

Mentoring for Talent Development, Creativity, Social Skills, and Insider Knowledge:

The APA Catalyst Program

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Background on Talent Development

Talent Development and Mentoring

The mentoring component of the American Psychological Association Catalyst Program, and the Pinnacle Model upon which it was built, was derived from Bloom's (1985) model of talent development in six domains — two in the arts (sculpture and piano performance), two in sports (tennis and swimming), and two in the academic realm (mathematics and neuroscience). According to Bloom and his associates, optimal instruction for talent development takes place in three stages. During the first stage, young people are guided to fall in love with a topic,

The mentoring component of the American Psychological Association Catalyst Program, and the Pinnacle Model upon which it was built, was derived from Bloom's (1985) model of talent development. According to Bloom and his associates, optimal instruction for talent development takes place in three stages. During the first stage, young people are guided to fall in love with a topic, idea, or discipline. The second stage involves instruction in the skills, knowledge, and values of the domain. In the third and final stage, the talented young person learns to apply his or her passion and technical mastery to create a unique style and message, and to explore original problems. The Catalyst Program is a year-long program designed to support the transition from the second to the third stage of Bloom's talent development model through instruction by renowned masters in science and the arts and places a premium on the mentor/scholar relationship in guiding participating adolescents in their scientific interests and career aspirations. For the Catalyst Scholars, connecting to their team Master was the thread through which the Scholars integrated their experience with chemistry, creativity, and insider knowledge. Catalyst participants came to the program having already "used up" any resources they had available to them in their school or in other out-of-school programs, and sought more intense involvement with a career path they had tentatively committed themselves to. In the course of the experience, they refined their goals, learned what it takes to be successful, and made powerful and lasting friendships and contacts that should prepare them optimally to be future innovators.

Summary

idea, or discipline. The second stage involves instruction in the skills, knowledge, and values of the domain. In the third and final stage, the talented young person learns to apply his or her passion and technical mastery to create a unique style and message, and to explore original problems. The Catalyst Program is designed to support the transition from the second to the third stage of Bloom's talent development model through the guidance of renowned masters in science and the arts.

The concept of mentoring goes back at least 2000 years to Homer, who in his epic poem *The Iliad*, describes the goddess Athena disguising herself and calling herself Mentor to act as a teacher and guardian to Odysseus' son Telemachus. Mentoring in the modern era is wonderfully described by Zuckerman (1977), who highlighted the professional and intellectual networks provided to American Nobel laureates by their mentors (many of whom were laureates themselves), as well as the guidance provided in identifying the most promising scientific research questions.

Like other departments of culture, science has its own esthetic. Among the elite scientists, the prize criteria of scientific taste are a sense for the "important" problem and an appreciation of stylish solutions. For them, deep problems and elegant solutions distinguish excellent science from the merely competent or commonplace. This requires good modeling and intuition and develops during interaction with mentors. (Zuckerman, 1977, p. 127)

Mentoring programs in schools often focus on short-term role modeling, designed to motivate and inspire. However, mentoring in the case of Zuckerman's (1977) example and the Catalyst Program involves long-term commitments in which mentors choose their mentees as potential protégés. The relationship comprises not only role modeling, but intellectual "sparring," connections with important members of a field, and sometimes emotional support (Jacobi, 1991).

Talent Development and Psychosocial Skills

The Catalyst Program encourages the development of psychosocial skills for participating adolescents as they transition between the acquisition of expertise and scholarly productivity described in the Scholarly Productivity/Artistry (SP/A) model of talent development (Subotnik & Jarvin, 2005). SP/A was developed in response to 5 years of research at three elite conservatories of music and later applied to the development of mathematical talent (Subotnik, Pillmeier, & Jarvin, 2009). As a developmental model, it focuses on transformations of abilities into competencies, and competencies into expertise and beyond to SP/A. Each transition is enhanced by growth in the psychosocial skills unique to each transition period. During the transition between the acquisition of expertise and scholarly productivity, talented young people begin to challenge their teachers' ideas with their own, understand that they need to promote themselves to people who can help them, make an effort to be a good colleague, take creative risks, and learn to restore their self-confidence when it diminishes in challenging contexts.

