of essence somewhere in the inner world, is impossible to put into words.

The inner world is from where I view the world outside. Creativeness means living in essence, which is almost the reverse of living in the outside world. It means being concerned with being rather than becoming 'better', 'bigger', 'more knowledgable'. It means understanding that man is collective, not individual. It means seeing man as embryonic, not developed. It means seeing that all men are unconscious, not conscious. It means understanding that the more you move to the outside, the less your own depth. It means understanding that only through the subjective does objectivity peak. It means knowing that the inner world is real and the world in which we live socially is unreal. Essence is to be discovered, not to be found! It is not an outside phenomenon and only insight will unearth it. And essence manifests through love - when we ask children to put aside that which they love to do - that is like saying kill yourself. Each day I see a little of Kate dying.

The death of the essential Kate is also measured by the dwindling output of pictures she draws. Once she drew as a natural expression of her discovery of the world and she enjoyed it. Then, when the realities of the outside world hurt her, she drew to elicit the feelings of enjoyment that she recalled. When the hurt becomes too great, she does not draw at all.

It is not too late. I look at my innocent child. I see how the magic of life is still alive in her. Often I wonder whether it is not more cruel to encourage her to retain her natural sensitivity. I should perhaps have dulled her long ago to save her from this pain. But it is impossible to do this when one is aware of the long term repercussions for her inwardly. Instead, I hold her often. I tell her of a world that many grown-ups seem to have forgotten long ago; a place where the dimension of the heart still waits for them to return. My daughter becomes very compassionate and quite melancholy for the sad lot of the adult, and once whispered in my ear that she would remember her heart forever and ever! I look at her shining face and there is a familiar feeling in my heart, one that I recall so many years ago and I know that it is not impossible with a wonderful inner certainty that she will indeed remember her heart for ever and ever!

Follow-up Insights on Rapid Educational Acceleration

Jane C. Charlton
Donald M. Marolf
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Too little is known about what happens, when they grow up, to youths who reason extremely well mathematically. Few tell their story to specialists in education of the gifted, either in writing or orally. Julian Stanley brought two successful former "radical accelerants" to the November 1993 annual meeting of the National Association for Gifted Children in Atlanta and also provided some information about 12 other mathematically precocious youths. Jane C. Charlton and Donald M. Marolf, the two young adults featured, told the symposium audience about themselves and answered questions. They were amazingly frank, insightful, and humorous about their lives thus far. Both are convinced, and are convincing, that rapid progress through school grades all the way to the Ph.D. degree is the nearly optimal way for persons like themselves to enrich their education and prepare for adulthood. All three speakers agreed, however, that extremely fast educational advancement might not be the ideal curriculum path for some other equally capable boys and girls.

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Since 1969, the Study of Mathematically Precocious Youth (SMPY) and the Center for Talented Youth (CTY), which I created in 1979 independent of SMPY, have been finding and helping boys and girls who *reason* exceptionally well mathematically (Stanley, Keating, and Fox, 1974; Lubinski and Benbow, 1994). SMPY and CTY, both based at Johns Hopkins University, have evaluated about a half a million boys and girls of upper 3% intellectual ability. These annual talent searches have identified thousands of extremely able seventh graders, most of them twelve years old or less. Although all those whom SMPY itself has aided are excellent reasoners about quantitative matters, few become mathematicians. Most of the mathematically ablest boys find their vocations in fields such as computer science, physics, electrical engineering, and medicine. The ablest girls tend to choose more widely, many of them becoming physicians.

The first five math prodigies were male Baltimoreans, four of them in public schools. Joseph Louis Bates caught my attention during the summer of 1968, just after he completed the seventh grade. His SAT and College Board achievement test scores were so high that, because of the dearth of suitable educational opportunities for him below the college level, we reluctantly let him enter Johns Hopkins as a regular student in the fall of 1969 after the eighth grade; he was 13. To our astonishment, he made excellent grades at Hopkins in computer science, physics, and honors calculus during his first semester. Following this introduction, he did well in almost everything, receiving his Bachelor's and Master's degrees in 1973 at age 17. While still 17 he entered Cornell University, earning a Ph.D. degree there in computer science. After postdoctoral years at Cornell and MIT, Dr. Bates joined the faculty of Carnegie Mellon University. Now he, at age 38, and the research group he leads are on the cutting edge of a new computer science field, virtual reality. They are working productively on the dramatic aspects of this potential scientific and entertainment phenomenon (see Peterson, 1992).

