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ABSTRACT

The paper examines the problem of highly gifted junior high school students who are intellectually ready for college-level study before beginning high school. The term radical accelerates is used to describe gifted students who jump from junior high to college education, bypassing the high school years. Briefly described are two widely known and successful radical accelerates, Norbert Wiener and Charles Fefferman. Presented in greater detail are case histories of two boys who are current radical accelerates. Methods used by the authors in seeking out mathematically and scientifically precocious students of junior high school age are explained. Possible disruptive effects of academic acceleration are considered, with particular reference to social and emotional development. Previous literature on acceleration is referred to, although little study has been done on radical acceleration. Radical acceleration is seen as the method of choice for some, but not all, extremely able students; alternate possibilities are also mentioned. (KW)

From Eighth Grade to Selective College in One Jump

Case Studies in Radical Acceleration

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Perhaps it would be best if we were to begin by posing a question: is it fair to compel an individual to remain in a situation which restricts his abilities, particularly his ability and eagerness to learn? If we pose the question abstractly, as we have just done, it would be a rare person indeed who would not say that it is unfair. If we were to elaborate the circumstances in the following fashion, the feeling that an injustice is being done will probably be even stronger: let us consider a bright and able student, applying to a selective college or university with a Scholastic Aptitude Test mathematical score of, say, 710, and a College Entrance Examination Board Mathematics Level I Achievement test score of, say, 730. We also test his knowledge of general science and discover that he places ahead of 99 per cent of college sophomores at a typical college who were tested in the spring. All in all, a very talented student. But now we say to him, "It seems as though your grammar school and high school credentials are not entirely in order. Therefore, before we will allow you to take courses in college physics, mathematics, computer science, and so on, you must first return to the eighth grade and work through grades eight to twelve, inclusive."

Preposterous? Of course it is, if you imagined an eighteen year old high school graduate eager to begin collegiate studies. But if you will picture instead a twelve year old seventh grader with those scores we mentioned above, your assessment of the situation will undoubtedly change, and perhaps change dramatically. It is clear that we need to reassess the situation in light of this last bit of information, namely, that we are discussing a twelve year old rather than an eighteen year old. The important question, though, it seems to us, is how drastic should our reassessment be. Is it any fairer or more just to compel the twelve year old to undergo five years of boredom, "learning" material he already knows, with our only justification being that he is, after all, only twelve?

We think not. If anything, it might be more frustrating for the younger student, since he is almost certainly brighter, in a number of important ways, than an eighteen year old with the same scores. By the way, our twelve year old seventh grader is not imaginary at all; he is a quite real student whom we tested a month ago today, and he did indeed get those spectacular scores of 710 on SAT-Math, 730 on Math Level I achievement, and above the 99th percentile of college sophomores on a test of general science knowledge. The only part of the picture that needs correction is that he is not scheduled to begin college next year or even to take high school courses; he _is_ scheduled to continue on into the eighth grade.

It is certainly not unheard of for a twelve or thirteen year old student to begin college work. We have yet to come up with a clear and euphonic neologism for such students, so let us be content for the moment with the clumsy phrase "radical accelerates." Let us discuss briefly two widely known and successful "radical accelerates," and then concentrate on two current "radical accelerates" associated with our project.

Norbert Wiener was perhaps the most celebrated "radical accelerate" of the recent past, no doubt because later in his life he chose to write a book about his experiences as a child prodigy, which he entitled _Ex-Prodigy_:

My Childhood and Youth. It is a deeply interesting and challenging book. We are confronted with the problem of what is to be done for such talented and precocious young people. One correctly infers from Wiener's account that it is not a simple problem.

Wiener did his earliest scholastic work under the tutelage of a stern and demanding father. The trauma of this type of early education is eloquently captured in Wiener's book. Nonetheless, by the time he was eleven, Wiener had been graduated from high school and was beginning college. He received a bachelor's degree, Phi Beta Kappa, from Tufts at fourteen, and at eighteen he received his doctorate in mathematical logic from Harvard University.

