibilities might include options of reading biographies of Edison, Curie, or Ford in literature classes to develop an appreciation of literature through content that interests these students most. Of course, it is important to remember that these interventions should be evaluated carefully to determine whether they actually make a difference in the content domain being taught in an incremental manner as demonstrated by many studies reviewed in this chapter. Moving from science in the laboratory to application in the classroom is not an easy task, but one that is essential.

Conclusion

It is evident that just as the wings of a flying bird are supported by the air beneath, the SMPY model is supported by solid empiricism. Taking into account all three specific abilities as well as preferences within the context of TWA will help educators facilitate the intellectual development of gifted youth and help propel them toward their ultimate educational, career, and life goals. However, what we know about providing optimal opportunities to spatially talented youth pales in comparison to what we know about mathematically and verbally precocious youth. And because of this, a gap in our scientific understanding has led to a current gap in practice.

To mobilize our scientific knowledge for practice, it might help to point out that there is also an increasing concern about the competitiveness of the U. S. (Friedman, 2005). Can our educational system produce the talent needed by tomorrow's society? Are there untapped pools of talent? We have presented evidence that the spatial dimension has been neglected and hence the population of individuals who excel in that area. SMPY has convincingly shown that not including measures of spatial ability will likely leave a hole unfilled in our population of STEM professionals. If our educational system could be structured so that such students are encouraged to go on to blend their potential with passion, then the individuals who can productively address crises such as global warming may emerge in the force needed.

G. H. Hardy, the famous Cambridge mathematician, who was "accelerated" or appropriately developmentally paced through "forms" or grades, would note that one of the rare romantic moments in his life was what he called his "discovery" of the famous Indian mathematician Srinivasa Ramanujan, who reinvented a great deal of mathematical history on his personal slate before being identified for his potential, despite rising from a far less privileged background, a rural part of India (Kanigel, 1991). And Newton once remarked that, when he was in his early twenties, he was in the "prime of [his] age for invention" (Gleick, 2003, p. 55; Hardy, 1992). Although we may not always be identifying talent that by necessity leads to genius, it is our responsibility, as scientists, counselors, and educators, to identify all intellectually talented youths (including the spatially talented, who are more likely to come from lower SES environments), and provide for them rigorous opportunities to learn and develop in accordance with their individuality, so that they too might invent for themselves an education, career, and life characterized by a confluence of potential + passion for capitalizing on their promise.

References

Achter, J. A., & Lubinski, D. (2003). Fostering exceptional development in intellectually talented populations. In W. B. Walsh (Ed.), *Counseling psychology and optimal human functioning* (pp. 25-54). Mahwah, NJ: Lawrence Erlbaum.

Achter, J. A., & Lubinski, D. (2005). Blending promise with passion: Best practices for counseling intellectually talented youth. In S. D. Brown & R. W. Lent (Eds.), *Career development and counseling: Putting theory and research to work* (pp. 600-624). Hoboken, NJ: John Wiley & Sons.

Achter, J. A., Lubinski, D., & Benbow, C. P. (1996). Multipotentiality among the intellectually gifted: "It was never there and already it's vanishing." *Journal of Counseling Psychology, 43,* 65-76.

Achter, J. A., Lubinski, D., Benbow, C. P., & Eftekhari-Sanjani, H. (1999). Assessing vocational preferences among gifted adolescents adds incremental validity to abilities: A discriminant analysis of educational outcomes over a 10-year interval. *Journal of Educational Psychology, 91,* 777-786.

Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence, 22,* 227-257.

Allport, G. W., Vernon, P. E., & Lindzey, G. (1970). *Manual: Study of values*. Cambridge, MA: Houghton Mifflin.

Austin, J. T., & Hanisch, K. A. (1990). Occupational attainment as a function of abilities and interests: A longitudinal analysis using Project Talent data. *Journal of Applied Psychology, 75,* 77-86.

Benbow, C. P. (1991). Meeting the needs of gifted children through use of acceleration. In M. C. Wang, M. C. Reynolds, & H. J. Walberg (Eds.), *Handbook of special education* (Vol. 4, pp. 23-36). Elmsford, NY: Pergamon Press.

