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Talent Development in Science:

A Unique Tale of One Student's Journey

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This narrative presents the educational route followed by an Intel Science and Engineering Fair (Intel ISEF) winner who was not always recognized for his scientific abilities. Factors contributing to the success of this gifted student are presented, as well as his creative insights for solving the problem that gave rise to the winning project. Further, the major issues that emerged from this student's story can inform both professional development and instructional practice. These issues include: the need to recognize science talent or creative productive behaviors in students with special needs; students' need for an experiential science curriculum that incorporates multidisciplinary perspectives from which to study and apply the discipline of science, not merely the subject matter; the power of collaboration between students with similar interests; and the value of developing instructional strategies that accommodate a variety of learning difficulties and learning styles.

Science fairs have long been the showcase of gifted students across the United States. The following story describes the path of one student as he developed a project that eventually won the Intel International Science and Engineering Fair (Intel ISEF).

Perhaps the most extraordinary aspect of this case is that this gifted student was atypical in numerous respects in his pursuit to win this prestigious competition. First, he had been identified years earlier with a specific learning disability. He also suffered from bouts of depression and experienced social isolation. Not surprisingly, he was unmotivated. Finally, he did not like school. The typical response to this type of student would include medication, social skill instruction, and remediation. Instead, his parents firmly believed that more was to be gained by accentuating the positives, so they encouraged him to pursue his passions and follow his dreams. This article will describe how a talent-development approach influenced the success of one young scientist and what schools can do to identify and nurture twice-exceptional students appropriately.

Bill, a high school senior, smiled with pride as he described the award-winning project. As Bill explained, "I'm a Civil War buff, and my buddy loves science. We thought, if we could

team up, we would improve our chances of winning an award." These two young men's research project, "*Photobacterium luminescens*: Its Inhibition of Pathogens and Possible Relationship to the Healing of Civil War Wounds That Glowed," placed high in two prestigious competitions: second place in the Siemens Westinghouse Competition and first place in the Intel International Science Fair Competition in 2001. It is always interesting to trace the development of talent, and, in so doing, we can usually discern some predictable patterns. However, this story of success follows a path less traveled from novice to expert, and it offers new insights into ways to develop science talent in nontraditional students.

Bill's Academic Background

To understand the uniqueness of this triumph, we need to explore how Bill was able to accomplish this feat despite his disabilities and school difficulties. A twice-exceptional learner in school, Bill was plagued throughout his school career by mild depression, as well as learning and attention deficits. School was not always an ideal environment for him. Bill was

diagnosed as learning disabled in 7th grade when the school system finally acknowledged that there was a 2-year discrepancy between his ability and performance. But, Bill's problems had surfaced as early as preschool. Poor peer relations, inappropriate social behaviors, and a reluctance to complete written assignments punctuated his early childhood years. His parents requested a psychoeducational assessment when he was in 4th grade, but the psychologist declared that the discrepancy between his performance and ability was not large enough to merit special-education services.

Fortunately for Bill, his 4th-grade teacher was sensitive to his needs and skilled in working with youngsters with learning differences. Her classroom, a veritable learning laboratory, was often transformed into a museum-like setting, mirroring ancient Egypt or China or some other venue related to the curriculum. In this class, simulations, arts integration, and project-based instruction allowed children to learn in ways that best suited them. What's more, knowledge was measured in many ways besides writing.

When Bill arrived in her 4th-grade class, the teacher recognized that he was troubled; he would hide under the desk and display other inappropriate behaviors, especially when confronted with writing assignments. She also saw his considerable talents as he engaged in creative projects. She arranged for the enrichment coordinator to work with Bill and a group of several other boys with similar problems. They dug for dinosaurs on the school playground during recess and built models with LEGO kits. Concerned about these boys' difficulties with writing, the teacher also arranged for them to have assistance in developing their fine motor skills. When this teacher transferred to another school, however, the support came to an abrupt halt, and Bill began a rapid decline.

The pupil personnel team thought Bill was just lazy and recommended remediation. His parents had him tested privately. His scores on the various WISC subtests ranged from the 4th to the 99th percentile. He was diagnosed as depressed, and medication was recommended. His parents objected and instead insisted that the source of the depression be the focus of attention. To this end, Bill transferred to a school with a gifted education program in which he participated and, in addition, received support in organization and learning strategies. Bill regained some success in this setting.