Although Wiener did not take advantage of his early degree by immediately embarking on original research, his eventual success can not be questioned. As the "father of cybernetics," he must be ranked among the truly creative minds of this century. This raises a point to which we will return later: one of the primary advantages of educational facilitation of extremely able students, which leads to an early degree, lies in the longer and more productive period of creative research which can be undertaken in the early years of a career.

A striking example of this is Charles Fefferman, who is a professor of mathematics at the University of Chicago. After taking several courses informally, Fefferman officially entered the University of Maryland at the age of fourteen, and by nineteen he had received his doctorate in mathematics from Princeton University. Just last year, at the age of twenty-two, he was promoted to full professor. From what one can gather from the news services, his promotion met with no objections; it would appear that his research with the

Fourier series was impressive enough that his colleagues decided his age was not a significant factor.

There are a number of other examples of successful "radical accelerates" which could be cited, but we would prefer to discuss in more detail the cases of two "radical accelerates" who are still undergraduates.

When he was thirteen years old, Bill was "discovered" by an astute computer science teacher at the university who noticed a young student spending a great deal of time around the computers, and constantly asking questions. Shortly thereafter, he was answering other students' questions about basic programming. Due to Bill's interest and evident ability, it was eventually decided that he should take the college board exams in the spring.

The scores were very impressive. Remember, too, that they belong to an eighth grader, thirteen years and five months old, with no special scholastic experiences to this point: Scholastic Aptitude Test, mathematical -- 669; Math achievement, Level I -- 642; Math achievement, Level II -- 772; Physics achievement -- 752. Two of the scores are somewhat confusing: 772 on Level II Math , which is the harder of the achievement tests, and 642 on Level I.

This pattern of better scores on harder tests is seen in several other tests Bill has taken. For example, on Bennet's Mechanical Comprehension Test, Form BB, Bill got 52 of 60 correct. This placed him at the 33rd percentile of engineering school freshmen. On the harder form (Form CC), however, he got 55 of 60 correct, including the last 22 in a row, which are the hardest. This score ranks Bill at the 95th percentile of college seniors.

It was clear that something other than merely continuing on into the ninth grade was advisable for Bill. A number of alternatives were considered, some of which were investigated and found to be unworkable for various reasons. It was finally decided, with some reservations, that Bill should begin college the following school year. He would take those subjects in which he seemed ablest and most interested. The speculation was that he might make mostly B's and C's and occasionally an even lower grade, but that perhaps the intellectual stimulation would be worth the shift. If he did not do reasonably satisfactory college work, he could return to high school after a semester or two.

In the fall of 1969 he enrolled for honors calculus, sophomore general physics, and introduction to computer science, a 12-credit load. This would be a disastrous set of courses for the usual freshman, but it was clear that he was better prepared for them than for Shakespeare, political science, and other such courses. His success exceeded all expectations. He made a high B+ in honors calculus, an A in sophomore physics, and a [illegible] in computer science. His gradepoint average was 3.69, where 4.0 is straight A. It was obvious that, intellectually at least, Bill had without question found his place.

His success has continued well beyond this first semester. Bill is now a full second-semester junior who plans to have both a B.A. degree and a Master's degree in computer science by the time he is 17 1/2 years old. Then he will go on for a Ph.D. degree in computer science. We should point out that Bill has already taken the Graduate Record Examinations, once as a fourteen year old freshman, and once as a fifteen year old sophomore.

The first time around, Bill scored 800 on the quantitative section, and 630 on the advanced test in physics, which is the 53rd percentile of graduate students and applicants taking the test. On the second try, a year later, Bill scored 750 on the advanced test in mathematics, the 71st percentile of a similar group, and 720 on the quantitative aptitude section. Again, it is difficult to account for the eighty point drop in the quantitative score -- had the test become "too easy" for Bill with his additional year's expertise, during which he made an "A" in honors advanced calculus? We don't really know.

Where did Bill's exceptional talent come from? Surely his father must be a mathematics or physics professor, or a research scientist, who has worked diligently with Bill for years. Not so. Both of Bill's parents are very intelligent, but neither has had any special training or interest in these areas, nor have they specifically tried to tutor Bill in them.