Benbow, C. P. (1992). Academic achievement in mathematics and science between ages 13 and 23: Are there differences among students in the top one percent of mathematical ability? *Journal of Educational Psychology, 84,* 51-61.

Benbow, C. P. (2006, May). *Studying the development of math/science talent for 35 years through SMPY: Implications for the flat world.* Julian C. Stanley Keynote Address, Henry B. and Jocelyn Wallace National Research Symposium on Talent Development, Iowa City, IA.

Benbow, C. P., & Lubinski, D. (Eds.). (1996). *Intellectual talent: Psychometric and social issues.* Baltimore: Johns Hopkins University Press.

Benbow, C. P., Lubinski, D., Shea, D. L., & Eftekhari-Sanjani, H. (2000). Sex differences in mathematical reasoning ability: Their status 20 years later. *Psychological Science, 11,* 474-480.

Benbow, C. P., & Stanley, J. C. (Eds.). (1983). *Academic precocity: Aspects of its development.* Baltimore: Johns Hopkins University Press.

Benbow, C. P., & Stanley, J. C. (1996). Inequity in equity: How "equity" can lead to inequity for high-potential students. *Psychology, Public Policy, and Law, 2,* 249-292.

Bleske-Rechek, A., Lubinski, D., & Benbow, C. P. (2004). Meeting the educational needs of special populations: Advanced placement's role in developing exceptional human capital. *Psychological Science, 15,* 217-224.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies*. New York: Cambridge University Press.

Colangelo, N., & Davis, G. A. (2003). *Handbook of gifted education* (3rd Ed.). Boston: Pearson Education.

Colangelo, N., Assouline, S. G., & Gross, M. U. M. (Eds.). (2004). *A nation deceived: How schools hold back America's brightest students*. Iowa City, IA: University of Iowa.

Corno, L., Cronbach, L. J., Kupermintz, H., Lohman, D. F., Mandinach, D., Porteus, A. W., et al. (2002). *Remaking the concept of aptitude: Extending the legacy of Richard E. Snow*. Mahwah, NJ: Lawrence Erlbaum.

Cronbach, L. J. (1996). Acceleration among the Terman males: Correlates in midlife and after. In C. P. Benbow & D. Lubinski (Eds.), *Intellectual talent: Psychometric and social issues* (pp. 179-191). Baltimore: Johns Hopkins University Press.

Dawis, R. V. (1991). Vocational interests, values, and preferences. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of industrial/organizational psychology* (2nd ed., Vol. 2, pp. 833-871). Palo Alto, CA: Consulting Psychologists Press.

Dawis, R. V. (1992). The individual differences tradition in counseling psychology. *Journal of Counseling Psychology, 39,* 7-19.

Dawis, R. V. (2001). Toward a psychology of values. *The Counseling Psychologist, 29,* 458-465.

Dawis, R. V., & Lofquist, L. H. (1984). *A psychological theory of work adjustment*. Minneapolis, MN: University of Minnesota Press.

Day, S. X., & Rounds, J. (1998). Universality of vocational interest structure among racial and ethnic minorities. *American Psychologist, 53,* 728-736.

Friedman, T. L. (2005). *The world is flat*. New York: Farrar, Straus, & Giorux.

Getzels, J. W., & Jackson, P. W. (1962). *Creativity and intelligence: Explorations with gifted students*. New York: Wiley & Sons.

Gleick, J. (2003). *Isaac Newton*. New York: Vintage Books.

Gohm, C. L., Humphreys, L. G., & Yao, G. (1998). Underachievement among spatially gifted students. *American Educational Research Journal, 35,* 515-531.

Gottfredson, L. S. (2003). The challenge and promise of cognitive career assessment. *Journal of Career Assessment, 11,* 115-135.

Hardy, G. H. (1992). *A mathematician's apology*. Cambridge, England: Cambridge University Press.