In 1970, another computer whiz entered Johns Hopkins at age 13. He was generally an excellent student, albeit a bit erratic. After four years he left, one course short of having a Bachelor's degree. In the nearly two decades since then he still

has not taken that easy course. Nevertheless, having graduated only from elementary school, he earns a good living as the technical expert in a large computer software company that he helped found. It specializes in devising computer software for banks.

The third early entrant came to Johns Hopkins in 1972 after the tenth grade, made a splendid academic record his freshman year, and then transferred to Princeton University. There he graduated *summa cum laude* in mathematics, Phi Beta Kappa, the month he became 20 years old. He then attended the University of California at Berkeley for two years of graduate mathematics, in which he excelled, before entering medical school. Now, at age 37, he is an outstanding research cardiologist specializing in heart pacemakers and gene replacement.

The fourth boy was the first math prodigy we found after formally establishing SMPY on September 1, 1971. One of the most remarkable young persons we've ever discovered, he received his Bachelor's degree in quantitative studies the month he turned 17 (and was a varsity golfer and writer at Johns Hopkins by age 15). Then he received his M.B.A. degree from the University of Chicago at age 19 and his Ph.D. degree there the month he became 22. He became a *full* professor in one of the nation's top business schools at age 31. His specialty is psychological aspects of financial decision-making.

The fifth boy received his B.A. degree in the humanities, Phi Beta Kappa, from Johns Hopkins University in 1982 at age 18 and his J.D. degree from an outstanding U.S. law school at age 21, graduating first in his class. Currently, at age 30, he is completing a Doctor of Philosophy degree at one of England's two most prestigious universities. He had mastered college calculus at age 11, become a Life Scout at age 14, and was both a Fulbright and a Marshall Scholar. Now he teaches law to Britishers.

Clearly, all five of these young men had found "radical" educational acceleration stimulating. This would not have surprised the great early proponents of encouraging able students to complete college young (Terman, 1947, pp. 264-281; Pressey, 1949).

Seven Math-Talented Girls

The first five youths we identified who reasoned *extremely* well mathematically (see above) attended Johns Hopkins University for at least a while. In contrast, only one of the first seven mathematically precocious girls we found (the first not until 1978) attended that university. Born 10 years after Joseph Bates, SMPY's first female mathematics prodigy graduated from the Massachusetts Institute of Technology (MIT) and worked as a researcher for a year. She then became a graduate student in quantum optics at a leading university. Presumably, she is still there, working toward a Ph.D. degree. At age 12 years 2 months she had scored 710 on the verbal part of the College Board Scholastic Aptitude Test (SAT-V) and 760 on the mathematical part (SAT-M), one of the best sets of test scores we have ever found in testing about half a million able boys and girls.

The next girl we discovered was Japanese, born in 1966 and temporarily in this country with her parents. Later, she studied awhile at Princeton University before graduating from the University of Tokyo. She now lives and works in Tokyo, but at what we do not know. Her SAT scores at age 12 were 760 on SAT-M and (because English was not her first language) 330 on SAT-V.

Later we discovered a Chinese-American girl who, in the month she became 13 years old, scored 760 on SAT-V and 790 on SAT-M. She graduated from Johns Hopkins University at age 17. After earning her M.D. degree elsewhere at age 21, she worked for a year as a paralegal and then completed Harvard Law School. Currently, at age 26, she is a patent attorney.

The other four girls were born in 1967. One, a Princeton University graduate and accomplished violinist whose IQ at age 7 was 212, works in children's television. Another, a high-achieving graduate of Harvard, is a postdoctoral fellow in chemical physics. The third (also a Harvard graduate) is an assistant professor of mathematical statistics at a renowned university, the only mathematician among the twelve being discussed. The fourth, who also graduated from Princeton, is a senior in medical school after trying chemistry for several years. Thus, none of the first seven women is old enough to be as far along a career track as most of the men are.

This gives you a little background about the 12 earliest superb quantitative reasoners SMPY found. Professors Camilla P. Benbow and David Lubinski at Iowa State University are conducting long-term, systematic follow-up studies of thousands of mathematically precocious youths born between 1958 and 1970, many of whom were not extremely accelerated mathematically. Also, see Gustin (1985) and Wiener (1953).

There's no substitute, however, for getting details about their experiences from some of the "radical accelerants" themselves. Therefore, below, two highly educationally accelerated, most remarkable young persons write about their experiences. First is Dr. Jane C. Charlton, an assistant professor of astrophysics at Pennsylvania State University who received her Ph.D. degree in astrophysics from the University of Chicago at barely age 22. Then will come Dr. Donald M. Marolf's analysis of his educational and professional background. He completed his Ph.D. degree in physics at the University of Texas at age 20.

