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## User-Friendly Science and Mathematics

### *Can it Interest Girls and Minorities in Breaking Through the Middle School Wall?*

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*Jacquelynne Eccles*

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#### ABOUT THIS CHAPTER

The middle school years are a critical make-or-break point for girls and minority students. Experiences they have, and decisions they make then, can effectively determine the options they will be prepared to pursue during the remainder of their education and the career choices that will be realistic for them. Given those consequences, it is essential for scientists to understand what exactly is going on in these middle school years that causes so many girls and minority students

to behave in ways that will severely limit the choices they will have in life. It is essential to understand because that is the first step in altering environments so as to assure the middle school years expand, not limit, opportunity.

Like the other researchers in this volume, Jacquelyne Eccles is an activist. Not content simply to understand, she wishes to cause positive social change. Her research points the way to changing middle schools so that they will nurture the aspirations of all children, particularly those most at risk during early adolescence. Beyond her research, Dr. Eccles has also given her time to connecting science with policy. Not only has she come to Washington to explain her findings to lawmakers. She has also chaired the National Science Foundation's (NSF) Committee on Equal Opportunity in Science, Engineering and Technology, a congressionally mandated body that helps the NSF create and monitor programs that promote the entry of women, minorities, and those with physical disabilities into science and engineering and that reports to Congress on the progress made by the Foundation. She has also chaired the Advisory Committee of the NSF's Directorate for Social, Behavioral, and Economic Sciences, the NSF division that supports most of the behavioral and social science research in the country, including much of the research relevant to girls and members of minority groups.

I'd like to begin this discussion with a joke. That is often a good ice breaker. But I can't. The issues we have to discuss are too serious. They are so serious that the American Association for the Advancement of Science (AAAS) is calling for a radical reform in science and math education from preschool through the university. Their report on the state of science education in the United States (Rutherford & Ahlgren, 1990) makes clear that many U.S. citizens, even those who are otherwise well educated, have little understanding of science or how it affects their standards of living nor do they possess the intellectual skills to act effectively on scientific matters that they encounter in their personal, professional, and civic

experiences. The report also emphasizes how especially critical it is that we recruit more women and minorities into science-related careers and into the teaching of science: With changing demographics in the next 20 years, and I won't bore you with all those statistics, it is very clear that we will not be able to meet our resource needs if we continue to rely primarily on the White male population, our source in the past for scientists. In fact, the situation is serious enough that unless more young women and minorities choose to concentrate in the natural sciences, jobs calling for specialized preparation may go unfilled.

The late Betty Vetter, who was a deeply valued member of the Scientific Manpower Commission in Washington, D.C., was among the strongest advocates of that same position. The data she produced has been extremely valuable to those in my field of research. She prepared numerous reports showing that if we project from right now and look at what is likely to happen over the next 20 or 30 years, we are facing a very serious problem in terms of lack of person power. And the only way we will solve that problem will be by recruiting minorities and women into science and maintaining them in such careers. We need to do that in addition to continuing to tap the white male talent pool.

What I find most disturbing about the AAAS report is that it is not "new news"—that is, we've known this for quite a while. I went to a talk that Vetter gave 10 years ago; she laid out the problem quite succinctly clear back then. And several past presidents of AAAS have chosen to focus their presidential addresses on this particular issue. I became interested in the question of why women and minorities do not choose to go on in math and science when I responded to a Request for Proposals on this topic from the National Institute on Education (NIE), which no longer exists. NIE targeted money to develop a body of research on that topic, which led to a large number of researchers becoming interested in it. And that was in 1977! The problem persists, however: Some of Vetter's last statistics show the number of women entering engineering peaked in 1985 at 18%; currently, it's back to 14% (Vetter, 1989). And, as most of you know, the number of college-aged students has declined over the last 10 to 15 years. So the pool from which we are going to draw our scientists, mathematicians, and engineers continues to shrink.

In my discussion, I will make five major points:

1. We have a very serious problem with the level of training U.S. students receive in math and science, and it is affecting the supply of adequately trained workers at all levels of proficiency. It is easy to focus on the few numbers who are entering bachelor's degree programs in math or science, but the issue is much more serious than that. The issue is that a very, very small proportion of our students are leaving secondary school with training in math and science adequate enough even to operate in the workforce, much less to specialize in those fields.
2. This problem is especially marked for minorities and for females, although for slightly different reasons.
3. For minorities, in particular, the problem is symptomatic of an even larger problem of inadequate education and high dropout rates. Their problem is not just in math and sciences but across the board.
4. The high dropout rate among minorities as well as the low involvement of women and minorities in math and science result in part from the educational climate and organizational structure prevalent in our junior high schools—in particular, low teacher sense of efficacy, person-unfriendly instructional practices in the math and science courses, ability level tracking, large size and bureaucratic organization, and inadequate adult-child personal contact.
5. Changes in these aspects of the middle-grade educational climate and organizational structure can ameliorate declines in both general school motivation and interest in math and science.

Before addressing these issues, let me give you (a) some background on how I became interested in this particular research problem and on why I have centered my research attention on middle schools, and (b) let me give you a brief picture of how serious our math and science problem is in the United States, particularly for women and minorities.

I was initially interested in the general question of sex differences in career choice. My interest began in college when I looked around (this was in the late 1970s) and realized there were four women in our

graduate program in psychology—and psychology is a field that attracts women! I began to wonder what was different about the four of us. Why were we there? Why were none of the women with whom I had gone to high school there?

Then I learned that the NIE had issued a request for proposals to look at why females weren't going on in math and science. I thought this was an excellent opportunity to try to translate my personal question into a research question. So I began to look at that question, focusing specifically on junior and senior high school.