Heller, K. A., Mönks, F. J., Sternberg, R. J., & Subotnik, R. F. (2000). *International handbook of giftedness and talent* (2nd ed.). Amsterdam: Elsevier.

Holahan, C. K., Sears, R. R., & Cronbach, L. J. (1995). *The gifted group in later maturity*. Stanford, CA: Stanford University Press.

Holland, J. L. (1996). Exploring careers with a typology. *American Psychologist, 51,* 397-406.

Hollingworth, L. S. (1926). *Gifted children*. New York: The Macmillan Company.

Hollingworth, L. S. (1942). *Children above 180 IQ*. Yonkers, NY: World Book Company.

Howe, M. J. A. (2001). *IQ in question: The truth about intelligence*. London: Sage Publications.

Huber, J. C. (1999). Inventive productivity and the statistics of exceedances. *Scientometrics, 45,* 33-53.

Humphreys, L. G., & Lubinski, D. (1996). Brief history and psychological significance of assessing spatial visualization. In C. P. Benbow & D. Lubinski (Eds.), *Intellectual talent: Psychometric and social issues* (pp. 116-140). Baltimore: Johns Hopkins University Press.

Humphreys, L. G., Lubinski, D., & Yao, G. (1993). Utility of predicting group membership and the role of spatial visualization in becoming an engineer, physical scientist, or artist. *Journal of Applied Psychology, 78,* 250-261.

Kanigel, R. (1991). *The man who knew infinity: A life of the genius Rumanujan*. New York: Pocket Books.

Katzell, R. A. (1994). Contemporary meta-trends in industrial and organizational psychology. In H. C. Triandis, M. D. Dunnette, & L. M. Hough (Eds.), *Handbook of industrial/organizational psychology* (2nd ed., Vol. 4, pp. 1-89). Palo Alto, CA: Consulting Psychologists Press.

Keating, D. P., & Stanley, J. C. (1972). Extreme measures for the exceptionally gifted in mathematics and science. *Educational Researcher, 1,* 3-7.

Lippa, R. (1998). Gender-related individual differences and the structure of vocational interests: The importance of the people-things dimension. *Journal of Personality and Social Psychology, 74,* 996-1009.

Lofquist, L. H., & Dawis, R. V. (1991). *Essentials of person-environment-correspondence counseling.* Minneapolis, MN: University of Minnesota Press.

Lohman, D. F. (1994). Spatially gifted, verbally inconvenienced. In N. Colangelo, S. G. Assouline, & D. L. Ambroson (Eds.), *Talent development: Proceedings from the 1993 Henry B. and Jocelyn Wallace National Research Symposium on Talent Development* (Vol. 2, pp. 251-164). Dayton, OH: Ohio Psychology Press.

Lubinski, D. (1996). Applied individual difference research and its quantitative methods. *Psychology, Public Policy, and Law, 2,* 187-203.

Lubinski, D. (2000). Scientific and social significance of assessing individual differences: "Sinking shafts at a few critical points." *Annual Review of Psychology, 51,* 405-444.

Lubinski, D. (2001). Interests: A critical domain of psychological diversity: Review of M. L. Savickas & A. R. Spokane (Eds.), Vocational interests: Meaning, measurement, and counseling use. *Contemporary Psychology, 46,* 82-86.

Lubinski, D. (2003). Exceptional spatial abilities. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 521-532). Boston: Allyn & Bacon.

Lubinski, D. (2004). Long term effects of educational acceleration. In N. Colangelo, S. Assouline, & M. Gross (Eds.), *A nation deceived: How schools hold back America's brightest students* (Vol II, pp. 23-37). Iowa City, IA: University of Iowa.

Lubinski, D., & Benbow, C. P. (1992). Gender differences in abilities and preferences among the gifted. *Current Directions in Psychological Science, 1,* 61-66.

Lubinski, D., & Benbow, C. P. (2000). States of excellence. *American Psychologist, 55,* 137-150.

Lubinski, D., & Benbow, C. P. (2006). Study of Mathematically Precocious Youth (SMPY) after 35 years: Uncovering antecedents for the development of math-science expertise. *Perspectives on Psychological Science, 1,* 316-343.