Dr. Charlton's "The Story of My Life"

My childhood was an extremely happy and confidence-building experience. My parents always provided me with the stimulation I needed and encouraged me to excel in school. I was, perhaps, unusual in the sense that I did not know how to read fluently until I entered first grade. My mother says that she didn't want to teach me because I wouldn't then have anything to learn in the first grade.

In elementary school, classes were pretty repetitive, but I kept myself busy by always being sure to get a perfect score, and by helping my classmates and the teacher. After school, I studied piano, played baseball and rooted for the Pirates, worked on crafts, and completed workbooks that my mother graded for me. I wrote a story on becoming best friends with a purple polka-dotted alien, drew pictures of Saturn, and used a telescope that my grandparents bought me. Science class in school was pretty much non-existent (it was always the first thing to go if we had an assembly), but my parents provided all the guidance I needed. A distinct memory from the fifth grade was being the head of the Safety Patrol. I remember walking from station to station and checking with the other student patrols to see that all was well. I had not felt so consistently that same tremendous sense of worth and satisfaction again until recently in my role as university professor.

My junior high school was not as good as my elementary school had been. The idea of repeating yet another year of addition, subtraction, multiplication, division, fractions, and percentages seemed pretty ridiculous to my parents and me. So I went to talk to the guidance counselor to make arrangements to take algebra in the seventh grade, a year earlier than was normally allowed. She recommended that instead I should take tennis lessons and cook dinner for my family once a week. Amazing, isn't it? Science class in seventh grade was terrible. I remember a teacher reading aloud definition after definition on astronomy and having us write them down and memorize them. Their idea of a gifted program in those days was to have the student write a term paper along with the ordinary work. I wrote some of mine on black holes, and the possible connection of near-death experiences and the entry into the black holes. I think that I always knew I wanted to explore the purpose of life by doing astronomy.

With some perseverance I did succeed in getting permission to take algebra while in the 7th grade. It was that year that I took the SAT as part of Dr. Stanley's talent search. Through this experience my parents and I learned what was possible, and I have been challenged ever since.

The summer after 7th grade, at age 13, I took my first college class, in computer programming at Carnegie Mellon, and received an *A*. I remember quite a few nights that my father patiently waited on campus as I struggled to complete assignments. Every other week, my parents drove me from Pittsburgh to Baltimore, where I received private tutoring to complete Algebra II and Geometry. My mentor that summer was Kevin Bartkovich, an accelerated undergraduate at Hopkins. I admired him a great deal, and his example certainly had an influence on my future.{1} That tutoring enabled me to enroll in Trigonometry, Chemistry, Analytic Geometry, and Calculus during the next academic year.

I spent half a day in 8th grade and half a day at the high school. I always had some pretty close friends through school, but during this time a few people were not as close friends as they might have been because of the teasing they received from the other kids for hanging out with "Jane the Brain." I honestly don't think this bothered me too much. I've always liked being different. And I understood that people who teased me didn't really dislike me.

The summer after 8th grade, when I was 14, I took Chemistry and Calculus at Carnegie Mellon, receiving *A*s in both classes. The following year I planned to skip 9th grade and move to 10th. The idea after that was to complete two years of high school, accumulate AP credits, and then perhaps move on to college. However, due to a two-month school strike and encouragement from my Calculus professor at CMU, I dropped out of high school and started at CMU in January, at age 14.

I found the work in college extremely challenging, but loved it. I majored in chemistry and physics. Of course, I would have liked to get all *A*s in college, but found that difficult, particularly in my physics courses. I had mostly *A*s, but there were a good number of hard-earned high *B*s as well. I especially enjoyed a summer after my junior year, spent with my favorite chemistry professor in a graduate-level theoretical inorganic chemistry course. I applied to several graduate schools. Accepted by all but Harvard and Princeton, I decided to go to the University of Chicago to work in cosmology with Professors Schramm and Turner.

Many people seem to worry much about social adjustment for children who accelerate, but I never found that to be a problem. I moved into campus housing my sophomore year. Most people could not tell that I was any younger than my classmates (I looked older than my age), and I found these new academic peers much more stimulating to be around than my own age group had been. All through college I dated young men who were around four years older than I, and always had a few close friends. I spent a good deal of time working with the Astronomy Club, serving as its president in my senior year. I didn't go to a lot of parties and football games because I enjoyed philosophical discussions more.

For three of the summers while I was in college, I participated as teaching assistant and later as an instructor in summer residential programs for the Johns Hopkins University Office of Talent Identification and Development (OTID), an expanded version of SMPY. OTID is now called the Center for Talented Youth (CTY).