Bill's mother reports, however, that he has "studied physics seriously since he was three." Whether that age is precise is relatively unimportant; it is undoubtedly true that he was greatly interested and extremely precocious in math and science throughout elementary school.

One might argue from the above that Bill is indeed an exceptional student, so exceptional that his case necessarily came to the attention of individuals who could make the required special arrangements. It would be comforting to believe that this would happen most of the time in similar circumstances, but this does not appear to be the case. This brings us to our second "radical accelerate," Eric.

While Bill was clearly able to do work well beyond his age-in-grade level, he was routinely performing the tasks required of him at school. Eric, on the other hand, was visibly dissatisfied with his educational situation. He was bored with school, and didn't hide the fact. This in itself didn't endear him to the powers-that-be; the situation was further complicated by peer group difficulties. Eric's ability and his ease in doing assignments apparently engendered resentment among his classmates.

His scholastic talents were evidenced, however, by his outstanding College Board scores. At age 13 years, 2 months, Eric earned scores of 716 on the Scholastic Aptitude Test, mathematical and, on Math Level II achievement, 722. Two months later, he scored 726 on the CEEB physics achievement test and 525 on the chemistry achievement test. These were both attained prior to any formal instruction in these subjects.

The problem of facilitating Eric's further education was complicated, of course, by the non-academic, primarily social adjustment factors mentioned above. But, because of Bill's earlier success, it was again decided that entering college in the fall was the method of choice, with the same reservations that had attended Bill's entrance.

Eric's first year performance was no less encouraging than Bill's had been the year before. His first semester gradepoint average was 3.75, and his year gradepoint average was 3.59 (on a 4.0 scale), which included A's in general physics, honors calculus, and programming language. An unanticipated bonus was the disappearance of the adjustment problems which had marred Eric's junior high school years. The rebelliousness he had shown only a year earlier was gone, and he reports that he is extremely satisfied with his new situation.

Eric is now 15 1/2 and is well on his way to a distinguished B.A. with two major fields, mathematics and philosophy. There is every reason to believe that he will go on for a very early Ph.D., at 20 or 21, perhaps earlier, in mathematical logic. In his sophomore year he moved into a campus dormitory, and he seems to have adjusted extremely well to the huge jump from eighth grade to the first year of college.

Eric's case raises an issue which deserves closer attention. When individuals learn about the nature of our project, and specifically about Bill and Eric, we are frequently asked, "But have you thought about the social and emotional development of these students?" The answer is, of course, that for long periods of time we have thought about little else.

The possible disruptive effects of academic acceleration have been studied carefully by a number of researchers (Coombs, 1957; Oden, 1968; Pressey, 1949; Terman & Oden, 1947,1954). Later we will describe their studies in more detail, but the general conclusion seems to be that the disruption is not as great as many would expect. One aspect which seems to have been neglected, however, is the possible harmful effects on a highly precocious student's social and emotional development if he is forced to endure several years of academic boredom and intellectual frustration. Eric's case may indicate that this latter problem is not insignificant.

Another concern, which is often voiced in conjunction with the questions about social and emotional development, is that these students will be intellectually narrow because of their concentration on quantitatively oriented courses to the exclusion of the humanities and social sciences. This, too, is an important consideration. We certainly don't want to "program" students into a specialized area, blithely assuming that their greatest eventual interests must lie in the same fields as their strongest early abilities.

This danger is partially alleviated by the very nature of their test scores. For an eighth grader to do well on a college level achievement test, it is necessary for him to have done a considerable amount of work on his own in that subject. This is in and of itself a strong indication of deep interest in these subjects.

It has been suggested to us, on the other hand, that we <u>should</u> "program" these students into humanities and social sciences courses so that they may benefot from the exposure. Some who have suggested this, though, would object to a fine arts major's being required to take advanced calculus or some similar course

This may in fact be an illusory problem. Bill and Eric, and other students like them, are quite intelligent and typically have a fairly wide range of interests anyway. Eric, for example, has taken courses in psychology and philosophy, and Bill has done independent study in the history of art. There still exists the possibility that some students such as these might have somewhat undesirably narrow academic interests, and this indeed bears watching. But any rigid program requirements would seem unwise for students of this caliber.