Lubinski, D., Benbow, C. P., Shea, D. L., Eftekhari-Sanjani, H., & Halvorson, M. B. J. (2001). Men and women at promise for scientific excellence: Similarity not dissimilarity. *Psychological Science, 12,* 309-317.

Lubinski, D., Benbow, C. P., Webb, R. M., & Bleske-Rechek, A. (2006). Tracking exceptional human capital over two decades. *Psychological Science, 17,* 194-199.

Lubinski, D., & Humphreys, L. G. (1990). A broadly based analysis of mathematical giftedness. *Intelligence, 14,* 327-355.

Lubinski, D., & Humphreys, L. G. (1997). Incorporating general intelligence into epidemiology and the social sciences. *Intelligence, 24,* 159-201.

Lubinski, D., Schmidt, D. B., & Benbow, C. P. (1996). A 20-year stability analysis of the Study of Values for intellectually gifted individuals from adolescence to adulthood. *Journal of Applied Psychology, 81,* 443-451.

Lubinski, D., Webb, R. M., Morelock, M. J., & Benbow, C. P. (2001). Top 1 in 10,000: A 10-year follow-up of the profoundly gifted. *Journal of Applied Psychology, 86,* 718-729.

Lupkowski-Shoplik, A., Benbow, C. P., Assouline, S. G., & Brody, L. E. (2003). Talent searches: Meeting the needs of academically talented youth. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 204-218). Boston: Allyn & Bacon.

Muller, C. B., Ride, S. M., Fouke, J., Whitney, T., Denton, D. D., Cantor, N., et al. (2005). Gender differences and performance in science. *Science, 307,* 1043.

Muratori, M. C., Stanley, J. C., Gross, M. U. M., Ng, L., Tao, T., Ng, J., et al. (2006). Insights from SMPY's greatest former prodigies: Drs. Terrence ("Terry") Tao and Lenhard ("Lenny") Ng reflect on their talent development. *Gifted Child Quarterly, 50,* 307-324.

Parsons, F. (1909). *Choosing a vocation.* Boston: Houghton Mifflin.

Paterson, D. G. (1957). The conservation of human talent. *American Psychologist, 12,* 134-144.

Prediger, D. J. (1976). A world-of-work map for career exploration. *Vocational Guidance Quarterly, 24,* 198-208.

Pressey, S. L. (1955). Concerning the nature and nurture of genius. *Scientific Monthly, 81,* 123-129.

Rounds, J. B., & Tracey, T. J. (1990). From trait-and-factor to person-environment fit counseling: Theory and process. In W. B. Walsh & S. H. Osipow (Eds.), *Career counseling: Contemporary topics in vocational psychology* (pp. 1-44). Hillsdale, NJ: Lawrence Erlbaum.

Savickas, M. L., & Spokane, A. R. (1999). *Vocational interests: Meaning, measurement, and counseling use.* Palo Alto, CA: Davies-Black/Counseling Psychologists Press.

Schmidt, D. B., Lubinski, D., & Benbow, C. P. (1998). Validity of assessing educational-vocational preference dimensions among intellectually talented 13-year-olds. *Journal of Counseling Psychology, 45,* 436-453.

Sechrest, L. (1963). Incremental validity: A recommendation. *Educational and Psychological Measurement, 23,* 153-158.

Shea, D. L., Lubinski, D., & Benbow, C. P. (2001). Importance of assessing spatial ability in intellectually talented young adolescents: A 20-year longitudinal study. *Journal of Educational Psychology, 93*, 604-614.

Shepard, R. N. (1978). Externalization of mental images and the age of creation. In B. Randhawa & W. Coffman (Eds.), *Visual learning, thinking, and communication* (pp. 133-190). New York: Academic Press.

Silverman, L. K. (1998). Personality and learning styles of gifted children. In J. VanTassel-Baska (Ed.), *Excellence in educating gifted & talented learners* (3rd ed., pp. 29-65). Denver, CO: Love.

Snow, C. P. (1959). *The two cultures and the scientific revolution*. New York: Cambridge University Press.