I faced an even larger challenge in graduate school at the University of Chicago. The first semester of Mathematical Methods of Physics, Quantum Mechanics, and Stellar Interiors was a true test. Our first-year class of eight ("Snow White and the Seven Dwarfs") formed a closely knit group; we often pooled our resources to do the homework. It was during this time that I met a post-doc who later became my husband. He helped me with many a homework problem. The candidacy exam at the end of the first year was in some ways the most difficult hurdle I've had to face, but I made it through. After that, I started my research career, and I've been working on that ever since.

When I received my B.S. degree from Carnegie Mellon at age 17, I decided to "go public." Although I expected that only the local newspapers would carry the story, it hit a number of others, including one in Chicago. Unfortunately, it was posted on the bulletin board at the University before I arrived. However, it didn't take long for people to get past that. The most popular question reporters asked me was: "But don't you regret not going to your senior prom?"

After four years of graduate school, I spent two years as a postdoc at Cornell and three years at the University of Arizona before beginning my current position as an assistant professor at Penn State. This length of time as a postdoc is not unusual in astrophysics. There may have been a bit of age discrimination when I first applied for faculty positions at age 25. I did hear that there was at least one position for which I was not interviewed because I was thought to be too young.

I consider myself very fortunate to be an assistant professor of astrophysics at Penn State. I have a good NASA grant, though I still need some further support from NSF to appease the dean. I have been teaching 300 non-science majors this term and designed a course on Cosmology last term, also for non-science students. I supervise the research of four graduate students as well. The main thing I need to work on right now is picking up my publication rate, but in general I have no complaints. Life is nearly perfect. And the amazing thing is that I am where I always wanted to be four years sooner than I might have been had I not accelerated. I have Dr. Stanley to thank for that.

I have no regrets having to do with social aspects. I have been challenged and intellectually satisfied all through my life. The only concern is related to my very strong urge to be the absolute best. Many competitions for awards at the graduate school, post-doctoral, and professorial levels require one to appear better than others at the same level. Perhaps if I had studied more physics in high school before starting into college physics, I might have been able to learn it with a little better understanding. Would I then have been able to get straight *A*s in graduate-level physics? Would I then have been able to

publish more papers? Would I now be able to answer my graduate students' questions about power spectra and kurtosis? However, I believe that I have been learning and improving all these years. I also know that I will never be completely satisfied with my knowledge (after all, it is hard to know everything about the universe). And I believe that I am on track and that my success has been the result of the great opportunities I've had. What more valuable gift could one be given than four more years to pursue one's goals?

Dr. Marolf's Story

Let me first say that I was accelerated and liked it. Every time my teachers asked me if I would like to be accelerated further, I enthusiastically said "Yes!" The promise of new people to meet, new things to do, and, of course, new things to learn would make me almost giddy. I can also honestly say that the times when my education was most normal were the unhappiest periods of my life.

Perhaps I should tell you a bit about my education. I know that Dr. Stanley is most interested in early entry into college, but I am also a strong believer—for the right individuals—in much earlier acceleration.

I don't remember much about my very early years except that I loved books, stories, and the out-of-doors—a natural enough combination, I thought. My two strongest early memories are of a Russian olive tree that grew almost parallel to the ground, just right for little feet to climb, and of children's books about life on a submarine and a man named "Jack." In fact, I think I probably read about Jack while sitting in that tree.

Somewhere back in my pre-memory, I entered kindergarten at Briarcliff Elementary School in the North Kansas City, Missouri, school district. Because of a September birthday, I was four at the time. This was in 1976.

I must have already known something about reading because before long my teacher was sending me down the hall once a day to work with the high-level first-grade reading group. I remember thinking that this was a lot of fun, especially since it meant that I would sometimes miss "nap time," but always seemed to catch juice and cookies back at the kindergarten. Also, the first-grade kids were pretty neat and didn't seem to mind me at all. I'm not sure anyone ever told them that I was from the kindergarten; I just miraculously appeared at the proper time every day.

Now, this was a busy time for our school system, as they were just beginning a program for gifted students. As a result, I was tested, evaluated, and told that next year, when I entered the first grade, I would get to take a bus to another school one day each week to do interesting things. My new friends from the reading group were already going.

Before I entered the first grade, the school district approached my parents and asked if it might be better for me to start off in the second grade instead of the first. My mother, trained as a high school counselor, feared for my "social development" and said no. So I started first grade on schedule, excited enough about the different school day one day a week. I now learned it was North Kansas City's "Gifted and Talented," or GT, program. The program was great, and I met more kids from higher grades, since GT grouped several grades together. I also continued going to the second grade for reading class.