The more I got into that work, the clearer it became that "something" was going on at the *junior* high school level. I saw that females were, indeed, less likely than males to go on in math and the sciences. But even more interesting was a fundamental developmental question: Why were very few people in *general* going on in math and science? The dropout rate was exceedingly large. Something was happening during junior high school that was affecting both males and females. Keep in mind that I was looking at white, middle-class school districts, not inner-city school districts suffering from major, horrendous problems. I saw that kids were "turning off" to math and science during this period of time—all kids, kids who were doing well and kids who were doing poorly. This made me very interested in what might be going on in junior high school. That is why the work I have done since has looked at this transition. So that's how I became interested in this problem and involved in the Carnegie report on education in the middle grades as well (Task Force, 1989):



### How Serious Is the Problem?

From data produced by Vetter (Task Force, 1988) let me illustrate the declining interest of students in the United States in studying math, science, and engineering. If we start with 7 million kids who are moving through the educational system, what can we predict if they follow the path that currently exists? By seventh grade, only 11% of the original group of 7 million express an interest in those fields. That means we've lost 89% of the kids by junior high school! By high school, that drops to 8%; by college entrance, 5%. The number who actually get B.S. degrees in math, science and engineering is only 3%, and only 1% go on to graduate programs in those fields. At the doctorate level,

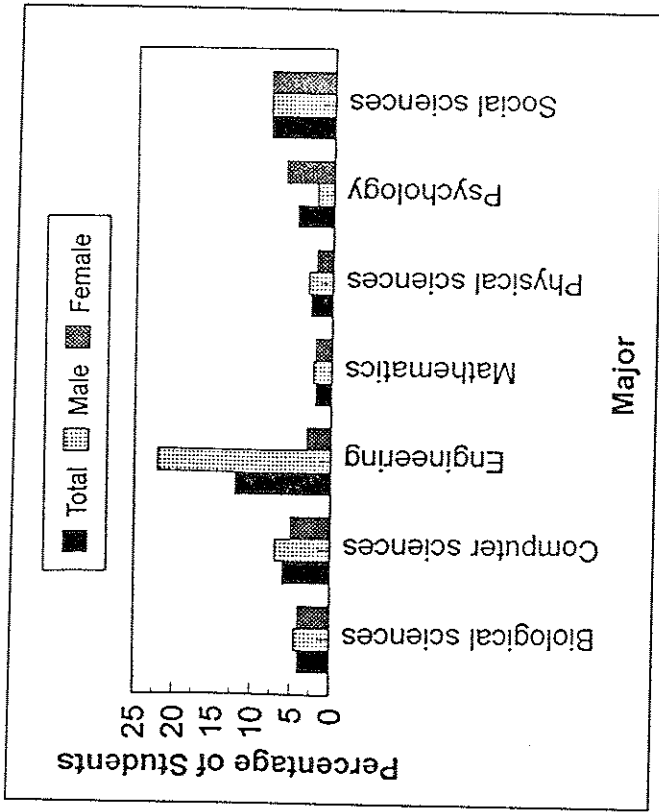


Figure 3.1. Anticipated Majors of College-Bound Seniors  
SOURCE: Adapted from Vetter & Babco (1987).

we're down to 0.15% of the original population. So that is the nature of the problem we're talking about. And the percentages are far less if we consider only minorities or women (or both)!

In 1982, the average high school graduate had taken 2.2 years of science and 2.7 years of math in the last 4 years of secondary school education. What this means is that, by tenth grade, most kids are finished with math and science. The situation, again, is even worse for minorities and women, especially with regard to advanced-level math and physical sciences. For example, on the average, only about 10% to 15% take introductory physics in high school. And, indeed, only 5% of Hispanics have had some exposure to physics in high school.

Figure 3.1, from Vetter's data (Vetter, B. M., 1981), illustrates the sex differences in the choices of the approximately 32% of college-bound seniors whose first choice was to major in math, science, or engineering.

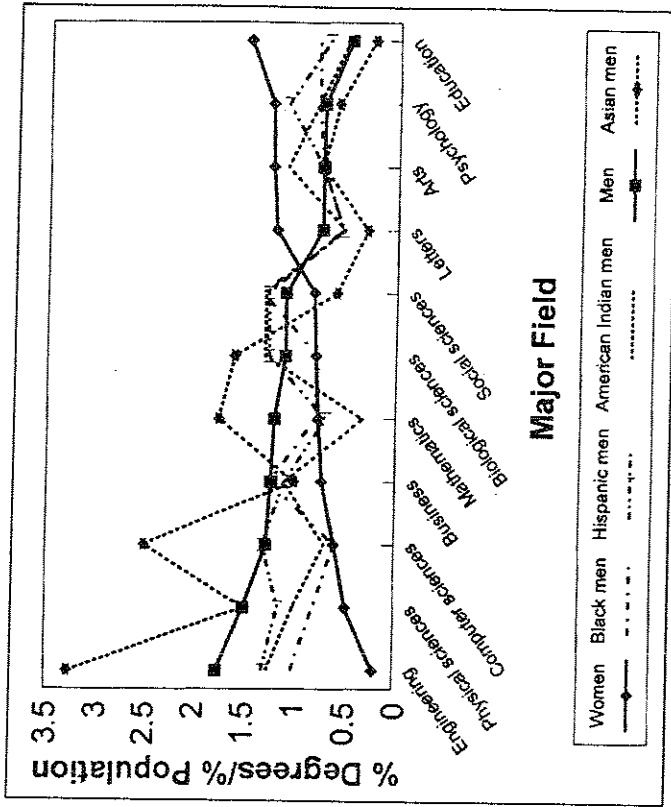


Figure 3.2. Majors for Bachelor of Arts Degrees by Gender and Ethnic Group of the Males  
SOURCE: Chipman and Thomas (1984).

Figures 3.2 and 3.3 are from the work of Chipman and Thomas (1984). The figures show the propensity to select major fields at the bachelor's level, showing the distribution of degrees in different areas by their proportion in the population—for men and women as well as for American Indian, Black, Hispanic and, Asian men (Figure 3.2) and women (Figure 3.3). If the proportion of degrees for a group were equal to its proportion in the undergraduate population, the line would be at 1.0.

