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Manipulate Important Educational Variables

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For nine years personnel of the Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins have found thousands of youths, chiefly seventh-graders, who reason extremely well mathematically. SMPY strives in various ways to help these students proceed considerably faster and better in mathematics and related subjects than is usually permitted or encouraged. Its work is offered as an example of important problems that, in the judgment of the author, educational psychologists should attack vigorously. SMPY's four-D model is described, which emphasizes educational acceleration of youths who are highly able and eager to move ahead quickly.

From the vantage-point of many years as an educator, the first four and one-half of them as a high-school teacher of science and mathematics, I believe that the professional educational psychologist's prime commitment should be to the betterment of education, rather than imitating basic research in psychology that seems little related to education in the short or the moderately long run. I urge that a considerable number of us help tackle directly the big, important problems of the schools with all the knowledge and intelligence at our command. This will lead to what some like to call applied research, and that in turn may suggest basic research. Like Bridgman (1945), though, I am convinced that "the scientific method, as far as it is a method, is nothing more than doing one's damndest with one's mind, no holds barred."

All the naming, all the methodology, will not get us far if the research is really irrelevant to education or concerned with trivial problems. Too often, as I scan the top-rated educational research journals, I get the sinking feeling that many researchers who term themselves educational psychologists have neither relevance nor importance in mind when they choose research topics. Excessive emphasis on theorizing, neatness of design, and cleverness of approach often leads to ingenious fun-and-games in which one "plays around with" an idea that can be handled with whatever semi-volunteer students happen to be available. Even at best, applicability and generalizability often get second billing to what Campbell (1957) has termed the internal validity of the experiment. The searcher looks for his wallet under the street light, rather than in the dark alley where it was lost.

A Neglected Powerful Variable

Let us consider a familiar factor crucial to the educational success of homogeneously grouped brilliant students in my Study of Mathematically Precocious Youth (SMPY). Over and over, in more than a dozen fast-paced mathematics classes, we have found that the main variable differentiating the successful students, who forge ahead well at astonishing speeds, from the unsuccessful ones is homework. Those who do it well thrive, and those who do it poorly cannot keep up. The more equal the students in the class are in mathematical aptitude and general intelligence, the more striking the phenomenon becomes.

Clearly, this is a most important problem. From any rational standpoint it would seem to deserve massive attack with all the interdisciplinary tools of psychology, sociology, psychiatry, and common sense at our disposal. I suspect that enough knowledge and powerful enough procedures are already available to provide much help to parents and teachers. Behavior modification techniques, augmented by careful study of the dynamics of families within homes, in communities, and in schools,

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should enable a considerable percentage of these brilliant youths to function far more effectively. The direct gains to them and society would be enormous. Theory might be enriched. Interesting research topics of a less macroscopic nature might be byproducts of this applied-research on what is in effect a symptom.

Yet mention of such a prosaic-sounding problem is likely to be met with yawns or worse. Not interesting, some say. One does not get far in research by starting with symptoms, others insist. Expensive service, not research, the third group says. And so the objections go.

We at SMPY came to appreciate the crucial importance of homework only recently and have not systematically done much about it yet. It may be instructive, however, to examine with me the large, seemingly diffuse problem that got us started in 1971.

SMPY's First Fast-Math Class

SMPY began because over a period of many years I had become convinced that homogeneous grouping for fast instruction of youths in school subjects for which they were especially talented should work exceedingly well. Letting them race ahead at their own natural pace should do wonders for their educational development. That was in the face of considerable published evidence, mostly negative or equivocal, about the effectiveness of homogeneous grouping. It seemed to me, however, that if the students were chosen because of their special aptitude for the particular course and if they were moved fast enough and at a high enough level, the education of most of them should diverge radically from that of their agemates.

In June of 1972, three of us put this speculation to its first empirical test. Those pioneers were two of my graduate students, Lynn H. Fox and Daniel P. Keating, and myself. From the results of an aptitude survey done among sixth-graders in Baltimore County by two juniors in my introductory testing class we quickly set up a class of 19 boys and girls who had scored in the top 1% of their grade on national norms for a numerical ability test and also in the top 1% on *either* verbal aptitude or nonverbal reasoning — we did not know which of the latter might be the more suitable supplemental criterion. By sheer good luck we happened upon a brilliant, young ex-physicist eager to teach such a class, and the results were indeed spectacular.