Maybe because I preferred my friends from the gifted class and the second grade, or maybe because I hated my first-grade teacher, my parents changed their minds by Christmas. One day when I came home from school, Mom asked me if I'd like to attend the second grade full time. Of course, I said yes eagerly. After Christmas break, I was a regular.

School settled down to normal for a while. I attended third, fourth, and fifth grades in the usual way, reaching the end of elementary school. I liked third and fourth grade, but by fifth grade I had become less and less happy both in school and out. I tried Cub Scouts and other groups, but wasn't particularly impressed. I kept looking forward to a summer camp that I liked where things were more flexible.

Fifth grade did have one bright spot. Somewhere toward the end of the year, our teacher said that we could work ahead on our own in math. Boy, was she sorry. I finished our fifth grade text in about half the time that remained, expecting that something else would be provided. I'd seen the word algebra while poking around in the public library. I had no such luck, but at least the teacher now let me read library books during math period.

Sixth grade in North Kansas City meant middle school: different teachers for every class and new kids to meet. New classes, like foreign language, home economics, and industrial arts, appeared. I landed a seat in the student government. Even the more usual courses seemed to take on new life as our social studies moved outside the USA, science taught a bit of physics instead of the familiar life science, and English was introduced as a separate entity from Reading—which disappeared altogether with the GT program, since the middle school strategy was to have GT class one hour each day during Reading period.

Perhaps even better, the math teacher gave the O.K. for independent work from the beginning. Taking this as a good sign, I dived in again. Someone must have forewarned her, because this time my math teacher was ready. When I finished the text, a seventh grade book was provided, and then an eighth. My excitement began to dwindle when I realized that all three of these were pretty much the same, but there was enough new stuff to provide some incentive. Besides, I was making a point. When I finished the eighth grade book, the year was nearly over, but my math teacher said that she would look for something new.

I'd also like to add that I kept in touch with a number of my sixth-grade classmates for several years and have heard more about them since through my parents and the community. *All* of the students who had worked ahead in math but were not accelerated ran into trouble after high school. While everyone at the high school agreed that they were bright and did well there, they seemed more and more unwilling to work hard as time went by, and this continued into college. I don't mean to draw the conclusion that all of us should have been accelerated in the same way, but I wish that something could have been done to keep them interested in and excited about working hard to learn, as they had done before.

So I entered eighth grade, the last year of middle school, with its full-fledged algebra course and its new people and options. While I did fine in school, this was an unusual year for me as I did not take advantage of all my opportunities. There are a number of possible explanations for this, of which family problems are the most prominent in my mind. This was the year of my grandfather's long and losing battle with lung cancer. He died in the early spring.

Sometime during the year, Mom introduced me to a new set of math problems—the SAT. Her counselor friends had told her about Dr. Stanley' program, and she thought I might be interested. In her usual way, she mentioned that I could take the exam if I wanted to and that, if things went well, I could

attend a special summer program. She made a point of deemphasizing the exam by saying that it was really just practice since I was young enough to take it again next year, and even the next. I thought it was fun and scored high enough that I went off to the residential Johns Hopkins Center for Talented Youth (CTY) that summer.

Despite what I saw as my less-than-spectacular eighth grade performance, the middle school staff convinced the high school to give me special status. They would allow me to take a number of upper-level courses. I could select which ones to take after I returned from CTY.

CTY was a wonderful new experience that I would heartily recommend to as many people as possible. I took a course called pre-calculus mathematics, and it was just like the sixth grade all over again, as they handed me math book after math book as the summer progressed. When the school year began, everyone back home agreed that I was ready for Calculus, the high school's top math course.

It was time to choose the rest of my classes as well. Before CTY, the high school people had thought they could provide me with two years of interesting courses. Now the official line was "one or two." I chose a wide selection, including calculus and biology courses that were offered at the high school but for college credit. At the other end, not feeling confident of my English skills, I took the (honors) 9th grade English class, almost certainly a mistake because it was not advanced enough.

High school was great fun. I was active in the German club and American Field Service (AFS), and thoroughly enjoyed my new friends from the math and biology classes. Two of the high points were a group camping trip with the biology class and a German club trip to Oktoberfest in Herman, Missouri.

As the year progressed, the high school people realized that one year of high school was enough for me. In principle, I could have stayed to take a number of college-credit courses in English, history, chemistry, physics, and German, but they seemed to think that I should give college itself a try. This made sense to me: I was already doing college-certified work. Besides, most of my friends were seniors on their way to college. Why shouldn't I go, too?