We have been using phrases such as "these students", "students of this type", and so forth, without really defining the group that we have been talking about. True, Bill and Eric were "discovered" in consecutive years in the same general geographic area, but this does not necessarily mean that it is anything more than a very rare occurrence. Are there many students like Bill and Eric? We began actively seeking out mathematically and scientifically precocious students of junior high school age this past September, with the help of a grant from the Spencer Foundation. Dr. Julian Stanley is director of the project, and Mrs. Lynn Fox and Mr. Daniel Keating are project associates.

At first, using only informal techniques (teacher, parent, and peer referrals primarily), we discovered some very promising prospects. Three students discovered in this fashion, an eighth, a ninth, and a tenth grader, are taking a college course in computer programming this semester. The ninth grader, who is already accelerated one year, and the tenth grader will in all likelihood begin college full time in the fall. The eighth grader, who is also accelerated on year, will most likely wait until the fall of 1973 before entering college.

These students were identified from tests given in informal Saturday sessions during the autumn of 1971. The basic battery included the School and College Ability Test (SCAT), Level 1C, which is for admitted college freshmen, and a college level test of knowledge of general science (STEP II, Level 1A). We also gave the advanced Raven's Progressive Matrices when possible.

The score of the three boys who are taking the computer science course were very impressive. Of 50 quantitative items on the SCAT, the 12 year old eighth grader got 45 right, the 13 year old ninth grader, 48 right, and the 15 year old tenth grader, 49 right, which are the 95th, 99th, and 99th percentiles of admitted college freshmen. On the 75-item general science test, the eighth grader scored 64, which is the 97th percentile of college sophomores tested in the spring, the ninth grader 54, which is the 84th percentile, and the tenth grader 71, which is the 98+ percentile.

A number of other students who took the tests, but were not included in the project for various reasons, did nearly as well on one or both of these tests as these three students. We began to suspect that this was more than just an artifact of the tests we were using, so to secure data comparable to those we had for Bill and Eric, we sponsored a mathematics and science contest.

The primary purpose of the testing was to be more systematic and complete in our search for mathematically and scientifically precocious students of junior high age to work with. We offered sizable cash prizes for the high scorers in a math and a science test, and the contest was run in conjunction with the local Science Fair. There was no official screening of students wanting to take one or both of the tests, but we did recommend that the student's percentile ranks on nationally standardized tests (such as the Iowa Tests of Basic Skills) be at least above 95, and preferably 98 or 99. We also announced that the tests would be on a college level, and thus extremely difficult for most seventh and eighth graders.

Of the 526 students (seventh, eighth, and 13 year old ninth graders) who registered for the math test, 396 showed up. Of 226 science entrants, 192 came. (The depletion apparently resulted from the student's appraisal of the practice materials which we sent prior to the testing.) Many students took both math and science, of course. We used the Scholastic Aptitude Test, Mathematical (SAT-M), and the Math Level I achievement test (M-I) for the math contest, and the Sequential Tests of Educational Progress, Series II (STEP II) Science, Forms 1A and 1B for the science contest. We really didn't know what might result from administering such difficult tests to a large group of (mostly) gifted junior high students. Our inability as prognosticators was vividly demonstrated by our last minute rush to secure space and materials to test 500 people; we had originally anticipated little more than 100.

There certainly are a lot of quantitatively able junior high students around. On SAT-M, 89 students scored at or above 540, which is about the 80th percentile of male high school seniors, and 41 students scored 620 or above, which is about the 91st percentile. The total distribution is shown in Figure 1. On M-I, the situation was very similar: 35 at or above 540, about the 37th percentile of high school seniors with seven or more semesters of high school math, and 10 at or above 620, the 65th percentile. In table 1, you will see the SAT-M and M-I scores of the top [illegible]9 students.

The science test scores were also excellent. Adding the scores of Forms 1A and 1B together, we found that 27 students had scored 100 or higher (out of a possible [illegible]), which is the 73rd percentile of sophomores at a typical college tested in the spring. Continuing: 15 scored at or above 110, the 87th percentile; 7 above 120, the 94th percentile, and 2 above 130, the 98th percentile. Figure 2 shows the complete distribution and table 2 lists the [illegible]7 top scorers.