But as I said, I think the problem is much more serious. The problem isn't just the declining number of kids who are going on to seek advanced training in math and science. And the problem isn't just that even fewer women and minorities are going on to seek advanced training in math and science. Nor is the problem only the shortage of scientific person power this nation faces as a result of the first two

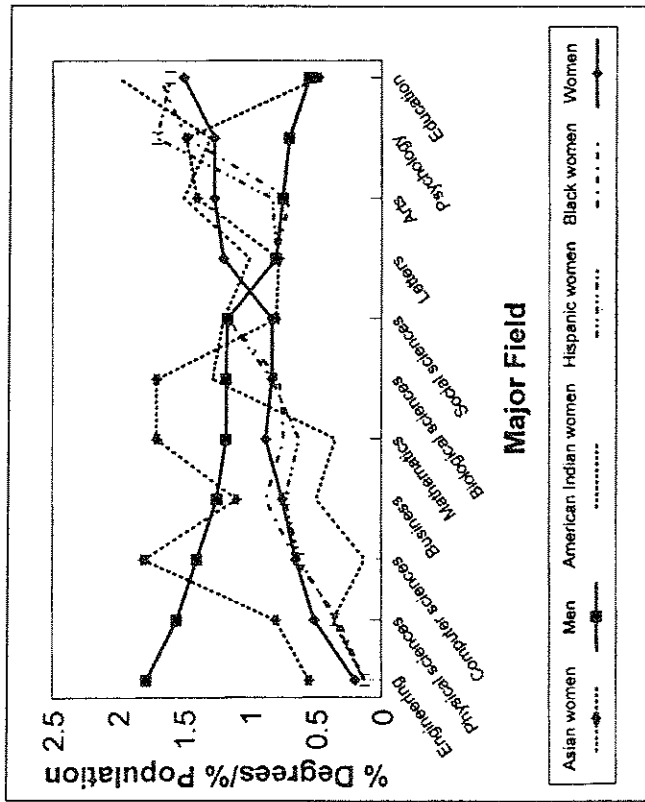


Figure 3.3. Majors for Bachelor of Arts Degrees by Gender and Ethnic Group of the Females  
SOURCE: Chipman and Thomas (1984).

problems. We have a more fundamental problem. Kids are not getting very good math and science training across the board:

- ◆ The latest round of National Assessment of Educational Progress (NAEP) tests, for example, suggests that kids today are still performing below the level that U.S. kids were performing in math and the sciences in the mid-1970s, and they are below all other industrialized countries.
- ◆ Blacks and Hispanics, by age 17 years, are testing 4 years behind their White peers in the sciences, although there has been an increment in their relative position.
- ◆ At age 17 years, less than one half of the kids in the United States have enough math knowledge as measured by the NAEP to take a job requiring technical skills or to take a job requiring them to

- learn technical skills on the job. Only 7% have learned enough math and science to take a basic-level course in science at college.
- ◆ In addition, according to the latest data, the gap between men and women in knowledge of math and science has more than doubled since 1970. And this gap is just as large among men and women taking the highest levels of math and science as it is for those taking lower levels.
- ◆ Nearly one half of young adults are unable to do well on tasks of even moderate complexity, such as balancing a checkbook or using a map.
- ◆ If we look at trends in SAT scores, we find a fairly consistent pattern across the years from 1976 to 1985: White students perform better than all other groups on the verbal scores, and Asian and White students perform better than all other groups on the math scores. None of our interventions over this period seems to have changed these inequities in performance.
- ◆ In the Hispanic population across the country, by age 13, close to 50% are already behind in school by at least 1 year.

That last point is an important one because falling behind in school is one of the best predictors of subsequent dropout. As soon as kids start to fall behind, especially in the junior high school years, they appear to be on a track that leads many of them to dropping out. Incidentally, dropout statistics are interesting because they do not make clear whether someone is a dropout for his or her entire life. At what point do you classify a person permanently as a dropout? For Hispanic groups between the ages of 18 and 21 years, 35% nationwide are not in secondary school and are not on a GED track toward graduating from high school. A proportion of these dropouts do eventually go back. The number is lower for Blacks and Hispanics than for Whites. It is much lower for females than for males.

Being a dropout increases the odds of being unemployed or if employed, that the employment is intermittent or at a job that is marginal or below the level of one's skills. The Carnegie Council's *Turning Points* summarizes the costs of school dropouts at national and personal levels (Task Force, 1989):

◆ MINORITIES AND GIRLS IN SCHOOL ◆

- ◆ Each year's class of dropouts, over their lifetime, will cost the nation about \$260 billion in lost earnings and foregone taxes.
- ◆ Each added year of secondary education reduces the probability of public welfare dependency in adulthood by 35%.
- ◆ In a lifetime, a male high school dropout will earn \$260,000 less than a high school graduate and contribute \$78,000 less in taxes. A female who does not finish high school will earn \$200,000 less and contribute \$60,000 less in taxes.
- ◆ Unemployment rates for high school dropouts are more than twice those of high school graduates. Between 1973 and 1986, young people who did not finish high school suffered a 42% drop in annual earnings in constant 1986 dollars.

Why is this happening? Why are we seeing these low levels of achievement, these high rates of dropout, and this lack of involvement in science and education?

Let me step back and talk about what I think is going on in the junior high and why I'm looking at that period in particular as being very important. As I said, we began doing our work looking at sex differences in interest in math and science. That was the primary question of interest to us.

What we did was to go out and gather surveys and sit in math and science classrooms in junior and senior high schools all over southeastern Michigan. At this point, I have assessed more than 3,000 kids, and my colleagues and I have looked at hundreds of hours of classroom instruction. We looked at the classrooms in a variety of ways. We used what we call a high-inference methodology, where we essentially sat in the back of the classroom for a week and formed an impression about what was going on. We also used low-inference techniques, where we looked at the teacher's interaction with every child in the classroom and reported exactly what went on, to see whether boys and girls were being treated differently in the math and science classrooms.

As I said, these are mainly White, middle-class students from 15 different school districts in southeastern Michigan. They come from families of low-middle to middle socioeconomic status. We didn't have a lot of minorities; we didn't go into the inner-city Detroit