The trouble was, where should I go? The news came down to me quite suddenly, and while I considered it a great idea, I hadn't thought much about the possibilities. In addition, it was rather late to apply through the standard process or to seek out scholarships and financial aid in the usual way. I was also worried about which college would take me without a high school diploma. Through some process, a local school was found that would accept me and provide a large scholarship. It was also close enough that I could continue to live at home with my family.

William Jewell College is a small liberal arts school with less than 1500 students located in Liberty, Missouri, about 20 miles north of my home in Kansas City. I had dealt with them before and happened to know that a prominent physicist had graduated from there sometime before. It also had a good reputation in Missouri for physics, so it sounded fine to me. That summer I returned to CTY to study computer science and, for variety, also studied physics at a similar program through Duke University's TIP.

I didn't mean to give the impression that my precollege life was all fun and games. I didn't get along with everybody, and there were some drawbacks to being younger than the rest. However, most of these were confined to physical education class, where my youth combined adversely with my natural lack of coordination. In every class, I found at least some sympathetic and very supportive classmates with whom I became friends.

Now, the big moment was about to arrive, the event most feared by those concerned about my social development. I was about to enter college at age 12. Luckily, no one had told ME that I should be scared.

I did, however, have a few things on my side. I looked much older than I was, and no one suspected that I was particularly different. Even the fact that I lived at home wasn't peculiar, as almost a third of William Jewell's students were commuters.

My freshman year was delightful. I took a wide range of courses, not just math and physics. Since William Jewell was a liberal-arts college, this was encouraged. When I discovered that 21 hours of classes a semester was no problem, I began planning to graduate in three years. Also, despite living with my parents, I made a number of friends through my classes. We would often go to football games or concerts on the weekends. Most of these were senior students, and they seemed intent on introducing me to their version of the college experience.

As my second year of college commenced, I began to feel the need to move onto campus. Several of my friends had graduated and some had married, so I was looking to meet new people and become more involved with campus life. I wasn't all that excited about getting a roommate at random or about being dropped into the middle of a large and noisy dorm, *either.*

Luckily, a number of upper-level students lived in college-owned houses—about twelve students to a house. That fall, a friend of mine from a philosophy class told me that he was looking for a third roommate for a three-person room in one of these houses. I already knew the other roommate from another class and liked the idea of living with them. Everyone soon agreed that it would be a great place for me to move into. In January, I arrived.

Throughout the rest of my college career, I became quite close to my roommates (Bruce and Steve) and to their girlfriends, who later became their fiancees and then their wives. I was lucky enough to be in their weddings as well. We still keep in touch and see each other from time to time, though more and more seldom. I also spent a lot of time with other friends I made through the physics department and with their friends. Although I never attended a single frat party, I thoroughly enjoyed my time in college. I didn't date much, but then neither did the people I hung out with.

By now, I felt that I should move beyond CTY and try to earn some money for college expenses. I thought that I might return to CTY as a teaching assistant, as I already had practice in tutoring and as a teaching assistant at William Jewell. I asked Dr. Stanley to write a recommendation for me, but instead he suggested that I attend another mathematics program at The Ohio State University.

I wasn't sure if this was a good idea, because the program was designed for high school students and I was just finishing my second year of college. On the other hand, I knew that William Jewell was exceptionally weak in mathematics and that a number of extremely able high school students from other parts of the country were likely to know more mathematics than I did. Assuming that Dr. Stanley knew what he was doing, I decided to go.

This may have been the best decision of my life. Upon arrival at Ohio State I found a program, originated many years ago by math Professor Arnold E. Ross and still conducted by him, that is designed to immerse students in as much math as

they can absorb. The subject matter was number theory, something not even mentioned in any of William Jewell's courses. While I got along best with the counselors, the teaching assistants of the program who were also college students, I found that the mathematics offered filled a vital gap in my education. Perhaps even more importantly, the students, counselors, and staff provided a much better understanding of what mathematics IS and how it is done.

Armed with this understanding, I returned to William Jewell in the fall. It was this year that the negative aspects of attending William Jewell became more obvious. Relevant course work was limited and was offered only occasionally, so that my graduate school applications and physics Graduate Record Exam scores were not what I would have liked. I was, in fact, worried that my background would not be sufficient for grad school. I also found that, because the faculty at William Jewell did little research and had little knowledge of the specialty I wanted to pursue, I was applying blind, unsure both of just which specialty I wanted to follow and of which universities were best in that field.