The implications are clear. There exists a not insignificant number of students who, even before they begin high school, already know most of the math and science which they will supposedly be "taught" in high school. This is not an entirely new revelation. Learned & Wood (1938) tested a large cross-section of high school and college students and discovered that "Fifteen per cent of these high school science specialists... have part scores in science superior to the science part score of nearly 40 per cent of the comparable college seniors who will teach [p. 43]."

Why then do we insist on locking these especially able students into curricular which are, for them, useless at best and almost certainly stultifying? That question alone could be the topic of a completely different study; the question we want to deal with today is, "How can we get these students out of the lockstep in the most beneficial way?" Let us hold that question while we make a short digression.

Upon closer inspection, figures 1 and 2 reveal a striking sex difference at the upper ends. There are no girls at or above 610 on SAT-M, while there are 43 boys, even though 44% of those taking the math tests were girls. The high scoring girl in science earned a 103 (out of 150); 22 boys topped that score. Thirty-two per cent of those taking the science tests were girls. We were quite disappointed with this particular result, because we had hoped to find at least several girls doing extremely well on these very difficult tests. It has long been known, of course, that by the end of high school there are major differences between males and females in the quantitative area, due to girls dropping out of math programs, but we had hoped that this would not have occurred, at least so drastically, in junior high school.

We have been speculating about this discrepancy, but we haven't yet looked closely at the auxiliary information gathered at the time of the testing (an interest inventory and a brief questionnaire). One possibility that is suggested by the results is the biological explanation of greater variability among males than females. If, for example, it is true that there are four times more male than female dyslexics, then perhaps the greater variability explanation has effects at both ends of the distribution of abilities.

But even if this were the case, it would be only a partial explanation. There are, after all, female dyslexics, and we would analogously expect to find at least a few very quantitatively able girls. The powerful hand of socialization is thus clearly seen in these data. As mentioned above, in order for a 12 to 14 year old student to do well on these tests it is necessary for him to have done much work on hi⌒ ⌒wn in these area. It hardly needs to be pointed out that little girls in our culture are not normally encouraged to spend their spare time readi math and science books.

Differentiation of ability by sex has been studied recently by Very (1967) and Aiken (1971). It is not our main purpose to look at these differences, but their strong appearance in our data demands that we give the topic some attention in the future.

To return from our digression, we ask again--what are we to do for these precocious, quantitatively able students? Although the percentage of such students is very small, the number throughout the whole population is probably sizable. Because of the method of selection of our sample, we can't make any firm predictions about the population. But for the sake of information, there are just over 80,000 seventh and eighth graders in the areas represented by the students we tested. The top 25 students, who clearly require very special educational facilitation of some sort, thus represent about .03% of the population. This is obviously a minimum estimate; it may be slightly (or even much) higher.

For the best of these students, as we can see from the cases of Bill and Eric, radical acceleration is almost certainly advantageous. The literature on academic acceleration is quite extensive, but there have understandably been no comprehensive studies of radical acceleration because of its rarity. What can be learned from these earlier studies?

In Volume IV of Genetic Studies of Genius, Terman & Oden (1947) discussed the problem of school acceleration: "If the child's intellectual welfare were the sole criterion, then promotion ought to be based primarily on mental age, since it is this factor that chiefly determines the intellectual difficulty of the school tasks one is able to master [p. 279]." As evidence for this statement, they submitted the following statistically significant comparisons for an accelerated group (A) and a non-accelerated group (NA) of the gifted children in the Terman (1925) study: more A's than NA's were graduated from college; more A's than NA's went on to graduate school (Terman & Oden, 1947, Ch. 20). Although this can not substantiate the worth of acceleration, it would seem to suggest strongly that it is not educationally detrimental.