Some adolescents are highly adept socially and exhibit resilience and incremental views of intelligence and talent; many more can benefit from interventions that provide instruction in social skills, reinforcement of self-confidence and resilience, and support for psychological strength when coping with challenging and competitive environments (Good & Dweck, 2006; Subotnik, 2002).

Creative Link Between Science and Art

At the highest levels in each field, scientists seek aesthetic solutions to scientific problems and artistic path breakers shake up ideas that have taken hold in their community (Root-Bernstein, 2003a, 2003b). Root-Bernstein (2008) has written extensively about interdisciplinarity as it relates to creativity. He maintains that the art and science communities are made up of creative polymathic (multitalented) individuals, and that serious involvement with artistic endeavors on the part of scientists predicts scientific success. More

specifically, he compares Nobel-prize-winning scientists' degree of engagement in arts avocations with those of members of the National Academy of Science, British Royal Society, members of Sigma Xi (a scientific honor society), and the general U.S. public. "Nobel laureates were almost three times as likely to have arts and crafts avocations as Sigma Xi members and the U.S. public, and 50% more likely to have such avocations than the Royal Society or National Academy of Science members" (Root-Bernstein, 2008, p. 290). This connection, Root-Bernstein (2008) hypothesized, may be related to scientists seeking effective communication of new and often radical ideas.

Braun (1997) provided historical examples of how expertise in the arts inspired an invention or other moment of scientific creativity. 'Frequency hopping' is the term used to describe the random changing of radio frequencies used in torpedo guidance, and refers to

broadcasting a signal . . . over a seemingly random series of radio frequencies, switching from frequency to frequency at split second intervals. A receiver hopping between frequencies in sync with the transmitter can pick up the message, while any eavesdropper will hear only random blips. (Braun, 1997, p. 5)

If an attack submarine stayed on one weapon delivery frequency or varied in a predictable pattern, the commands to the weapon could be easily jammed by an enemy. Actress Hedy Lamarr's first husband was an armaments manufacturer, and she became familiar with some of the technological challenges of the business. She collaborated with composer and concert pianist George Antheil to invent what is now known as frequency hopping based on their understanding of music theory and structure.

As a result of his experience with the mechanics of human physiological functioning, ventriloquist Paul Winchell received a patent for an artificial heart that once kept a transplant patient alive for 65 hours until the patient could get a donated organ. These brief examples illustrate how musicians, actors, and other

creative individuals can directly influence and contribute to scientific advancement based on their own specialized knowledge and tendency to “think outside the box.”

Insider/Tacit Knowledge

As previously mentioned, Zuckerman (1977) reported that mentors of Nobel laureates were successful at passing along an extremely salient piece of tacit knowledge to their mentees—how to generate the most important scientific questions. Even before reaching the advanced graduate level, talented and committed young people get socialized into the science enterprise as they learn the logic of inquiry and evaluating evidence (Gaston, 1989). Their socialization often takes place in the course of apprenticing with active researchers as undergraduates (Bowman & Stage, 2002) or, as in the case of the Catalyst Program, as early as high school.

Many high school students who are outstanding achievers in mathematics and science have not experienced persistent failure in their path through school. An apprenticeship with a Master scientist exposes them for the first time to both the exciting and deflating patterns of success and failure that are part of the life in a laboratory or research institute. Students who have not been actively involved in science fairs will not have practiced defending their creative work to others who question their methods, conclusions, or even the purpose of the study. Preparing for these kinds of challenges is an important component of being socialized into the culture of science, a chance to “try on for size” a career as a scientific researcher.

Talent Development at the American Psychological Association

The Center for Gifted Education Policy

The Center for Gifted Education Policy (CGEP) resides in the American Psychological Association’s Education Directorate.

Its mission is to generate public awareness, advocacy, clinical applications, and cutting-edge research ideas that will enhance the achievement and performance of children and adolescents with special gifts and talents in all domains, including the academic disciplines, the performing arts, sports, and the professions. The Center was first created and funded by the American Psychological Foundation in order to bring more attention to the topic of giftedness, particularly to psychological scientists and practitioners. Since 2004, CGEP has been supported by the American Psychological Association (APA) and grants from the Jack Kent Cooke Foundation, The Camille and Henry Dreyfus Foundation, and the National Science Foundation. Although CGEP pursues its mission through several programs and initiatives, CGEP's current direct services project is the Catalyst Program, a mentorship program for adolescents talented in the chemical sciences.