It turned out that getting accepted was not the problem I expected. I was turned down only by Princeton University. The other schools not only accepted me, but also offered more or less equivalent financial aid in the form of teaching assistantships. This left me with a choice between a number of schools, including Caltech, the University of Chicago, and the University of Texas—all at roughly the same cost. Also, I had the opportunity to discuss my background with faculty at these schools. They thought that, while I might not be as prepared as some, my William Jewell background was adequate for their graduate program.

To make a decision about which school to attend, I talked to a number of researchers and found one at the University of Texas whom I thought I might like as a thesis adviser. I therefore decided to go to Texas in the fall. Graduation came, and my roommates and I celebrated with a camping/fishing/canoeing trip.

I spent the next five years in Texas pursuing my Ph.D., finishing slightly faster than average and often returning to Ohio State during the summers as a counselor. I graduated in 1992 and accepted a job with the Gravity Research Group at Syracuse University, which has since moved to Penn State. This is one of the leading research groups in the world in the field of quantum gravity, so I feel that I have in some sense caught up after my less prestigious start at William Jewell.

Would I change anything? Not the general outline, to be sure. But, knowing more now about other universities, I wish that I had at least applied to be an undergraduate at Harvard and Rice. Both are rather special places where I might well have felt at home, and could have prepared me better for a research career in physics. On the other hand, my William Jewell education seems to be working out well.

When people discover my age and position, they often ask a number of questions. In addition to the ever-popular "Did you miss your senior prom?", a favorite is "How did it feel to teach students who were older than you?" Neither one was a problem. However, I didn't advertise my age to my students. I'm never exactly sure what the problem is expected to be, but I was concerned that my students might be intimidated if they knew. Usually, it would come out somewhere in the middle of the semester, at which point it was harmless, though it may have added to their respect for me.

Dr. Stanley's Concluding Comments

Radical acceleration in grade placement of the kinds that greatly benefited Drs. Charlton and Marolf is, of course, not for everyone. Brilliant youths *must,* however, accelerate their progress in those school subjects where they excel, or else (as Dr. Marolf pointed out) they are likely to be so bored and turned off academically that they do poorly in college. We of SMPY have seldom observed an extremely accelerated student who did not earn the Bachelor's degree readily (even at age 12 years 47 days!), whereas a number of those who completed high school age-in-grade have even flunked out of college. They tended to cut many classes, hoping to coast on their brilliance. By the second or third year they became so far behind that they dropped out or were terminated academically. Others went through in four years but with mediocre grades. Sometimes, perhaps cynically, I say that they have a defective academic character brought on by 13 long years of being grossly under-challenged.

An excellent alternative to radical acceleration for many precocious students is the Advanced Placement Program (AP) of The College Board. Twenty-nine different exams yield college credit for high school students who score high on one or more of them. For example, one of SMPY's proteges entered the Massachusetts Institute of Technology (MIT) a year early after having scored extremely well (10 *5*s—the highest possible score—and 1 *3*) on 11 AP exams. He graduated four years later, while still age 20, with four majors: computer science and electrical engineering, mathematics, physics, and economics. Then he entered graduate school in the first of these majors.

The main problem with the AP approach is that few high schools offer many AP courses. Extremely able students can prepare for the exams largely on their own by securing course materials and supplementing the regular high school course appropriately. A high school senior in Florida did this for both parts of the difficult AP Physics Level G (Mechanics, and Electricity & Magnetism) and earned *5*s on both. This and other special work on his own enabled him to rank third in the annual Westinghouse Science Talent Search and win a $20,000 scholarship. It also made his academic record look good enough to the California Institute of Technology that he was admitted there and won several academic awards his freshman year.

Taking courses in a nearby college on a part-time basis while still in high school is another option, often used by intellectually highly able students. For several years, one of SMPY's proteges took about a two-third load in a first-class university. Then he entered Harvard College at age 17 with sophomore standing. His first mathematics course there was, however, at the graduate-student level.

As both Dr. Charlton and Dr. Marolf pointed out so well, each highly precocious boy and girl and his or her parents must be continually vigilant to seek or create the special, supplemental, accelerative educational opportunities the able youth sorely needs and richly deserves in order to use great talents effectively for self and society.{2}

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1 Dr. Bartkovich is now a teacher of mathematics at the famed North Carolina School of Science and Mathematics, instructing mathematically talented 11th- and 12th-graders.

2 For comprehensive views of educational acceleration, see Southern, Jones, and Stanley (1993) and Brody and Stanley (1991).

An Addendum: *Lenny Ng's Story*

It's too bad my younger brother, Jakun, isn't here today, because by all rights he should be the one to speak. At one of his recent math competitions, someone who apparently recognized my name asked Jakun what it was like to have a famous brother. "I don't know, but I imagine it must be tough," he replied, "just ask my brother, Lenny."