However, his continued difficulties with some types of learning assignments encouraged his family to request that he be formally classified. Acknowledging the increasing discrepancy between Bill's ability and his performance, the team was able to identify his specific learning disabilities and classify him accordingly, which assured that he would receive academic support at the secondary level. Throughout middle school and high school, Bill attended a resource class for academic support where his high ability was accommodated. He was allowed to

enroll in some Advanced Placement courses, as well. His high school offered a special counseling component for learning-disabled gifted students, which provided both academic and emotional support.

Even in this adaptive environment, Bill performed inconsistently. Neither listening to lectures nor writing papers was his style of learning, and often he would become discouraged and not turn in assignments. To counteract Bill's feelings of inferiority and depression his family found outside activities that would enrich and inspire him. One such program was a community college summer program focusing on the Civil War, a topic with which Bill had become fascinated during his elementary school years. His parents enrolled him in the program, and for two summers he participated in reenactments of battles and visited many battlefields on the East Coast. His curiosity peaked; he wanted to learn more and more. He soon became an expert on the topic and enjoyed talking about the Civil War with anyone who would listen.

Although both of Bill's parents had a background in science, Bill did not seem to share their enthusiasm for it. In fact, he needed to be coaxed to achieve in his science classes at all. A notable exception, however, was the middle school science curriculum, which included opportunities for students to conduct original research projects and enter local science fair competitions. Bill's first entry during middle school tapped his knowledge about an event that had occurred during the Civil War.

Bill had learned that, after one long battle, a battalion had exhausted its supply of bandages. To address this problem the medical corps decided to reuse the soiled bandages by first boiling them. Motivated by hearing this story, Bill generated a project describing the sterilization techniques used in the Civil War. This project won him first place in a competition for his school. Reinforced by this success, Bill began to understand that there are historic connections to scientific discoveries and that his interest in and knowledge of history could serve as an entry point for science investigations. Indeed, the internationally award-winning project was his fourth involving the Civil War.

Even though he found that he could be motivated, especially when the assignment interested him, he really did not engage during science classes in high school. During his sophomore year, in fact, Bill failed the standard (traditional) biology course, but convinced authorities that he could enroll in an AP course during the summer at a local college. He excelled in this 6-hour-a-day class and received an A for the course. "I hated the way biology was taught in my school. It was mostly listening to a lecture and writing tests and papers," Bill explained. "In the AP course we had lab every day, and during the lecture we discussed what happened in the lab. I took the AP exam the next spring and scored a 4. I would have gotten a 5, but I was tired when I got to the essay, as it was my sec-

ond exam of the day. I was amazed how well I did since I did very little review.”

Bill remained unenthusiastic about his school’s science class until he met John, who happened to be in the same chemistry class. Bill said, “John is my polar opposite. That is why we complement each other well. We liked each other right away. He could keep up with my jokes and me. He is quick-witted like I am and also a smart-aleck.” Chemistry was fun with John in the class, and Bill received an A for the course, but had no interest in entering a competition that year.

Entering the Science Fair

“John was more interested in science than me,” Bill said. “He would tell me how much he wanted to win the Westinghouse award. He had entered the previous competitions, but hadn’t won. I felt sorry for him and thought, if we worked together, we could produce a winning project. According to my research, the odds of winning would be better if we entered the team competition.”

Problem Finding

What the two needed was a hypothesis to research—problem finding. Interestingly, the idea grew out of Bill’s interest in history. Through his participation in the community college program, Bill had encountered a Civil War buff who related a story about wounds that glowed at the Battle of Shiloh, one of the largest and bloodiest of the war.

According to oral history, injured soldiers were observed to have glowing wounds. It is important to remember that, in the 1860s, sanitation and sterile surgery techniques were not well known or practiced. Many soldiers at that time survived their wounds initially, only to die of secondary staph infections or face amputation due to gangrene infection. According to the story, those soldiers who exhibited glowing wounds survived their wounds more often than the casualties whose wounds did not glow. When Bill heard this tale, he passed it on to John, and the two of them then explored the possibilities of investigating this intriguing phenomenon.

The young researchers questioned Bill’s mother for more details. Bill’s mother worked in a federal microbiology lab, and, familiar with certain new discoveries of glowing bacteria, she referred them to microbiologists who were knowledgeable about this type of bacterium. The boys found out that there is only one land-based bacterium that is known to glow and that has antimicrobial properties. This bacterium, *Photobacterium luminescens*, lives in the gut of nematodes in the genus *Heterorhabditis*. Nematodes are tiny life forms that can be found in soil samples and can infect certain species of insects.