Pinnacle: The Foundational Talent Development Model

The Catalyst Program, and its earlier iterations, were derived from the APA Pinnacle Model, conceived in 2000 by Martin Seligman, a key founder of the field of positive psychology. Seligman envisioned a mentoring program that supported and promoted optimal human performance in a number of important fields for the most talented young students in the U.S. With this vision in mind, CGEP developed a year-long program that teamed (a) a Master— an eminent scholar or performer in the arts, sciences, or the professions; (b) an Associate— a rising star in the same field, usually a graduate or postdoctoral student; and (c) a Scholar— a highly gifted high school student with demonstrated interest and talent in that field. The goal of the Pinnacle Model was to bring together developed and developing talent in order to:

- publicize the talent development needs of gifted adolescents;
- provide an opportunity for highly gifted adolescents to learn from and be guided by mentors in their fields of interest;

- plan investigations that would serve as a basis of mentoring relationships;
- discuss in a safe forum the joys, psychological stresses, and expectations associated with talent development at the very highest levels; and
- establish a venue for fertilization of ideas about talent development across disciplines.

The Pinnacle Model has been implemented seven times by various funders for various populations of gifted students in the U.S., and has attracted the participation of two Pulitzer Prize winners (Amy Goldstein, *Washington Post* and Alex Jones, Shorenstein Center, Harvard University); an Emmy Award winner (Philip Scheffler, *60 Minutes*); two Nobel laureates (Joshua Lederberg, Rockefeller University, and Barry Blumberg, Fox Chase Center); three *New York Times* bestselling authors (Faye and Jonathan Kellerman, Janette Turner Hospital); distinguished social scientists (Martin Seligman and Carol Dweck); an artist whose work is displayed in major museums in the United States and England (Sam Maitin); and renowned modern composers who are key faculty members at the Tanglewood Composer's Institute and the New England Conservatory (Michael Gandolfi) and the Juilliard School (Andrew Thomas). Additional Masters have included: a conductor of the Pennsylvania Ballet Orchestra (Beatrice Affron); a Juilliard choreographer (Stephen Pier); seven National Academy of Sciences members (Paul Barbara, Carolyn Bertozzi, Louis Brus, Francis DiSalvo, Daniel Nocera, William Klemperer, and Cumrun Vafa); one member of the National Academy of Engineering (Matthew Tirrell); as well as other distinguished scientists from top-ranked programs (Ronald Andres, Martin Head-Gordon, Tom Muir, Giacinto Scoles, and Stephen Sibener).

The Pinnacle Model focuses on optimal performance and the psychosocial support from colleagues and advisors needed to meet challenges of developing talent over time. According to Bloom (1985), young people with potential talent need: (a) peers to engage with at their level; (b) instruction in rules and techniques associated with their areas of passion; and (c) guid-

ance to transform interest in a topic into a great performance or idea. Pinnacle Masters and Associates provide participating youngsters with content expertise; values of the field or subject; and opportunities to engage with people of all ages with similar interests. Other teachable skills promoted by the Pinnacle Model include being a good teammate and dependable colleague, accepting praise graciously, and encouraging peers when they do not succeed at a difficult task (Jarvin & Subotnik, 2006).

The Catalyst Project

The Catalyst Program, based on the Pinnacle Model, has been funded by The Camille and Henry Dreyfus Foundation and is designed as an out-of-school program for adolescents with deep interests in and commitment to chemistry. The Catalyst Program immerses participants in the talent development of young scientists by combining intensive exploration in a specific discipline by way of intergenerational advice and consultation, as well as interdisciplinary creative stimulation. The Pinnacle Model includes one Scholar per team; however, the Catalyst version of the model includes three to five Scholars per team to increase the impact of the program and provide peer support for the participants. What follows is a description of the Catalyst Program in more detail. Each component parallels and builds upon the Pinnacle Model.

Participants. Each of four Catalyst chemistry teams consist of a Master, who leads and mentors a group of one or two Associates and three to five Scholars. Masters are selected based on their eminence in the field, willingness to mentor talented adolescents, and openness to engage in interdisciplinary discussion and activity. Associates are invited by each Master based on their promising career status as well as their ability to communicate well about their field of interest. From the perspective of the high school age scholars, the Associates serve as more proximal role models than the Masters and provide a more accessible expert to work with on their project during the academic year following the Summit. The Scholars are 14–17-year-old adolescents, most typically ris-

ing seniors. The program also includes three Masters in various artistic disciplines. The artists are integral to the Catalyst experience as they model creative exploration and problem solving in separate yet complementary media.