One might argue further, however, that educational success is not a significant enough criterion. The "lack of experience" in certain school stiuations might catch up to the accelerates after they have finished school. Again, this does not seem to be a tenable thesis. In follow-up studies of the Terman (1925) gifted group, one by Terman & Oden (1947) and the other by Oden (1968), a segment was devoted to comparing the "most successful" (group A) and "least successful" (group C) members at the time of the follow-ups. The primary criterion was vocational success. In the 1947 follow-up, the average age at completion of grade school, high school, and college was reliably lower for group A. Further, "at all educational levels the A's were reliably more accelerated than the C's [p.321]." In the 1960 follow-up (reported in 1968), which re-selected the A and C groups, the C's were again significantly older at both grade school and high school. This agrees with Pressey (1949), who in a series of studies reported that "the total findings...indicate that early beginning and ompletion of college programs tend to make for success in c ege d in adult career [p. 73].

Educational and later success are not the only impo t criteria, however. As DeHaan and Havighurst (1957) sta ed it.

Still another serious problem is tha skipping seldo provides intellectual challenge for a child without accelerating him i o groups which are beyond his physical, social, and emotional stages development [p. 123].

Are they right? Let us consider some evidence. An extensive study of early college entrance funded by the Ford Foundation was undertaken in the 1950's. Coombs (1957) reported the overall conclusions: for talented students, one or even two years of academic acceleration (the ost undertaken in this study) was decidedly beneficial. When early entrants residing on campus were compared with equally bright control students, no major differences, either emotional or social, were found. Some minor problems of the early entrants during the first year quickly disappeared. The adjustment problems of the early entrants were not significantly greater than those of the control students.

Terman & Oden (1947) also realized that adjustment problems might have beset the accelerates among their gifted group. The data for accelerates versus non-accelerates were therefore reviewed, and their conclusion was that "the data reviewed give no support to the fairly widespread opinion that rapid promotion in school is detrimental to physical or mental health [p. 279]."

A major benefit of radical acceleration for those students who go on for Ph.D.'s is the possibility of beginning creative work at an earlier age than they might have otherwise. This may be crucial for the cause of productive research, given Lehman's (1953) study of Age and Achievement. The average age for creative achievement in the physical sciences if often less than the age at which Ph.D. degrees are awarded to would-be researchers in these areas.

Although radical acceleration has been and continues to be the method of choice for some extremely able students, it is clear that better bridging mechanisms need to be devised. The differences among these students are often as striking as the similarities, and it should not be assumed that all of them will cope as successfully with radical acceleration as Bill and Eric have. In addition, not all students of this caliber will be located so conveniently near a top level university.

There are a number of possibilities which could be considered. Released time or night school courses at college while continuing on to high school for one or two years would ease the transition for some students. Correspondence courses are a possibility for those who are not near enough to a good college to work out a commuting arrangement. Independent study (at which these students already excel) with the help of a once-a-week tutor seems to hold a good deal of promise. And there is always the possibility of special college "prep" schools attached to some major universities where high school and college courses would be taken concurrently. It should be emphasized that no single program will accommodate every one of these students; thus, individualized direction is essential.

In conclusion, it is clear that whatever alternatives are eventually found to be the best and most facilitative, they must be sought.

It is not fair to anyone, particularly the student with this level of ability, to continue unaltered in the present course.

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Table 1

High Scorers in Mathematics Testing

Rank	SAT-M	M-1	Date of Birth	School Grade
1	790	770	4-27-58	9
2	780	720	10-25-58	8
3	710	730	8-31-59	7
4 1/2	740	660	1-18-60	7
4 1/2	680	720	11-02-58	9
6	740	630	1-14-58	8
7 1/2	730	620	7-05-58	9
7 1/2	710	640	7-02-58	8
9	670	660	7-10-59	8

Note. -- College Entrance Examination Board Scholastic Aptitutde Test - Mathematical and Mathematics Level I Achievement test, converted scores, Rank based on total score.

Table 2

High Scorers in Science Testing

Rank	Score on Form Taken First	Score on Form Taken Second	Date of Birth	School Grade
1	68	69	8-31-59	7
2	64	66	1-14-59	8
3	64	64	10-14-58	8
4	64	63	1-10-59	8
5 1/2	60	66	11-24-58	8
5 1/2	60	66	10-25-58	8
7	61	61	7-10-59	8

Note. - Sequential Tests of Educational Progress, Series II, Science, Forms 1A and 1B. Rank based on total score; highest possible score is 150.