Snow, C. P. (1998). *The two cultures*. Cambridge, England: Cambridge University Press.

Snow, R. E. (1991). The concept of aptitude. In R. E. Snow & D. E. Wiley (Eds.), *Improving inquiry in the social sciences* (pp. 249-284). Hillsdale, NJ: Lawrence Erlbaum.

Snow, R. E. (1999). Commentary: Expanding the breadth and depth of admissions testing. In S. Messick (Ed.), *Assessment in higher education: Issues of access, quality, student development, and public policy* (pp. 133-140). Hillsdale, NJ: Lawrence Erlbaum.

Snow, R. E., & Lohman, D. F. (1989). Implications of cognitive psychology for educational measurement. In R. L. Linn (Ed.), *Educational measurement* (3rd ed., pp. 263-331). New York: Collier.

Snow, R. E., Kyllonen, P. C., & Marshalek, B. (1984). The topography of ability and learning correlates. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 2, pp. 47-104). Hillsdale, NJ: Lawrence Erlbaum.

Stanley, J. C. (1996). SMPY in the beginning. In C. P. Benbow & D. Lubinski (Eds.), *Intellectual talent: Psychometric and social issues* (pp. 225-235). Baltimore: Johns Hopkins University Press.

Stanley, J. C. (2000). Helping students learn only what they don't already know. *Psychology, Public Policy, and Law, 6,* 216-222.

Strong, E. K., Jr. (1943). *Vocational interests for men and women*. Stanford, CA: Stanford University Press.

Super, D. E. (1949). *Appraising vocational fitness*. New York: Harper.

Swiatek, M. A., & Benbow, C. P. (1991a). A ten-year longitudinal follow-up of ability-matched accelerated and unaccelerated gifted students. *Journal of Educational Psychology, 83,* 528-538.

Swiatek, M. A., & Benbow, C. P. (1991b). A ten-year longitudinal follow-up of participants in a fast-paced mathematics course. *Journal for Research in Mathematics Education, 22,* 138-150.

Terman, L. M. (1925). *Genetic studies of genius: Mental and physical traits of a thousand gifted children* (Vol. 1). Stanford, CA: Stanford University Press.

Thorndike, E. L. (1911). *Individuality*. New York: Houghton Mifflin.

Tyler, L. E. (1974). *Individual differences*. Englewood Cliffs, NJ: Prentice-Hall.

U. S. Department of Education, National Center for Education Statistics. (1997). *Digest of education statistics*, 1997 (NCES 98-015). Washington, DC: Author.

VanTassel-Baska, J. (1998). *Excellence in educating gifted & talented learners* (3rd ed.). Denver, CO: Love.

Vasquez, M. J. T., & Jones, J. M. (2006). Increasing the number of psychologists of color: Public policy issues for affirmative diversity. *American Psychologist, 61,* 132-142.

Wai, J., Lubinski, D., & Benbow, C. P. (2005). Creativity and occupational accomplishments among intellectually precocious youth: An age 13 to age 33 longitudinal study. *Journal of Educational Psychology, 97,* 484-492.

Webb, R. M., Lubinski, D., & Benbow, C. P. (2007). Spatial ability: A neglected dimension in talent searches for intellectually precocious youth. *Journal of Educational Psychology, 99,* 397-430.

West, T. G. (1991). *In the mind's eye*. Buffalo, NY: Prometheus Books.

Williamson, E. G. (1965). *Vocational counseling*. New York: McGraw-Hill.

Discussion Questions

1. What can you conclude about the characteristics of intellectually talented youth in later years?

2. What insights are shared through the longitudinal study of precocious youth about their cognitive preferences?

3. To what extent do work habits impact life outcomes among students with strong intellectual profiles?

4. How is spatial ability related to future occupational fields?

5. Twelve-year old students with SAT scores over 500 can learn a high school course in 3 weeks of an intensive summer program. If your child had this opportunity, how would you share the results of the program with his/her middle school teachers?

6. Try to schedule an interview with a student who has been accelerated within your school district.