Chemistry Masters volunteer for this project not only because of their commitment to raising the next generation of talented chemical scientists, but because of the chance the project provides to mingle with outstandingly creative Masters from artistic disciplines. Associates, adult rising stars, find the Summit rewarding because it offers an opportunity to teach, spend intensive time with their mentor, and to meet other chemists who will serve as excellent contacts in the future. And, like the Masters, the Associates welcome the occasion to become acquainted with and be stimulated by interactions with outstanding artists.

The Summit. During a week in late June to early July, Masters, Associates, and Scholars delve into domain-specific and interdisciplinary discussion and project planning. Although the artist Masters do not mentor high school students individually, they provide lectures and demonstrations to everyone in the Catalyst community and participate actively in all aspects of the program.

The Summit site is selected for its proximity to arts venues and distance from distractions of Masters' daily responsibilities. Five of the seven iterations of the Pinnacle Model summit, including Catalyst, have been conducted at Williams College, in the Berkshire Mountains of Massachusetts. The campus is ideal as an interdisciplinary venue in that it houses two outstanding art museums, a library of historic documents, and a professional theater. Tanglewood Music Festival, Jacob's Pillow Dance Festival, and Shakespeare and Company are all within an hour of the College.

Each day of the Summit includes team meetings (where the Chemistry Master, Associate, and Scholars generate the beginnings of a yearlong project), Masters' lectures or demonstrations, round-table discussions, and cultural and recreational activities. The objective of the team sessions is to establish a yearlong mentoring relationship based on an original research project. Masters and Associates share the work they are doing in their laborato-

ries, explore Scholars' own interests, and find commonalities to explore. The objective of the round-table discussions is to focus on frank considerations of the insider or tacit knowledge it takes to attain career success. Some round-table discussion topics have included dealing with failed experiments, extrinsic and intrinsic rewards of scientific research, or addressing conflicts with parental expectations (e.g., wanting to be a researcher instead of a doctor or engineer). Other planned activities are designed to elicit creative connections among and across disciplines, and focus on developing support and friendships among talented adolescents and adults. For example, Arts Composition Master Andrew Thomas prepared the group for Tanglewood performances by discussing the structure of the pieces to be performed and the pieces' creative contribution to the music literature.

The Mentoring Project. In order to facilitate regular interactions among team members during the academic year, Scholar candidates must live within geographical proximity to the Master with whom they will be working. A pool of Scholar candidates is solicited from talent searches, local specialized high schools, and other gifted programs in the area. Each of these sources is provided with an application developed in consultation with each Master.

The application is designed to show that the students demonstrated interest and experience in advanced chemistry reflects the particular attributes and experiences each Master is seeking in potential Scholars (see Figure 1 for sample questions from a Master's application to Scholar candidates). Essay questions relate to the Master's area of expertise and topics that may end up being a basis for a group or individual project. Masters seek to elicit from Scholar candidates how they address material they may not have yet encountered, with opportunities to reveal interest and curiosity. The Masters then select their Scholar participants based on responses to the application and sometimes a follow-up interview.

Following the Summit, Masters and their Associates maintain a relationship with the Scholars on their team through visits, telephone calls, or e-mail correspondence. By the end of the next academic year, each Scholar is expected to complete a project dis-

Please respond to each of the following questions in not more than 1-2 paragraphs:

1. Please list and briefly describe hobbies or interests you pursue that relate in any way to science.
2. Please list any honors or awards you have received that are in any way connected to science. It would be helpful if you could provide the date and a brief explanation for each. If you have one, please attach a Curriculum Vitae.
3. Have you completed any projects in any subject that have extended beyond one semester? If so, please describe.
4. Do you enjoy working with your hands, if so, can you describe an effort you have made to build something to meet a need?
5. Write a brief letter of introduction to Dr. XX (bio provided), including information about what attracts you to this program, what you would like to learn from this mentorship in science and what you would like to accomplish over the course of the Catalyst summit and post-summit experiences. You can also include the following information—What are your career dreams? Do you envision yourself as a research scientist, engineer or physician? If so, is there a particular subspecialty or area in science that you are most interested in? What appeals to you about work in the clinic, laboratory or research institute?
6. If you consider yourself a hands-on experimentalist please describe briefly why and what role (if any) you think theory should have in science. Vice versa if you are oriented toward theory—please describe why and what the role of experimental science is as you see it in furthering the progress of human knowledge.