The *Photobacterium* bacteria and the nematodes share a symbiotic relationship that benefits both organisms. The bacteria benefit from the nematodes by being provided both a suitable environment to live in and transportation to a food source. The nematodes benefit from the bacteria that produce a virulence factor that aids in killing the insect host.

The boys began to investigate the feasibility of discovering whether this type of bacterium could be the source of the glowing wounds of the Shiloh story. Preliminary research revealed important information about the conditions existing at Shiloh that could explain the presence of these bacteria. The Battle of Shiloh was fought on a flood plain during a cool, wet spring—perfect conditions for nematodes and *P. luminescens*, which the nematodes carry. The soldiers were constantly struggling in the mud, and, in many cases, the wounded were left in the cool dampness of the mud for several hours. These wounded soldiers quickly developed hypothermia, which, again, would provide the perfect environment for growth of these bacteria. The *P. luminescens* does not grow well at body temperature, but if body temperature drops a few degrees, as in the case of hypothermia, the bacterium reproduces rapidly.

With this information, Bill and John developed the following research questions to guide their inquiry and shape their actual hypotheses:

- Is it possible that *Heterorhabditis* in the mud at Shiloh entered the wounds of the soldiers?
- Was *P. luminescens* able to grow in the wounds of men left in the field, suffering from hypothermia?
- Does *P. luminescens* actually suppress the growth of infectious bacteria?
- Did these circumstances come together to save these otherwise doomed men with antibiotics produced by *P. luminescens*?

In essence, the boys were asking (a) whether the local nematode (*Heterorhabditis*) population carried the bacterium (*P. luminescens*) and (b) whether the bacteria in the wounds inhibited the growth of infection, hence saving soldiers’ lives. Their two hypotheses were that these conditions were true.

Testing the Hypotheses

Having access to Bill’s mother’s lab and equipment allowed John and Bill to test their hypotheses. They acquired several common bacteria known to infect wounds in humans. The bacterial pathogens obtained included *staphylococcus sp.*, a common bacterium found in skin infections; *bacillus thuringiensis*, a bacterium used to simulate gangrene-causing bacteria; and *pseudomonas aeruginosa*, a bacterium commonly carried by insects that is resistant to many known antibiotics.

Bill and John used four different media to test their samples. One, L agar, is a basic nutrient used in most experiments

involving bacterial growth. Another, Tryptose blood agar, is used to simulate the nutrients found in soldiers' wounds. They also used Proteose Peptone #3, which provides a medium that favors the expression of insecticidal properties. And, finally, they experimented with Penassay agar, which favors the detection of antimicrobial activity.

The testing procedure was laborious and required extreme patience. Bill and John systematically tested various combinations of the pathogens and the media. To aid in their data collection they developed a testing system in which they drew grids on the back of each plate. The grids were ticked to note 1, 3, and 5 centimeters, the degree to which the *P. luminescens* bacterium could inhibit the growth of the pathogens. Data collected over several weeks confirmed their hypotheses.

Conclusion

The judges of the two major competitions—Siemens Westinghouse and Intel ISEF—each viewed with much admiration Bill and John's PowerPoint presentation and display of their study. Moreover, these young scientists impressed the judges sufficiently to come away with first place in the Intel ISEF Competition in 2001 and second place in the Siemens Westinghouse Competition.

Winning these awards encouraged the boys to continue their research. They would like to test the soil at Shiloh to further confirm their hypotheses. Furthermore, they are interested in learning more about the healing potential of *P. luminescens* bacteria. Given the persistence that has characterized their work thus far, they will very likely make the time and find the resources to continue their unique collaboration.

Typical and Atypical Factors of Success

An analysis of Bill's journey reveals elements that are typical to most winners of scientific awards, as well as some that are rather atypical. Identifying and understanding these elements can help us to encourage more twice-exceptional students to pursue and develop their science talent.

Typical Factors

Common to most award winners, resources these young men had available included access to a mentor, use of authentic equipment and materials, support from their families, opportunities for collaboration, and the personality characteristics needed for creative productivity (Bloom, 1985; Brandwein, 1995; Csikszentmihalyi, Rathunde, & Whalen, 1993; Freeman, Span, & Wagner, 1995; Renzulli, 1978).