◆ Eccles: Middle School Obstacles ◆

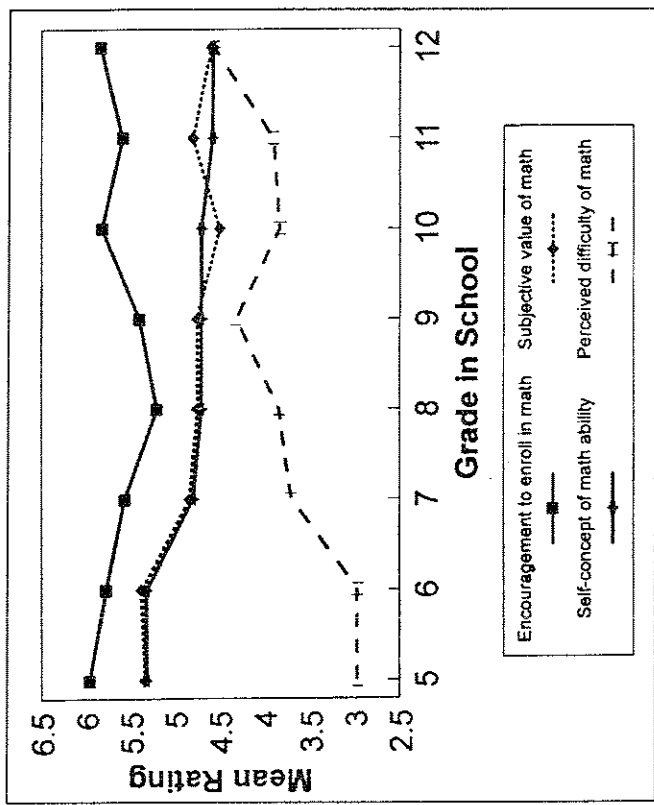


Figure 3.4. Grade Differences in Students' Attitudes  
SOURCE: Adapted from Midgey, Feldlaufer, and Eccles (1989b).

schools. We tried to pick schools without any major problems. These are kids who are headed toward college and headed toward being able to take advanced math. They have not had any difficulty. At the start of our studies, they had not been tracked down or tracked out of math classrooms. We asked them (a) how difficult they thought math was, (b) how good they thought they were in math, (c) how much they liked math and felt it was useful for their long-range goals (the subjective value of math), and (d) their perceived encouragement to enroll in advanced math. We asked them these same questions about English, and in English, we got no developmental trends: The kids remained positive toward English throughout secondary school. They felt good about their English abilities, and they didn't find English especially difficult. But in math, as you can see in Figure 3.4, we found a very different pattern. And again, what's important about this is that these kids are doing well in math.

As you can see, what we found is they get increasingly negative about math—they begin to see math as more difficult, they become less confident about their abilities, and so forth. Also, you'll note the dramatic break in the curves between sixth and seventh grades. That is the point at which you see the biggest change on all four curves. This was the first hint we had that something was going on in the junior high school. We have now replicated this in 12 different school districts. The pattern follows the same trend across school districts.

So the transition to junior high school becomes the critical point. We weren't initially interested in studying this transition. In fact, it never even occurred to us to study it! We used the junior high for sex difference reasons. We knew we would see these differences emerging at puberty—especially among the females who sprout breasts, start menstruating, get interested in boys, and so forth, at this age. We made sure we began looking at kids in elementary school so we could watch them move through this process of becoming more sex typed as they moved into adolescence. The data I described popped out at us. So we went back and checked, and, sure enough, in every district we were in, the kids went from sixth grade elementary school into seventh grade junior high school. This also means they experienced a building change and everything that goes with that building change. This then got us very interested in the question: Is it puberty or is it school change? Puberty and school change were co-occurring for these children between the sixth and seventh grades.

We went back to the literature to see if others were finding this same grade-level effect and if it was related to the transition. We started this work in the mid-1980s. We found that not very many people had looked at this question, so there was not a lot of evidence regarding the impact of the junior high school transition. Just as teachers specialize in secondary versus primary school, researchers specialize in childhood versus adolescence.

We had to piece together studies that looked at elementary school classrooms and studies that looked at junior high school classrooms. In the process, we had to compare very different methodologies—different measures of motivation, different measures of self-concept, and so forth. Studies usually reported that students were in the seventh grade—not what type of school they were in. So we didn't know if the kids were in a junior high school or a K-8 school (kindergarten

through eighth grade). We tried to go back and get that information from the investigators when we could. Even so, forming an impression of how general the findings in our data were was very difficult.

From this jigsaw picture emerged the following results, the following profile, of kids making the transition to junior high. The list represents our guess at the developmental changes in motivation that might be associated with the transition into junior high school:

A decline in general interest in school

An increase in extrinsic motivational orientation for school work (meaning the children are now working for a grade or because their teacher told them to—not because they like it, or want to master it, or like challenging material)

A decrease in intrinsic motivational orientation for school work

A decline in general self-esteem

A decline in confidence in some academic disciplines—and here, math and science yield a fairly consistent pattern of decline

A decline in the subjective task value attached to some academic subjects (math and science in particular)

An increase in anxiety and in the relationship of anxiety to school performance and intrinsic motivation—not only are they reporting greater anxiety, but anxiety appears to be having a debilitating effect on their performance

A decrease in the relationship between academic performance and confidence in one's academic abilities

An increase in confusion regarding the causes of one's academic performance—so at the same time their anxiety is going up (and anxiety seems to be related to how well they are doing), their sense of how good they are as people seems to be becoming less related to how well they are doing in school

An increase in self-focused motivation—the children are focusing on what indicators of performance mean about their personal abilities—so, for example, rather than using grades to determine whether they need to learn more to do better next time, they are using grades to tell them whether or not they have ability

An increasing endorsement of the view that academic abilities are stable

Now, let me show you some examples of the studies that are showing this—and I've picked the best. The graphs in Figures 3.5a, 3.5b, and 3.5c are from some work by Susan Harter (1981). She used the same measure across grade level. She pits two motivational orientations against each other. She says some kids like challenge, whereas others prefer easy work, and asks kids which they are. You'll note that over the period of time from Grade 3 to Grade 9, they become more and more likely to check that they prefer easy work as opposed to challenging work. And again, you see this dip between sixth and seventh grades. I called her, and she said that, in her school districts, students made the transition from elementary to junior high school between grades six and seven. Note also the decline in curiosity versus teacher approval as well as the decline and the dip between sixth and seventh grades on the desire for independent mastery versus doing it to please the teacher.

Harter does her work in Denver, Colorado. Denver recently shifted its school system from a junior high school model to a middle-school model. There is currently, of course, a big movement toward middle schools. What that usually means is that schools change their grade structure and not much else. In other words, kids move to middle school at the end of the fifth grade instead of to junior high school at the end of the sixth grade. Because it's easy to do, this is often how schools purport to incorporate the middle school philosophy. It may look like they're doing something, but they often don't go on to do the necessary work to create a new environment. The middle school philosophy is really very different from the junior high philosophy. To make that shift meaningfully requires a tremendous amount of resocialization. One cannot take the same teachers and principals who ran the junior high school and have them run a middle school the next year without doing major in-service training to change the nature of the environment. Presumably, Denver was going to do this retraining.