Figure 1. Questions from a sample application.

cussed and/or developed during the Summit, under the guidance of the team's Master and/or Associate.

Scholars, Masters, and Associates return to the Summit the following year to display the Scholars' projects and interact with members of the incoming cohort. Some sample Catalyst projects include: Antibiotic Susceptibility of E. coli Mutants Deficient in the Production of Reduced Sulfur, The Absorption of the Alzheimer's Beta-amyloid Protein Under Spatial Constraints Using Scanning Probe Microscopy Techniques, and Exploration of Nanoparticles as a Means to Fight Cancer. Return of the pre-

vious cohort creates a growing community of individuals who continue to help one another by providing connections, information, recommendations, and creative collaborations that allow for continued development of talent, successful career planning, support, and encouragement.

Participant Follow-Up

Participating Scholars are monitored for progress toward meeting Catalyst goals. Since Catalyst began in late 2007, two cohorts have completed the yearlong process. The universities attended by Catalyst Scholar Alumni include: Boston University, Brown University, Georgia Institute of Technology, Harvey Mudd College, Massachusetts Institute of Technology, Pomona College, Princeton University, Rice University, Stanford University, U.C. Berkeley, U.C. San Diego, University of Pennsylvania, Wesleyan University, and Yale University.

Each of the 23 Catalyst Scholars from the previous two cohorts was asked a series of questions regarding how the program had affected his or her interest in research science (see Table 1). The first set of questions focused on their experiences at the weeklong Summit and asked them to rate a list of skills and abilities that they felt were either enhanced, they already had, or they felt were neither enhanced nor did they already have them. Some of the Scholars indicated that they both came with a skill and it was increased over the course of the summit, resulting in some of the totals being greater than 23.

The two factors that the Scholars found were most improved by their experiences at the Summit were learning how to present their scientific ideas effectively and developing a deeper understanding of the creative process. These factors are stressed throughout the program as researchers present their complicated scientific procedures and conclusions in terms that laypeople will find understandable. Promoting creativity is one of the pillars of the program, especially given that creativity is not often linked in the minds of school-age individuals with the chemical sciences.

Table 1*Post Summit Responses*

	I came with this to the Catalyst Summit	Increased during Summit	Neither came in with or increased
I learn science fast	20	5	—
I'm open to being taught new things in science	20	10	—
I enjoy receiving recognition for my ideas and work in science	14	6	2
I'm persistent when it comes to science	18	6	1
I'm intrinsically motivated to pursue my interests in science	15	12	—
I know my strengths and weaknesses in science	9	15	2
I know how to present my scientific ideas effectively	10	17	1
I have good skills of teamwork and collegiality	16	10	—
I have self-confidence	17	10	2
I am willing to take intellectual/creative risks in science	9	13	2
I understand what makes for creativity in science and art	7	17	—

A follow-up survey was distributed to the Scholars after they had completed their yearlong programs to explore the overall effect of their experiences working alongside their Master and Associates on a long-term project. The questions included the following:

1. Where are you in school now? Include whether you're in high school or university, what year, and your major.
2. Have you maintained contact with other Catalyst participants? From your team? From other teams? One of the artists?

3. Do you think the experience made you more or less likely to go into the sciences in general? Into research science? Into chemistry related research?

Please comment on the major benefits (or lack of) accrued from your Catalyst experience with regard to each:

- Deeper understanding and expertise in chemistry
- Insights into being creative in chemical sciences
- Insights into the creative process in general (by exposure to artists)
- Insider knowledge about how to be successful in your career
- Association with your Master

The purpose of these questions was to ascertain whether the students had acquired a better idea of how to be creative in chemistry, gained useful advice through the program on how to be successful in achieving their career goals, achieved a deeper understanding of chemistry, and had acquired more experience on how to be creative in general.