Several students were eased out at the end of the summer because they were not learning fast enough. By June of 1973, after only 50 two-hour periods of instruction, the least-accelerated six members of the remaining group had completed, as seventh-graders, the first two years of high-school algebra. Two had gone somewhat further than that. The other eight continued classes until July 28 and covered all of precalculus mathematics in 120 hours rather than the usual 600 hours. Their success in every subject from Algebra I through analytic geometry was judged by national norms on a standardized test. Each of these students was certifiably proficient in every one of the courses at the 85th percentile or better. This is more than can be said for many able students completing the usual school classes in mathematics.

The 80 to 84% saving of time and the radical acceleration of subject-matter acquisition were indeed striking, but would they hold up? We carefully followed all the students, especially the top eight, as they went through subsequent school grades. The results are now in. The only girl in the top group chose no acceleration in grade; instead she spent her last two years of high school at a top New England independent school from which she went on, age-in-grade, to a famed Ivy League university. At the other extreme, one of the boys completed the M.B.A. program at the University of Chicago at age 19, after becoming (at age 17 years, 1 month) probably Johns Hopkins's second youngest recipient of the baccalaureate. He plans to have a Ph.D. degree in finance at age 21.

Another at barely 18 recently received his B.A. degree in mathematical sciences from Johns Hopkins. Two others have been graduated from Johns Hopkins, at age 18 or 19; another earned both the bachelor's and master's degree from Johns Hopkins at age 20 in a total of seven semesters. A member of the group who was two years older than the rest left high school two and one-half years early to enter a local state college; his grades were not good enough to get him into Johns Hopkins. The "baby" of the group, who was 9 years old and had completed only the third grade when the fast-math class started, went through four years of a parochial high school and was graduated from it at age 15 years 2 months. He then entered Johns Hopkins with sophomore standing.

Clearly, the degree of educational acceleration resulting from that one special class is staggering. Equally impressive, however, was the speeding up that eight of our nine other protégés who took college courses that summer did subsequently. Three went on to be graduated from Johns Hopkins at ages 17, 17, and 18, respectively, all winning three-year National Science Foundation graduate fellowships and going promptly to outstanding universities (Cornell, MIT, and Princeton) to study for Ph.D. degrees. Their major fields are computer science, electrical engineering, and physics.

Other Radical Accelerants

This account of distinguished early entrants resulting from SMPY's bountiful smorgasbord of special educationally accelerative opportunities could be continued for quite awhile. One of our protégés was graduated from Booklyn College in mathematics, *summa cum laude*, shortly after his 15th birthday. He had entered at age 11½ after completing the sixth grade of a public school. A couple of months after his 16th birthday, he finished in a highly successful manner the first year as a doctoral student in mathematics at Princeton, and a year later he received the master's degree there. He should have the Ph.D. degree by age 18 or 19. In the fall of 1978 an almost unbelievably able 12-year-old physics major entered Johns Hopkins with sophomore standing, and a 14-year-old enrolled as a junior. Coming to Johns Hopkins with sophomore standing in the fall of 1980 is a 13-year-old female. A twelve-year-old boy completed the first semester at Amherst College with all A's. A 12-year-old girl with an IQ of 212 is becoming a violin virtuoso. She learned considerable mathematics fast and well from SMPY's skilled young mentors, themselves graduates of our fast-math classes. Much of this fascinating story is written up in our seven books[1] and many articles, but life races ahead of our writing speed as each months unfolds astoundingly enhanced and accelerated learning in mathematics and related subjects.

The D4 Model

The model guiding all of SMPY's efforts is summarized in terms of four D's:

1. *Discovery* (that is, finding youths who reason extremely well mathematically). This was accomplished mainly by large annual talent searches among the mathematically upper-3% of seventh graders in Maryland, the four states (Delaware, Pennsylvania, Virginia, and West Virginia), that touch it, and the District of Columbia. In January of 1979, 3,675 such boys and girls participated. That was our sixth annual talent search. We had reached more than 10,000 youths by then. A year later, with verbal and general-ability as well as mathematics criteria, the search [now conducted by the Office of Talent Identification and Development (OTIC) at John Hopkins] reached another 9,000.

2. *Description* (that is, studying the high-scorers further — both cognitively and affectively). For example, for each of the 97 ablest boys from the 507 who were in the December 1976 talent search we have scores from 13 different cognitive tests, plus the Strong-Campbell Interest Inventory, the Allport-Vernon-Lindzey "Study of Values," and other self-report inventories and questionnaires.