A Denver newspaper, however, came out with some very interesting statistics. It looked at expulsion rates for sixth graders. It compared the rate when sixth grade was the last year in elementary school with the rate the next year when sixth grade became the first grade in middle school. Expulsion rates increased dramatically in that period of time. We know that expulsion rates are one of those indicators of entering the dropout track and certainly of falling behind in academic

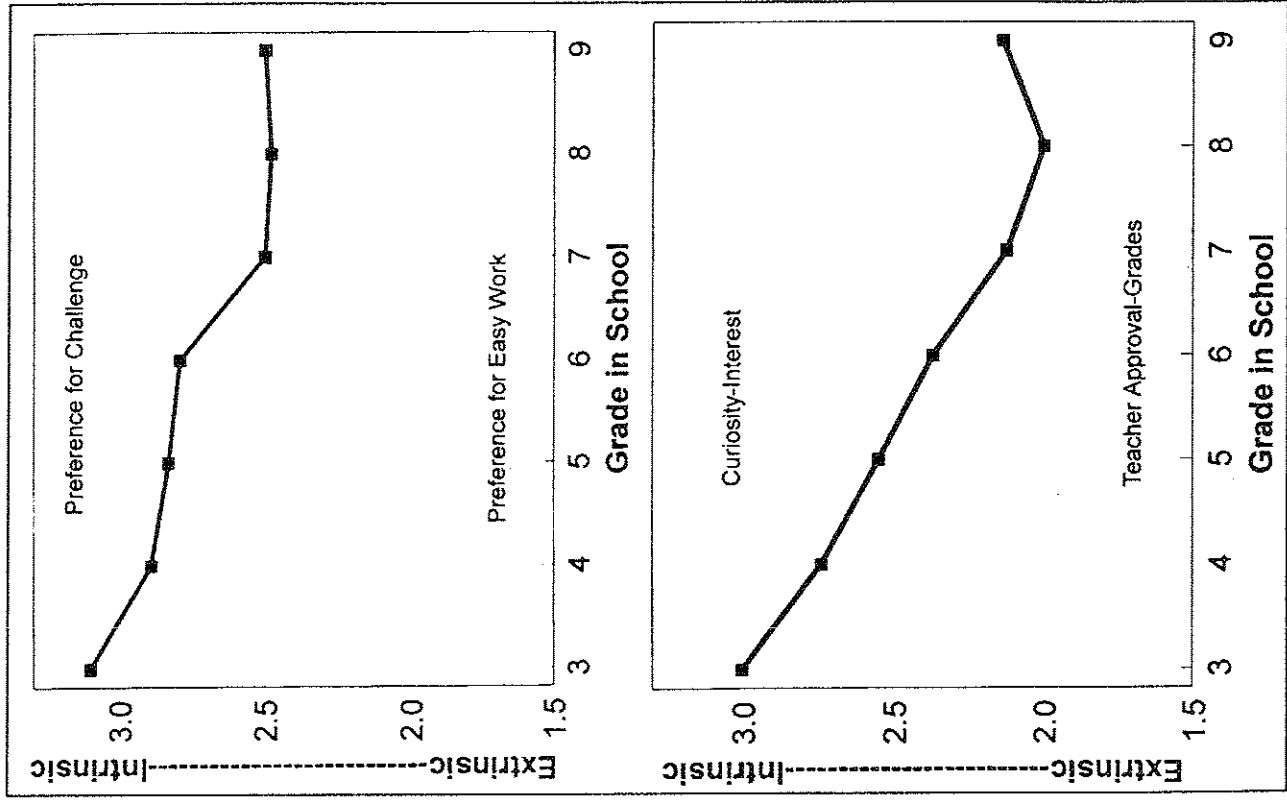


Figure 3.5. Grade Differences in Students' Motivational Orientation  
SOURCE: Harter (1981), reprinted with permission.



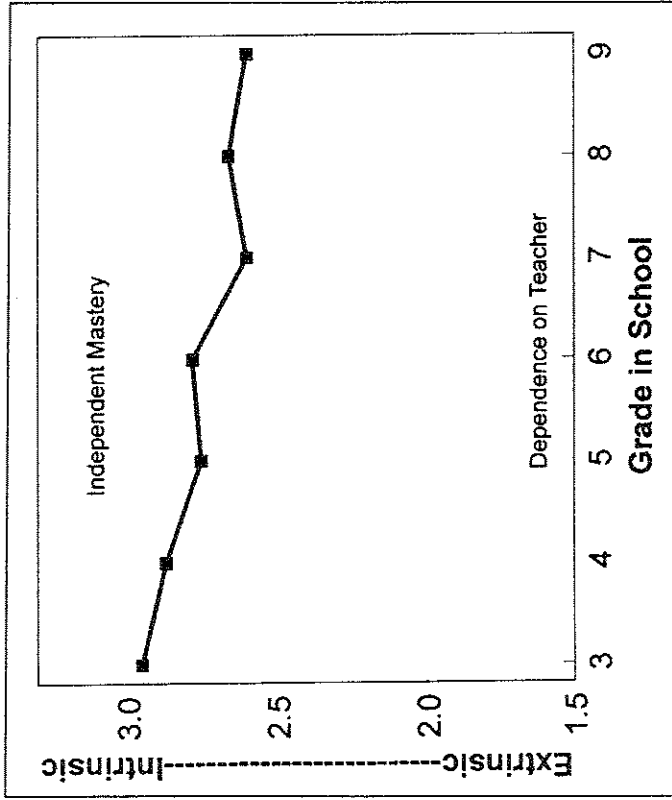


Figure 3.5c

1. Girls' self-esteem declines
2. GPA declines
3. Extracurricular activities decline
4. Leadership roles decline
5. Boys' sense of being victimized increases
6. Feelings of anonymity increase

These findings are neither unique to our school system nor only true of the current situation. Simmons and her colleagues (Blyth, Simmons, & Bush, 1978; Blyth, et al., 1983) have done this study in three different school districts spread over approximately the last 15 years. Their first study was done at the beginning of the 1970s. Simmons and her colleagues found the six effects I just mentioned fairly consistently. Some other effects vary by school district.