At the time of the data collection, 8 were entering their senior year in high school and 15 were entering their freshman or sophomore years in college. Of the college students, 10 had declared (or planned to declare) a major in a STEM (Science, Technology, Engineering, and Math) field and the remaining 5 were undeclared. The STEM fields either declared or intended to declare include:

- 7-year accelerated medical/liberal arts program (a dual degree in both medicine and psychology; 1 student)
- Computer science (2 students)
- Physics (2 students, 1 with a double major in math)
- Engineering (1 student)
- Dual degree in chemical engineering and materials science (2 students)
- Intent to major in chemistry, math, or microbiology (1 student)
- Intent to major in one of the sciences (1 student)

The participants noted that the program had an effect on their decision to go into a scientific field by either solidifying a previous decision, convincing them to consider entering the field by opening up the range of career possibilities, or by showing them that the reality of a career of a research scientist was not a good match for them.

Through exposure to the different areas of chemistry, Catalyst helped me to make the decision to go into chemical engineering and materials science. Further, I was able to use the advice and experiences I gathered from working at [my Master's] lab to help develop criteria for college selection and make my ultimate decision. (2007 Scholar)

Seventeen of the respondents reported keeping in touch with members of their team, either Masters, Associates, or other Scholars. Of those 17, 14 responded that they kept regular contact with Scholars not only in their own teams, but also other teams via social networking sites such as Facebook.

One of the main goals of the Catalyst Program is to encourage students with a demonstrated interest in Chemistry to pursue a research-based career by exposing them to advanced exploratory opportunities at a young age. When asked about the impact of the program on their decision to go into the sciences, into research science, and into chemistry-related research, 18 out of 23 responded that the Catalyst Program made them more likely to go into the sciences, with 10 saying that it increased their interest in pursuing research opportunities at the undergraduate level, although not necessarily in chemistry. Four students said that they had already come with an interest in science and while the Catalyst Program provided support for that interest, the program did not change their career or university plans. One student said that the experience was enough to show her that she did not want to go down a research path and that working in a lab was not for her.

I still plan to pursue science in my college major. While the experience has been AMAZING, I think it has made

me less likely to go into scientific research. That is OK though because it gave me such a great insight into what research entails and what kind of work I would be doing that it made me decide against choosing it as a career. (2008 Scholar)

Eleven of the Scholars commented specifically on how their exposure to creativity both at the Summit and while working in their Masters' labs increased their insight into chemistry as a creative field, either forging a link that previously did not exist or strengthening one that did.

I always thought of myself as a creative person, and though I've always been interested in math and science, I felt like these subjects did not give me enough avenues to be creative. Catalyst showed me that the whole research process is a reflection of an individual's creativity whether it be developing the problem to be tested or analyzing how to prevent error. (2008 Scholar)

In response to questions about career advice they received during the Catalyst Program, 5 Scholars reported that they did not receive any personal advice for how to follow a career path to become a research scientist and would have liked to (3 did not respond). However, 15 reported that they received a clearer impression or view of what constitutes a successful scientist and how those skills could be put into practice.

I got a valuable preview of what would be facing me if I chose this academic path, something which almost none of my school peers have, some of whom seemed to have picked their majors by throwing darts. (2007 Scholar)

Working so closely in a lab with graduate students and the professor, I received some great insights as to how things work in the science side of academia, and I was treated to a plethora of good advice about college and graduate

school in general as well as that which is specific to the field of chemistry. The thing that we did not see much of however (though I was relieved), was the political side of academia. In a later position, I received more information about research from the perspective of administrators and those running the lab, astonishing me with the infighting and challenges that are faced at higher levels. These insights combined will undoubtedly help me in whatever career I choose to enter. (2007 Scholar)

Talent Development and Mentoring at Catalyst

The Catalyst Program places a premium on the mentor/scholar relationship in guiding participating adolescents in their scientific interests and career aspirations. For the Catalyst Scholars, connecting to their team Master was the thread through which the Scholars integrated their experience with chemistry, creativity, and insider knowledge. According to Steven Sibener, a 2008 Catalyst Master in physical chemistry (University of Chicago):

We will play a singular role acting as mentors for an exceptionally gifted cohort of young scholars. Exposure to our laboratories, graduate students, undergraduates, and advanced instrumentation will emphasize that science is an open book, with many forefront questions to be answered, and related important discoveries yet to be made. The relationship developed over the year also gives these students many mentors that span the path from high school through university students to faculty, an invaluable resource for these young scholars. As a mentor, I act as the point person in this relationship, exposing them to forefront ideas in modern chemistry, and watching as they move well beyond the typical curriculum of their high schools. This road will undoubtedly lead to critical questions such as how one sifts through and chooses

research problems given the broad palette presented to a starting research student. Hopefully the excitement generated by this will continue with them as they enter their next phase of scholarly pursuit in their chosen colleges and universities.