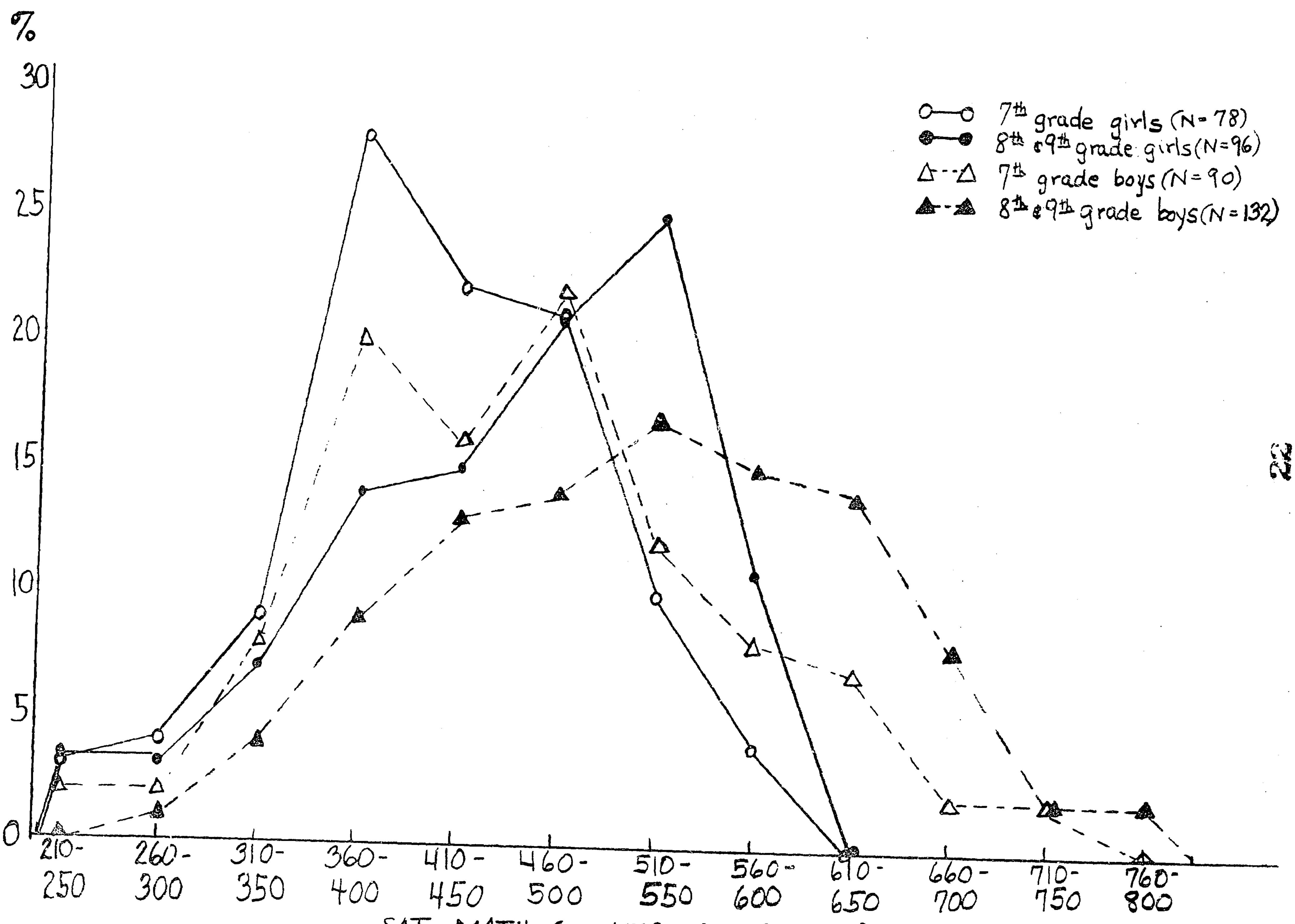

Fig. 1: Distribution of SAT-M scores of 396 students by percentage of equivalent group.