3. *Development* (that is, helping the youths improve their educations, including speeding up the process if they wish). This is the step ignored or derided by most researchers because, to them, it is "only" service and therefore not worthy of their attention. Of course, that is nonsense, because the developing of all these special, complementary, and interacting opportunities requires a great deal of theoretical structure and the careful assessment of outcomes at each step (see Wallach, 1978). SMPY conducts longitudinal follow-ups and cross-sectional comparisons, thereby permitting a wealth of formative and summative evaluation. We are trying to develop on a relatively firm base many principles, practices, program, and techniques that are widely usable.

Implementation of each of these three stages is described by Solano (1979), Stanley (1979), and George (1979), respectively.

[1]See Stanley, Keating, and Fox (1974); Keating (1976); Stanley, George, and Solano (1977, Note 1); George, Cohn, and Stanley (1979); Fox, Brody, and Tobin (1980); and Bartkovich and George (1980).

4. The fourth D is *dissemination* of SMPY's results far and wide to interested students, parents, educators, and political policy makers. This is described in more detail later.

How SMPY Operates

From the first talent search in March of 1972 onward, SMPY's primary criterion for mathematical aptitude has been a high score on the mathematical part of the College Board's Scholastic Aptitude Test (called SAT-M). The definition of "high" depends on the purpose in mind — the higher the better, of course. Arbitrarily, we consider a seventh-grader to be a really excellent mathematical reasoner if he or she scores at least 500 on SAT-M, that being a little above the average score of college-bound male twelfth-graders. Such persons can usually learn first-year algebra well from a skilled mentor in 3 to 15 hours. Many of them already score better on a standardized Algebra-I test than 50% of ninth graders do after a school year of instruction!

Obviously, SMPY is seeking already-developed mathematical aptitude, rather than trying to produce such aptitude. In the first six talent searches, any seventh-grader in the geographical area covered, or any student in a higher grade of seventh-grade age, was permitted to participate if he or she had scored in the upper 3% of national norms on the mathematical part of a standardized achievement-test battery administered by the school. There was no quota of any sort, for sex, race, socioeconomic level, ethnic or religious group, or public or private school. The 10,000 participants in those talent searches were from varied backgrounds. About 42% of them were female.

Mathematical aptitude may be a more "democratic" variable, at least from the standpoint of socioeconomic level of the participants' parents, than is verbal aptitude as measured by the SAT. Our 11- or 12-year-olds from modest backgrounds tend to score higher among the talent-search participants on SAT-M than on SAT-V. SAT-V ability seems more closely related to the Binet-type IQ than is SAT-M ability, which appears to be closely related to nonverbal reasoning ability as measured by the difficult, 36-item form of the Raven Progressive Matrices test. One might speculate that SAT-V scores of these able youths are strongly related to the left hemisphere of the brain and SAT-M scores substantially to the right hemisphere. Keep in mind that the SAT is intended mainly for the abler half of 11th- and 12th- graders, who have had much longer systematic schooling than these seventh-graders. Rather different mental processes may be used by the two groups in answering the same items.

Like McNemar (1964), who emphasized that if IQ is barred from the front door it will creep into the house via the back door or a window, we found to our considerable surprise that, above and beyond mathematical aptitude *per se*, intellectual aptitude of the SAT-V kind is important for learning mathematics rapidly and for doing well in the difficult "pure-math" courses such as analysis, higher algebra, and topology. Those students who lagged behind in our first fast-math class were chiefly the ones with the lower verbal scores, even though the lowest scorer in the group had done better on the verbal test than 85 percent of that student's agemates nationally. The gap in verbal ability between the 99th percentile and even the 90th or 85th proved large in its effect on ability to learn math fast at a high level and to take a speeded multiple-choice standardized test of Algebra I at the end of only nine, two-hour class periods. Our later experience has borne out this initial observation. Of course, as with all human enterprises, there are exceptions and surprises in both directions. We are more likely, however, to find a high scorer achieving poorly than to get brilliant performance from a relatively lower scorer.

Time does not permit me to say much about the mathematical reasoning ability and mathematical achievement of the girls who participate in SMPY's talent searches. On the average they score somewhat lower than the boys on SAT-M, and far fewer of them make high scores. Also, they are considerably less likely to accelerate their educational progress, mathematically and otherwise. These are the "whats" of the situation. The "whys" are being investigated extensively by Camilla P. Benbow of SMPY and Lynn H. Fox (Fox, Brody, & Tobin 1980), who heads the Intellectually Gifted Child Study Group at Johns Hopkins.