In all seriousness, people often ask me what it is like, as a friend put it recently, "to be so smart," to have appeared on the cover of *Parade* magazine and been featured in *Newsweek, Life* magazine, and even *Sports Illustrated for Kids.* I can tell you that it's been a lot of fun, and extremely rewarding. Through my activities and competitions, I have made lifelong friends, seen fascinating places, and met people even more famous than my brother. Perhaps my greatest blessing is a mind enchanted by everything from math to music, from literature to tennis. I have been fortunate to have a wealth of opportunities as eclectic as they have been numerous. And much of my success should belong to my hardworking, devoted, and visionary parents.

Even as early as preschool and elementary school, my parents fostered and encouraged my many diverse interests. When I was three, my father wrote up a multiplication table for me; I remember this because I drew all over the sheet. I was exposed to literature early, reading Dickens's *Oliver Twist* at the age of six before seeing the high school production of "Oliver!" My early artistic masterpiece, a crude painting of a pelican, still hangs in my father's office, and his colleagues often remark that they have never seen anything like it before. For good reason, too: still weak in biology, I had given the pelican four legs.

Most precious to my parents, I suspect, was my interest in music. My father taught me fractions not for the math but to help me understand half notes and quarter rests. I started taking piano and violin lessons when I was four, and a year later composed my first piece. I quickly learned to use my parents' enthusiastic support for my composition skills to my advantage: if I broke a plate or upset my parents, I would run to the piano and tell them that a sudden musical thought had come to me. The house would hush to preserve my concentration, and after I had finished composing, all would be forgiven and forgotten.

School was not quite as encouraging as home. Some at school were not especially sympathetic to my academic needs. My age denied me participation in many programs. One elementary school teacher, noting that I had not performed perfectly on a math placement test, wanted to incorporate me into the rest of the class because, she said, "there are gaps." Another especially outrageous incident concerns my parents' attempts to find out the school system's textbook for a math course for my use. The junior high school principal lied to my parents that she could not divulge the information, and referred them instead to the superintendent. When they arrived for a scheduled appointment, the superintendent's secretary told them that he was not in and could they please come back another time, all the while laughing as if to say, "What a pushy set of parents. Why couldn't they cause less trouble?"

The presence of such obstacles hardened my and my parents' resolve to find opportunities sufficient to challenge me. Luckily for me, some teachers turned out to be very helpful. On the recommendation of my second-grade teacher, I skipped third grade. In fifth and sixth grades I was put in a special "self-contained" class designed to stimulate the academically gifted. Throughout this period, I pursued an independent study of mathematics under my father's guidance, completing Algebra II by my sixth grade year. My sixth grade teacher suggested that I take the Scholastic Aptitude Test in order to participate in the Duke University Talent Identification Program,(TIP), a summer program mainly for gifted junior high students. So when I was barely 10 years old, I took the SAT, and was surprised to learn a couple of months later that I had aced the math portion.

This was probably my "big break." A few reporters from local newspapers found me, especially after I won the state Algebra II contest shortly after, and through them I was introduced to Prof. Stanley, who would become my academic guardian angel. He wrote letters to the principals of my junior high and high schools, advising them to allow me to take the courses most suitable for me. Through his influence I was able to take courses at the high school when I entered junior high, and by eighth grade I had taken Advanced Placement calculus and chemistry.

Outside of school, I continued to pursue various interests. I swam, ran track, and played basketball and tennis. My music compositions and playing began to win prizes. For three summers beginning when I was eight, I attended the Duke Young Writers Camp. It's hard to believe now, but back then I was cute enough that a newspaper feature article on the Young Writers Camp included a picture of me sitting pensively with a foot on my chair and a piece of bubble gum dangling out of my mouth. In the summer of my seventh grade year, I was fortunate enough to attend TIP on a full scholarship, studying number theory.

The next year I tried to apply to a state summer science program for rising high school seniors but was rejected, again because of my age. To my surprise, I was accepted to a much more prestigious national program for rising seniors, the Research Science Institute; I'm sure it didn't hurt that Prof. Stanley was on its board of trustees. I found my experience there during the summer of my eighth grade year to be enormously stimulating.

These summer programs were only one aspect of the opportunities I enjoyed. Various competitions also provided a much-needed challenge. When my mother discovered my knack for spelling, she interested me in the spelling bee, where in my eighth grade year I won a trip to the nationals. My greatest success was in math competitions, starting with MathCounts, in which I worked my way to a first place national finish in eighth grade. I was president of my high school's Math