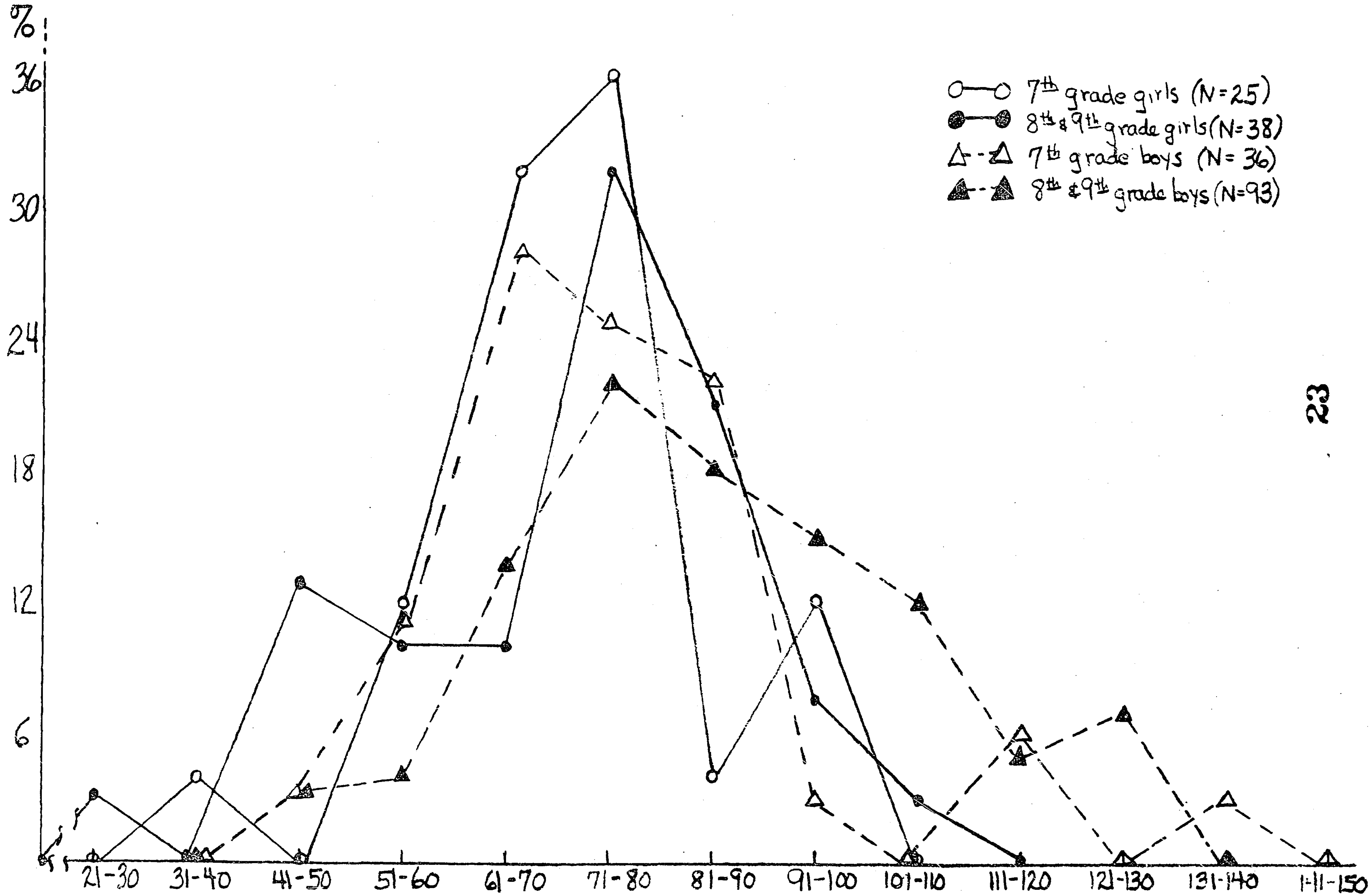

Fig. 2 ; Distribution of STEP II Science scores (1A & 1B) of 192 students by percentage of equivalent groups.