### And What Did We Find in Math Classrooms in Particular?

We have also studied changes in the school environment over the junior high school transition. In our work, we looked closely at what is going on in math classrooms in particular, and we followed the same children across time as they moved from sixth grade into seventh grade. The environmental changes that kids experienced with the junior high school transition that we observed in these math classrooms are these:

- Increase in extrinsic motivational strategies
- More rigorous grading practices resulting in lower average grades
- Increase in practices likely to focus students' attention on ability assessment—ability grouping, whole class instruction, normative performance-based grading practices, and competitive motivational strategies
- Increase in teachers' concern with control
- Decrease in teachers' trust of students
- Decrease in opportunity for student participation in classroom decision making

work. So, this wonderful shift that was to make the world better for these sixth graders resulted in more of them being kicked out of school for disciplinary reasons than had been the case under the old system!

Another study, work by Blyth and Simmons (Blyth & Simmons, 1978; Blyth, Simmons, & Carlton-Ford, 1983), looked specifically at those environments. They compared kids in a K-8 school with kids who were in a traditional junior high school. They looked at how involved kids were in extracurricular activity, for both males and females. In Figures 3.6a and 3.6b, you can see that moving to the seventh grade for the junior high cohort led to a decline in participation for both males and females. They became less involved with things that were going on in school.

In summary, Blyth and Simmons found the following negative effects of the structure of kindergarten through sixth grade (K-6) followed by Grades 7 through 9 versus the K-8 structure:

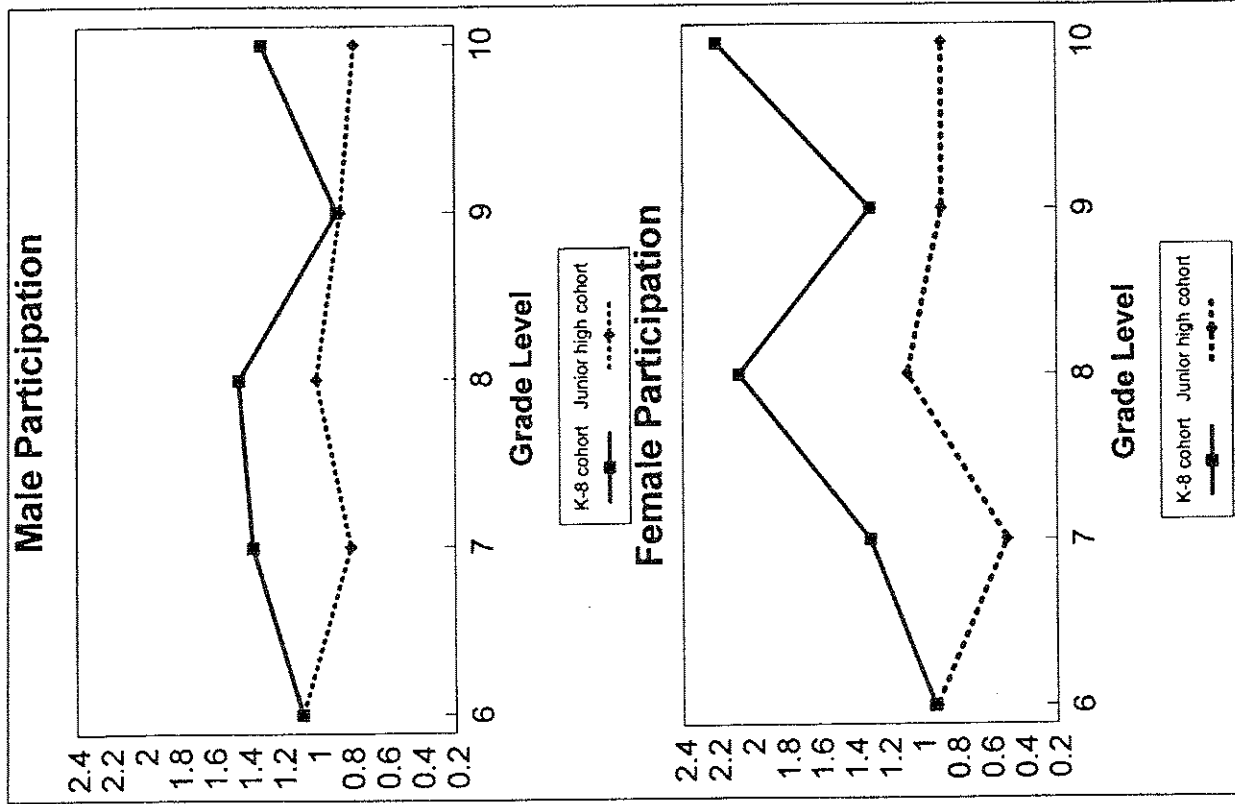


Figure 3.6a

Figure 3.6b

Figure 3.6. School Structure Changes and Student Participation in Extracurricular Activities  
SOURCE: Blyth, Simmons & Bush (1978), reprinted with permission.

Decrease in student autonomy

Initial decrease in the cognitive level of the tasks required of students  
Decrease in teachers' sense of efficacy

Imagine yourself making this type of transition. In the sixth grade, you had a teacher who trusted you, a teacher who gave you some autonomy and respect, and a teacher who felt confident about being able to motivate most everyone in the class. You were getting math material that was at a fairly complex level—proportions and so forth—and were getting a fairly good grade. You go to the seventh grade, and your grades drop, although the material is review. You thought you knew it last year, and now you're getting a lower grade than you got last year. Your grade seems to be based not on how much you learn over the course of the year but on your relative position to other kids in the class. Your teacher tries to motivate you primarily by stressing the need to do well on tests. You think you are growing toward adulthood and suddenly, you're trusted less and treated with less autonomy and respect. The material is essentially very repetitive in the way it is taught, and the classroom is very competitive. And you can't even choose where you sit! This is the modal experience that kids get in the seventh grade math classrooms.

In addition, your seventh grade teacher feels less efficacious than your sixth grade teacher. We asked the teachers in the sixth grade and the teachers in the seventh grade how confident they felt about being able to teach everyone in their class. What we found was—and this was the biggest difference we saw—that the seventh grade teachers were far less confident about their ability to reach everybody in their classes and far more certain that there were some groups of kids who would never learn math no matter what they did. This was true in spite of the fact that the seventh grade teachers were far more likely to be trained in math as their specialty.