Opportunities for intensive relationships with eminent scientists and artists like the Catalyst Program rarely present themselves until college, and even then, typically not before the junior or senior years. In his exploration of research mathematicians, Gustin (1985) discovered that the majority of his gifted study participants found high school to be lacking in challenging material and deficient of teachers who had the skills to be able to nurture their talents. Only when they got to university did they find professors who could offer advanced courses or lab experiences. In contrast, the Catalyst Program's goal is to provide an enriched and advanced experience during the high school years in order to solidify interest in science, show possibilities that exist in research, and hopefully nurture a commitment to a STEM (Science, Technology, Engineering, and Mathematics) major and career interest in the field.

The Contribution of Psychosocial Skills to Talent Development at Catalyst

By helping their Scholars gain confidence, providing a safe forum for exploration, and offering emotional support, Catalyst Masters are able to transcend young people's exclusive focus on academic expectations both from an established viewpoint (Masters) and from those who are entering the field as professionals (Associates). The team meetings and mealtime round-table discussions provide opportunities for discussions relating to issues associated with giftedness as well as the expectations that come along with it.

I think working/living/eating comfortably with [a mentor] of such high caliber has made me more comfort-

able interacting with people in general. I feel a lot more comfortable asking questions or speaking my mind. This was especially helpful during my college/med program interviews. Generally one of the objectives during the interview (other than evaluating my responses) was to see how I acted in uncomfortable settings, so I met plenty of slightly intimidating, unsmiling interviewers who asked difficult questions. But I felt I had an easier time of it, because I was so used to interacting with the science and art Masters. (2007 Scholar)

Catalyst Scholars network with individuals of all ages who share their interests in thinking creatively about science, arts, domestic, and global issues. The frequency and intensity of interaction at the Summit provides the foundation for forming strong personal relationships among participants, and the freedom to take intellectual risks during team meetings.

Creative Link Between Science and Art at Catalyst

A major draw of the Catalyst Program that sets it apart from other summer science programs is the connection it fosters between science and art. The experience provides relatively intimate contact with various art forms in the context of resolving aesthetic contradictions for artists and idea contradictions for scientists (Perrine & Broderson, 2005).

Art Masters participate in the Catalyst Program by offering presentations, demonstrations, and active contributions to discussion on every topic. The fields they represent include music composition, choreography, sculpture, journalism (not an art form but an area that many Scholars are interested in), and culinary arts. Although the idea is to enhance the Scholars' creative approach to science, watching the fascination, admiration, and engagement shown by the Master scientists for the artists models appreciation for conceptions of creative thinking across disciplines.

Before Catalyst, I hadn't considered the fact that creativity ties together art and science. Now I feel like creativity lies in recognizing patterns and striving to understand them, or maybe break them. (2007 Scholar)

Communicating with the artists, as well as attending art museums and performances, really juxtaposed the creativity required to produce great works of art with the systematic process used in the sciences. In the end I learned that it was a lot of give and take on both sides, as science required a lot of creativity to solve ever more complex problems, while music and art sometimes relied on organizational methods to perfect their pieces. I realized that to harness both to their fullest extent, one must create a synergy between creativity and a systematic approach, whether in the arts or the sciences. (2008 Scholar)

Based on examples in the arts and sciences, Catalyst Scholars observed how taking educated and calculated creative risks may result in failure or great discovery.

Insider/Tacit Knowledge at Catalyst

Highly academically talented students do not typically receive the kind of insider knowledge provided to elite artistic performers such as where to study and with whom, how to hold a successful interview, and how to promote oneself tastefully (Jarvin & Subotnik, 2006). The Catalyst Program, both through intergenerational exposure to scientific researchers and interaction with artists, offered a forum for sharing insider or tacit knowledge associated with career success.