As I had suspected nine years ago, much mathematical talent is being wasted in the lockstep, age-in-grade, Carnegie-unit curriculum of both public and private elementary and secondary schools. A visitor from outer space might think our educators insane for requiring virtually every student to wait until a certain grade, usually the ninth or the eighth, before beginning the formal study of elementary algebra. Even worse, no matter how well the youth reasons mathematically, he or she must spend 180-190, 45- or 50-minute periods in that grade studying Algebra I, even though the student may already know the material better than the teacher. For example, the top-scoring person in our 1974 talent search, a 12-year-old seventh-grader, made a perfect score (40 correct in 40 minutes) on the Cooperative Mathematics Test, Algebra I, before having had a course called algebra. With our help he forged ahead extremely fast. By age 17 he was one of the eight high-school students representing the United States in the Mathematics World Olympiad in London.

Our results have formed the basis for starting similar fast-math programs in several places besides Maryland, notably the Minneapolis-St. Paul-Duluth (Minnesota) area, Illinois, Delaware, South-central Nebraska, and Eau Claire, Wisconsin. We have been quite disappointed, however, that almost no university professors — psychologists, mathematicians, mathematics educators, or curriculum and instruction specialists — have yet replicated even a small part of our model.[2] Mathematicians seem greatly interested in our methods and results but are not accustomed to doing such things. The others appear to have little interest in youths who reason extremely well mathematically, or for that matter in gifted children in general. Nearly all effort is being directed toward slow learners and students otherwise handicapped. People seem to feel that fast learners get their knowledge too easily anyway, so why give them extra advantages?

Social and Emotional Adjustment

The trump card of such uninterested persons, and of a great many well-meaning but misinformed parents and educators, is their strong belief that even a little educational acceleration in subject matter or grade placement is harmful to the social and emotional development of intellectually brilliant youths. This is one of the most fervently held articles of faith imaginable. One of our protégés who, despite the almost hysterical objections of his mother, went off to a great university a couple of years early was hounded by her incessantly for four years until he was graduated loaded with top honors. Only then did she relent a little and feel proud of her remarkable son. We have seen fathers just as upset. Those prejudiced parents and educators refuse to consider the other possibility, that many dreary, boring, frustrating years in the Procrustean educational nightmare may ruin the academic motivation and seriously hurt the long-term social and emotional development of intellectually brilliant students who are eager to move ahead at what is for them a thoroughly appropriate rate. Those highly motivated potential accelerants can usually make personal adjustments to being young-in-grade or young-in-subject.

We have observed and studied those adjustments carefully as youths progressed from being as young as 9- (or even 5-) years old in the fall of 1971 to the present, especially among those students who chose to accelerate their educational progress most radically. For each youth there seems to be an optimum combination of program, pace, and timing. Those whose progress is synchronous with their needs and desires usually thrive, academically and otherwise. As a first-year *graduate* student in mathematics at a highly demanding university, the 15-year-old was happy socially and academically with his true intellectual peers there. An 18-year-old had a splendid first year toward the M.B.A. and Ph.D. in finance degrees; he did not even become 18 until December 4, and by that time had become well known from his editing of the business school's newspaper. During the following summer he worked on Wall Street for a major investment firm. The 18-year-old in electrical engineering at MIT was already a veteran researcher and comfortable student after three summers with major companies and three years in a college dorm.

The much-heralded social and emotional maladjustments did not arise among those students who earned their bachelor's degrees four to seven years ahead of their agemates. The record is by no means complete, of course.

[2]Notable exceptions include Professor Halbert B. Robinson's stellar work on acceleration at the University of Washington in Seattle and the 13-state talent search being planned for the fall of 1980 by Duke University professors Ellis B. Page and Robert N. Sawyer.

These young persons, nearly all of whom are from rather average socioeconomic backgrounds, entered the country's top graduate schools in the most difficult fields. It will be interesting and important to watch closely how they handle the tremendous intellectual stresses of the best graduate schools and the professional years thereafter. The signs thus far are encouraging.

It is far more difficult for students to make suitable adjustments to being vastly overqualified academically and yet required to sit endlessly in classes where they learn little. Because these students *already* know so much and usually suffer in silence, most teachers do not realize how seriously they are being shortchanged and prevented from functioning fully as human beings.

Dissemination of SMPY's Findings

In the hope that compilations of strong evidence will change the practices, if not the fundamental attitudes, of quite a few parents and educators, we at SMPY have published the following six books, cited earlier: *Mathematical Talent, Intellectual Talent, The Gifted and the Creative, Educational Programs and Intellectual Prodigies, Educating the Gifted: Acceleration and Enrichment,* and *Women and the Mathematical Mystique.* In addition to these books, we have written many articles and presented a number of papers at professional meetings. Also, for a number of years we published a printed newsletter-type journal called ITYB (Intellectually Talented Youth Bulletin) ten times per year. SMPY's small staff responds with letters or materials to hundreds of inquiries each month.