Given this important difference, we wanted to assess its impact on the children's motivation. We broke the kids into two groups based on whether or not they did well in school when they were sixth graders, using their standardized test scores to make this judgment. We then looked at teacher efficacy. On the average, the teacher efficacy, as I said, drops from sixth grade to seventh grade. There were, however, some teachers at both levels with high and with low efficacy,

so we could do a natural experiment. We could look at kids who moved from a teacher with a lot of confidence in his or her ability to a teacher without confidence. And we could look at all combinations of those two levels of teacher efficacy.

When we looked at the kids who were doing well in school, we found that the nature of the change of their teachers' efficacy had no effect on their self-perception. But for the kids in the bottom half of the class, this change made a lot of difference in their motivation, as you can see in Figures 3.7a and 3.7b.

In the first graph, the solid lines are kids who moved from a high-efficacy 6th-grade teacher to a low efficacy 7th-grade teacher, which is the transitional pattern for 50% of the kids. We measured the kids' estimates and expectancies for their own performance—two times in the 6th grade and two times in the 7th grade. The transition comes between the second and the third wave. Waves one and two are in the 6th grade; waves three and four are in the 7th grade.

As you can see, when the kids in the bottom half of the class experience the transition and go from a high-efficacy teacher to a low-efficacy teacher, their confidence in their own math ability drops. But when the kids in the bottom half of the class experience the transition and go from a high-efficacy teacher to a high-efficacy teacher, they essentially show a straight pattern—that is, they continue to be confident in their math abilities. Unfortunately, only about 20% of the kids experience that pattern.

If you look at Figure 3.7b, you can see some positive consequences. Moving to the 7th grade is not inevitably bad. If you go to a high-efficacy teacher in the 7th grade from a low-efficacy teacher in the 6th grade, your self-concept goes up. Notice, however, the consequences of going from a low-efficacy teacher to a low-efficacy teacher: Self-concept continues a downhill slide. These graphs, again, represent the low-achieving students. We found the change in teacher efficacy had no effect on the high-achieving students.

### What's Going on in Junior High Schools That is Causing This Problem?

The short answer is, we don't know. Some, including the writers of the recent Carnegie report (Task Force, 1989), have talked about the size of the institution as a cause of the problem: the fact that it is large

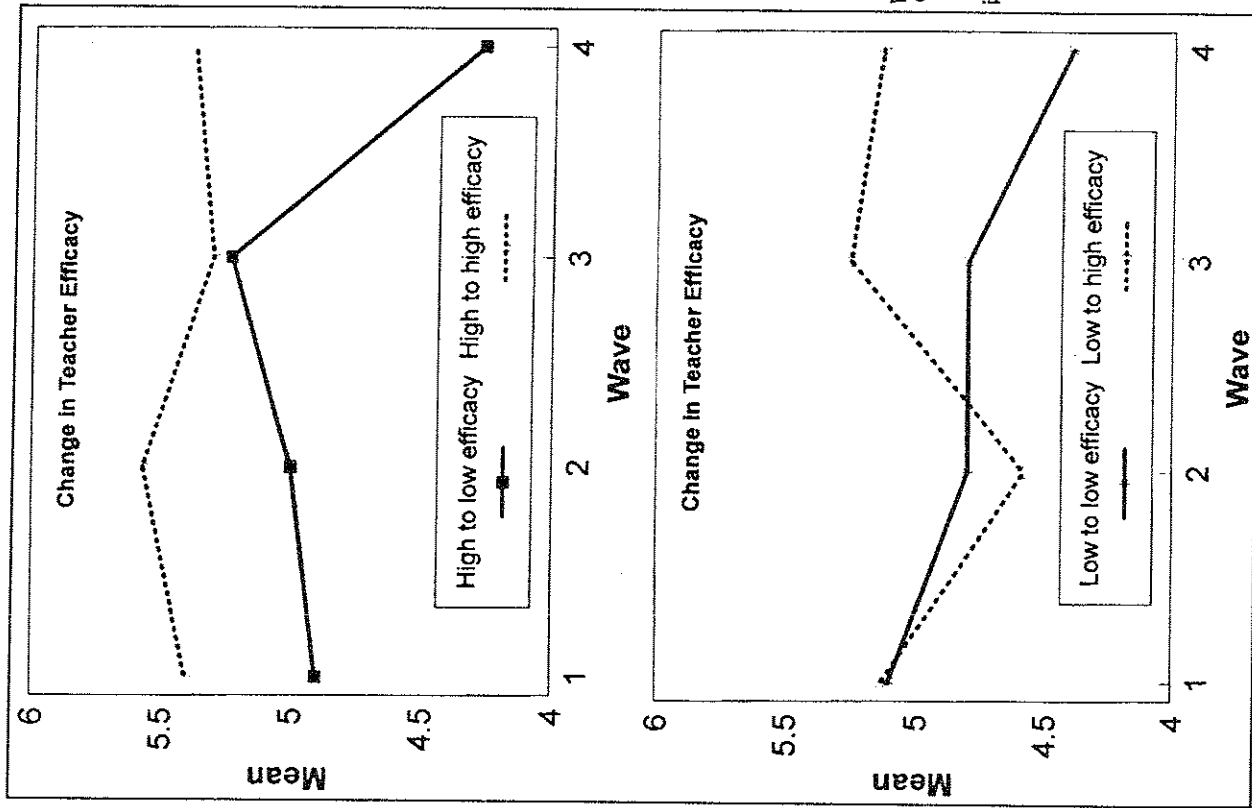


Figure 3.7. Changes in Low-Achieving Students' Expectations of their Performance as a Function of Changes in the Efficacy of Their Teachers. SOURCE: Adapted from Midgely, Feldlaufer, and Eccles (1989a).

and bureaucratic and teachers have to deal with so many kids at once so they don't get to know them. One of the big differences between the sixth grade in an elementary school and a seventh grade in a junior high school is that the 7th-grade teachers are confronted with having to teach 150 kids, which may be why they feel they have to control them so much. You can't get to know 150 kids, and if one kid is acting out, the only thing the teacher may feel he or she can do is to kick him or her out of the classroom. Teachers don't have the time or the personal commitment to know their students well enough to help them over their rough times.