Bill and John were fortunate to have Bill's mother as their personal mentor. An award-winning scientist in her own right, she introduced them to experts who assisted them with different segments of their project. Bill's mother, who serves as a mentor for many high school students and sees her role as a guide who makes herself available when needed, was careful in allowing Bill and John to direct their own study. For instance, they rejected her suggestions for measuring bacteria growth in auger plates, developing their own method instead. (Ironically, the lab has since adopted Bill and John's method of measurement for regular use.)

A second resource available to these young researchers was the use of authentic equipment and materials. Their mentors, practicing bacteriologists, were able to provide them with access to their lab, proper equipment, and the specific pathogen specimens needed to test their ideas.

Talent development relies considerably on family support (Bloom, 1985; Csikszentmihalyi et al., 1993) The families of both these young men were willing to provide the time, energy, and financial support to facilitate their sons' investigation. They offered transportation to and from the lab, purchased and delivered supplies as needed, and provided encouragement when the tasks seemed overwhelming.

The scientific community sees collaboration as important in creative productivity and thus offers team categories in their competitions. That these youngsters collaborated on their research was integral to their success: Bill and John were drawn to the team competition because they realized they had complementary talents and interests.

Finally, and probably most important, Bill and John possessed personality traits indicative of creative productivity: above-average ability, task commitment, and creativity (Renzulli, 1978). They demonstrated above-average ability in their understanding of scientific principles and skills in conducting investigations. In addition, their task commitment was evident in their dedication and self-regulation. They spent hours on the tedious and exacting tasks involved in collecting data on the bacteria growth. They persisted despite setbacks and glitches; they were determined to meet the deadlines required by the individual competitions. Lastly, they solved their problems creatively. They were able to make connections, see things in new ways, challenge assumptions, recognize patterns, and take risks—all elements of the creative personality (Barron & Eisner, 1980).

Atypical Traits

What makes Bill's story unique and interesting are the atypical traits that emerged. Firstly, most students who enter science competitions are high-achieving students who have an extraordinary interest in science; Bill, on the other hand, struggled in school due to his learning and attention difficulties.

He rarely applied himself to academic tasks if they were not intrinsically motivating.

Where support at school from educators is common for successful young scientists, many of Bill's teachers considered him lazy and had low expectations for his academic success. Without encouragement from his teachers, who did not recognize his talent, it came as no surprise that Bill did not even inform his teachers that he was involved in the science fair project. "Why would I tell them? I thought my teachers would laugh at me," he explained.

Supportive schools offer challenging curricula that entice students to embark on self-initiated learning. However, Bill was offered a traditional science curriculum consisting of lectures, reading, and writing papers. Bill rejected this type of instruction and, as a result, failed biology and had to retake it in summer school, where science was taught through laboratory experiences. This experiential approach aligned with Bill's learning style. Moreover, the summer program was an Advanced Placement course, significantly more challenging than the course he had taken during the school year. It should be noted that Bill excelled when the curriculum was tailored to his needs.

Typically, science students enter competition due to both their passion for a science topic and their strong desire to compete (Robinson, 2004). This was not the case for Bill; his motivation was social. Because Bill had few friendships in the school setting and was considered a social isolate, a major attraction to working on this science project was a chance to collaborate with a like-minded friend. His colleague had a similar spirit and, by his own admission, a "weird" sense of humor. Thus, the opportunity to work on a project with his friend provided Bill the social interaction he craved. Bill repeatedly stated that the friendship was a driving factor. He knew that John was extremely competitive and had set a goal of winning the competition years before. To help his friend accomplish his goal, Bill was willing to commit to tedious hours of lab work.

Most interesting in this case was the source of the topic used in the investigation. Interest in a domain usually fosters creative productivity in that domain. How common is it that students can see possibilities across disciplines? Bill's real interest was the history of the Civil War. After discovering the oral history reports of the glowing wounds of soldiers at Shiloh, Bill was able to make a connection with the scientific study of the possible medical applications. His love of history provided him with an entry point for the science investigation.