SMPY's first line of dissemination is to the subjects of the study themselves — that is, the participants in the talent searches, especially those scoring high on SAT-M. We write directly to the youths, rather than to their parents or teachers. The youths then disseminate our "findings" to their parents, and youths and parents carry them to the youths' schools and school systems. There is no intermediate agency between SMPY, which does the research and development, and the user of that research and development, namely, the mathematically precocious youth.

Somehow, this whole approach seems rather irregular to a number of professionals. (I doubt that an assistant professor working toward tenure at most top-level universities could risk SMPY's kind of undertaking. Perhaps only full professors can afford to do something this different.) Is it really "research," or is it "just service"? (See Davis, 1979; Wallach, 1978.) Well, a great number of research-type articles, doctoral dissertations, and master's theses have already come out of the study, and more are in preparation. We do not, however, waste time quibbling about words such as "research" versus "service." We study problems carefully, taking into account whatever background research there is. We develop procedures and try them out, usually with at least one subsequent replication. We test, modify, retry. We experiment, but not often with the full controls of Campbell and Stanley's (1966) Design No. 6. We are proud to consider ourselves facilitators of the education of youths who reason extremely well mathematically.

Conclusion

We like the individual students and know many of them personally. For hour after hour I can from memory give case studies about these youths, based on personal experience and loaded with specific facts and what Flanagan (1954) called "critical incidents." We want to make these highly talented students aware of every opportunity to turn potential into high achievement that will enrich their lives and also benefit society greatly.

Why did I, for 22 years an almost notoriously fervent proponent of rigorous experimentation and advanced methodology, rather suddenly become obsessed about helping mathematically apt youths move ahead educationally at their own preferred paces? Motives for such actions are complex and, of course, often involve one's own experiences when much younger. I shall not bother you with a full-scale analysis that would include my own early educational frustrations, but will merely comment that my interest in the intellectually talented dates from the first test-and-measurement course I took 42 years ago. That interest in the so-called gifted surfaced occasionally during the following years, but most of the time it was latent.

The precipitating event seems to have been, as B. F. Skinner might put it, exhaustion of my reflex reserve by the prolonged labor of preparing the "Reliability" chapter for the revision of the handbook entitled *Educational Measurement* under the able editorship of E. L. Thorndike's son (see R. L. Thorndike, 1971). Over a two-year period it occurred to me that the dry-bones methodology, largely devoid of substantive content, I had wooed so long had lost its appeal. Somehow, my Allport-Vernon-Lindzey social evaluative attitude, until then overruled by the theoretical one, gained ascendency.[3] I wanted to do some "real good" for a change, that is, to do work of direct and major importance for human beings. As a long-term Fellow of APA Division 20 (Division of Adult Development and Aging), I see in this shift some interesting research problems concerning the change of evaluative attitudes and cognitive orientation with age. I still enjoy test theory, statistics, and experimental design and teach courses about two of them, but my research, writing, and consulting now deal almost entirely with the mathematically talented.

Boredom with nonsubstantive research and a strong desire to do something more immediately linked to the betterment of individuals were the precipitating factors in my defection, but the activating agent was a generous five-year grant in 1971 from the newly formed Spencer Foundation of Chicago. Interestingly, its money came from the sale by Lyle M. Spencer of his Science Research Associates test organization to IBM, so in the words of an old antidote, I was cured by taking a hair of the dog that bit me.

Obviously, I favor doing research, development, and service that utilize currently available knowledge to improve education, broadly defined. Educational psychology can become a first-rate applied discipline. Professional educational psychologists need rigorous doctoral preparation, so some of the best will continue to come out of academic psychology, as did, for example, Jack Carroll, Bob Gagné, and Bob Glaser. Others will be produced by excellent departments of educational psychology. More equipment, courage, and persistence are needed to search effectively in the dark than to play intellectual games under the street light.

The schools and other educating agencies must go on. Educational practitioners will continue, partly because of what I consider undue emphasis on basic research, their rounds of cyclic faddism, or they can be helped by us to do their jobs better.

This is no minor point. For example, the "radical acceleration" of achievement in mathematics that SMPY is pioneering can greatly increase the size and, especially, the caliber of the top-level scientific group in any country that puts such ideas into practice. This might make the difference in whether or not the United States remains the world's technological leader. We educational psychologists are equipped to help make really great changes. Don't we want to give more attention to manipulating *important* educational variables strongly?

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