I learned that scientific research does not solely revolve around science. It requires communication skills and creative thinking. One of things that I really liked about the Catalyst program was the fact that it allowed me to gain insider knowledge about pursuing a career in sci-

entific research. Catalyst for example allowed me to see what pursuing a degree in chemistry would be like and where I could go from there once I finished my undergraduate education. Having connections, especially in the field of science, is extremely useful for future opportunities. Knowing my Master and the other Catalyst people I have met, and connections I have made by conducting this research will be an incredibly useful resource for any future endeavor. (2008 Scholar)

In the labs we saw what happened when an idea flopped, how grad students would work with what they had, tweaking and experimenting, and get something entirely new and valuable out of what initially seemed to be a failure. (2007 Scholar)

Implications for Out-of-School Programs

According to Brody (2006), programs for talent development in STEM need to have both short- and long-term goals. She identified the following elements as important to successful pre-college programs focused on STEM:

- Exposure to strong content knowledge in mathematics and science based on academic instruction and hands-on demonstration.
- Appreciation for the utility of STEM subjects in the workplace.
- Role models working in STEM fields.
- Peers who share interests in STEM.

Thus far, the Catalyst Program has met its immediate goals and the focus is shifting to the exploration of longer term impacts. Its impact is being measured in terms of increased exposure to content, raised interest and confidence, and enhanced views of the utility of the discipline on the part of participants. In the longer term, according to Brody, a program should be evaluated based

on whether participants of the program enter STEM majors and career fields at a higher rate than nonparticipants. A long-term aspiration of the Catalyst Program is that experiencing science research at such an advanced level as an adolescent will generate opportunities and possibilities that keep participants focused on careers in STEM innovation and research.

Work continues on refining the Catalyst Program, most particularly with regard to Scholar and Master selection. Another important area for improvement is providing more preparation and training to Masters about the learning needs of adolescents. Some Masters have not worked with undergraduates, much less with high school students. Even those Masters who host high school students in their laboratories rarely spend intensive time socializing them into the research domain.

Over the years, Catalyst Program organizers have become more successful at identifying Scholars whose eyes are primarily on research careers and not just an Ivy League letter of admission. And some Masters are more committed to their Scholars than others. One way to deal with the latter problem is to select Scholars who live in the vicinity of the Masters' universities, so getting together is fairly easy. Also, Associates are encouraged to take an active role in mentoring the Scholars to take some of the pressure off of the Masters for day-to-day guidance. These two processes have worked well, and the Associates have valiantly and generously stepped up to the plate.

Catalyst organizers have also gained the following insights from pursuing this model that apply to out of school programs in general:

- School based programs, even full time specialized schools, cannot provide enough stimulation for young people hungry to explore a scientific domain. These students need interaction of sufficient length and intimacy with working scientists to provide advice, guidance, and socialization into the field.
- The deeply engaged adolescent benefits from exposure to different career stages afforded by intergenerational teams. Interaction with top graduate students and post-

doctoral fellows highlights the skills and knowledge that develop over time to achieve expertise and then scholarly productivity.

- Deep pursuit of one domain should not exclude, and in fact should incorporate, engagement with other domains. The timing of the exposure is important, however, and should be viewed as an enhancement rather than a distraction. Catalyst participants came to the program with a great deal of experience with science content, so exposure to the arts was refreshing, stimulating, and provided new insights into the problem solving at hand.
- Practical, insider, or tacit knowledge is important to share. Young people are not necessarily capable of discovering tricks of the trade on their own. Some examples of insider knowledge might be complex, like picking a workable research topic or teasing out answers from data most productively, or more mundane, like requesting supplies or set-ups from laboratory technical staff.
- Many academically gifted young people have not experienced real setbacks in their school life. Out-of-school programs provide a safer environment than schools for practicing recovery of self-concept, risk taking with unconventional problem solving, and learning to persist in their pursuit of talent development through both good and bad times.

Catalyst participants came to us having already “used up” any resources they had available to them in their school or in other out-of-school programs, and sought more intense involvement with a career path they had tentatively committed themselves to. In the course of the experience, they refined their goals, learned what it takes to be successful, and made powerful and lasting friendships and contacts that should prepare them optimally to be future innovators. “Trying on” a life’s path is an exciting and potent experience for adolescents transitioning to adult levels of expertise and scholarly productivity.

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