Identifying and Nurturing Science Talent in Twice-Exceptional Students

Like Bill, there are many scientists whose talent-development journeys in science have followed intriguing, nontradi-

tional pathways. History confirms that leaders in scientific exploration such as Thomas Edison, Sir Isaac Newton, and, more recently, Jack Horner and Temple Grandin found formal education difficult and uninspiring. In school systems today, many students are being recognized as twice-exceptional (Davis & Rimm, 2004). Like Bill, however, these students still may not be recognized for their talents or be provided with an approach to talent development that encourages their participation (Baum, Cooper, & Neu, 2001; Neu, 2003). This failure of traditional school science programs to acknowledge *all* students with strengths in science may be preventing or discouraging these nontraditional students from fulfilling their science potential.

We have identified five issues that must be addressed if we are to attract the nontraditional students who may be highly talented in the sciences, but are underachieving in school.

Issue 1: Traditional instruction such as lecture, reading the text, and writing papers does not automatically engage students in the discipline of science. In many cases, such as Bill's, these instructional approaches only discourage highly able, but underachieving students (Nielsen, 2002; Reis, Neu, & McGuire; 1999).

Suggestion: Use an experiential science curriculum. Many schools that boast a long line of winners in science fair competitions use this type of curriculum. For instance, the Bronx School for Science has two channels from which students may select. The first is for high-achieving students who have no passion for scientific research. The instruction in this channel is traditional. The second channel offers an experiential curriculum for students who demonstrate both talent and passion for science. Students identify original problems and work to solve them.

Issue 2: Many students talented in the sciences may be underachieving or classified as having learning, attention, or behavioral problems (Baum, Olenchak, & Owen, 2002).

Suggestion: Recognize and nurture science talent or creative productive behaviors in underachieving students or students with special needs. Offering an experiential curriculum will many times identify these students, who tend to thrive under such conditions. Observing Bill in his AP Biology class, for example, a setting in which he was actively engaged, might have revealed his science potential to his regular classroom teachers. Once these talents are recognized, educators should encourage students to participate in talent-development opportunities.

Issue 3: Not all students pursue science for the sake of science. Gardner (1999) has argued that many students are drawn to a topic according their own interests, strengths, and talents.

Suggestion: Consider multidisciplinary perspectives in which students can see the application of science across disciplines. Gardner (1999) calls this approach "using alternative

entry points.” Using a student’s interest as a means to approach the core of any content area increases student motivation and provides a perspective for deeper understanding. As in Bill’s case, a fascinating story from a Civil War battle led to the scientific investigation of the antiseptic qualities of bacteria.

Issue 4: Students need opportunities to socialize and collaborate with like-minded peers in bringing talents, abilities, and interests to bear on realistic problems (Baum & Owen, 2003; Nielsen, 2002).

Suggestion: Encourage collaborations among students with similar interests and abilities to develop opportunities for social interactions and for using their complementary skills in the classroom. Creative productivity depends on finding a supportive environment in which people are like-minded and have similar goals and aspirations (Gardner, 1993; Renzulli, Gentry, & Reis, 2003; Sternberg, 1996). This could mean carefully choosing lab partners and developing science teams in which each individual receives attention for his or her own contributions.

Issue 5: Teachers have a low tolerance for diversity in students’ learning styles and personality (Tomlinson, 1999). This may lead to the underestimation of a student’s ability and lower expectations for his or her success (Reis, Neu, & McGuire, 1999).

Suggestion: Develop instructional strategies that accommodate a variety of learning and personality styles. Provide open-ended opportunities through which student creativity can emerge. Focus on students’ creative ideas or original responses. To inspire the scientific mind, the imagination must be engaged. There must be an opportunity to play with ideas. Teachers need to develop a playful attitude in their students if problem finding is a goal (Root-Bernstein & Root-Bernstein, 2001). This is especially true for students with learning disabilities, whose creative ideas evolve from messing around with ideas when one right answer is not required (Cooper, Baum, & Neu, 2004).

Conclusion

Bill had the good fortune of having support systems outside of the school that nurtured his talent and provided the elements suggested above. However, there remain many students whose potential is unidentified and underdeveloped. We hope that the insights gained from studying Bill’s story will reinforce the idea that there is an untapped talent pool of potential scientists in our classrooms who need our unconditional support, enthusiastic encouragement, and respectful recognition. In short, these students—who are often nontraditional and likely to be underachieving, but filled with scientific talent not yet recognized—need educators to supply the ORE:

opportunities, resources, and encouragement (Renzulli, 1994) these students need for developing their potential.

“To accomplish great things we must not only act but also dream, not only plan but also believe.”

—Anatole France

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