To excel in math and science, in particular, students need that kind of contact. If kids don't understand math, they will quickly fall behind. If they don't feel they have a good relationship with their teachers, they won't feel like they can go for help. Consequently, they will soon find themselves hopelessly lost.

Another cause of the problem may be the stereotypes we have of adolescence. You know as well as I do the stereotypical view adults in our country have toward adolescents—they are out of control, they are "ornery." Some psychologists have even suggested that adolescents' rebellious behavior and obnoxious ways are inherited and reflect our primate ancestry! We asked teachers what they thought about adolescents, whether they thought adolescents were overwhelmed with hormones and incapable of learning at this particular period. Sure enough, many of the teachers believed this. And the longer they had been teaching in junior high school, the more likely they were to believe this about their kids. This may be less true of teachers who are in K-8 schools.

In the Carnegie report (Task Force, 1989), we tried to look at middle schools, taking some of these possible problem causes into account. What I want to emphasize is that even though the effect of the differences between grade school and middle school may have general effects across subject areas, the effects are more marked in math and science classes—that is, they have an even bigger effect on students' interest in those subjects. The Carnegie report suggests a whole series of alternative ways of thinking about middle school education. The recommendations are an attempt to answer this question: What kind of middle school education would you create for kids if you

**Table 3.1** Design for an Optimal Middle School

1. Create a community for learning and development.  
Small groups (150-300)  
Teams of students and teachers who stay together throughout middle school years (5 teachers per 125 students)  
An adviser for each student who meets very regularly with each advisee
2. Teach a common core of knowledge to everyone.  
Assume all students can learn the material.  
Provide some opportunity for specialization as well.  
Use cooperative learning and peer tutoring.  
Take an interdisciplinary approach for core courses.
3. Ensure success for all students.  
Do not track by ability.  
Use alternative methods to adjust to ability-level differences.  
Cooperative learning  
Cross-age tutoring  
Flexible scheduling to provide varying amounts of time to master material  
Multiple learning opportunities to get additional help
4. Empower teachers and administrators.  
Give teachers greater flexibility in designing instruction.  
Create building-level governance committees.
5. Improve academic performance through better health.
6. Reengage families in schooling.  
Give parents a meaningful role.  
Help parents help their children.
7. Connect schools with communities  
Involve all youth in volunteer youth service.  
Connect schools with informal teaching programs out of school.  
Involve local businesses and community as resources for teachers and students.  
Expand career guidance programs and apprenticeships.

SOURCE: Adapted from Task Force (1989).

could design one optimally? I would urge you to consider carefully the seven points that are suggested in Table 3.1:

The first recommendation deals with the issue of size. We need to reduce the size of groupings, or at least the scale, to make sure kids have adequate contact with teachers in a consistent manner over several years of time. So, whatever we do for this age group, let's not

put them into a factory. Let's put them into an environment where they can have close contact with a few teachers who get to know them well (the same way the elementary school teachers did), can monitor their progress, can work with them if they begin to fall behind, and can work with them if they show that they don't understand particular things. We can't tear down the junior high school buildings. What can we do instead? The Carnegie Task Force (1989) report suggests schools within schools. We're not going to be able to go back to elementary schools, but we can do schools within schools. We can create small communities within larger buildings and let that be the teaching-learning unit.

You'll note the recommendation not to track by ability. Consider this summary of findings on ability tracking:

Clear evidence of social class and ethnic group bias:

Biased tests used for placement

Biased screening and placement strategies

Parents less likely to protest low group placement

Clear evidence that tracking undercuts achievement of students placed in low tracks

Tracking creates stratified social groups that, in turn, contribute to higher dropout rates and lower interest in math and science for students placed in low-ability tracks.

Teachers clearly treat students placed in different ability tracks differently; usually, these differences serve to widen the achievement gap between students in the high-ability and low-ability groups.

Track placement in math in junior high school affects curricular stream placement in high school.

Very little upward migration across tracks, even though one reason for ability differences at the point of assignment is different maternal rates—that is, birth date correlates with track placement. Differences between Catholic school (CS) versus public school (PS):

In CS, 72% of students in academic track versus only 38% of students in PS

CS students greater than PS students in achievement, desire to go to college, and high school achievement

Association between social class and achievement is less for CS students than PS students

The recommendation in the Carnegie (Task Force, 1989) report that I think has the greatest potential in the short run for us in terms of math and science is to connect schools with communities. We have to get scientists into the schools, to work in the instructional system, not as full-time teachers but to work with teachers on how to make science and math exciting. I have sat in math and science classrooms, and I can tell you they are deadly dull—even things as interesting as the computer or science experiments can be turned into memory work. It's no wonder the kids' interest wanes by the time they get to the seventh grade. They have not been taught math in a user-friendly or person-friendly format.

The one thing that is very clear from all the work we did with girls in math and science is that the practices that work in math and science classrooms are hands-on instruction and the opportunity to work on real problems rather than made up problems. The students must come to view math and science as tools, not theoretical systems. Use them interdisciplinarily. Don't treat them as having nothing to do with history and literature. An objective should be to integrate science and math with other subjects so kids see the utility of science and math as tools in domains other than simply science and math. Don't use competitive instruction. Don't use drill and practice. Put kids into teams. Let them work together, instruct each other, and do the experiments together—that works for girls, it works for minorities, it works for everybody. But it's not often done.

I think an important way to achieve our goals in science and math education is to break down the barrier between the school and the community. The people who are best at thinking about science as a tool are the people who aren't using it as a theoretical system, who weren't trained in it as a theoretical system, but who were trained to use it as a tool to solve real-world problems. People who know how to use science and math this way need to come into the school systems and help the teachers teach science and math that way.

Last, let me give you three other summaries to take with you, Tables 3.2, 3.3, and 3.4:

**Table 3.2** Advantages of Small Schools, Particularly for At-Risk Students

- Lower drop-out rates (2-3 times lower)
- Less drug involvement (6 times less)
- Less truancy (2 times less)
- Lower suspension rates (2-3 times lower)
- Less victimization at school
- More involvement in school activities
- Higher average achievement levels
- Higher rates of positive academic engagement
- Higher average levels of self-esteem
- Higher average levels of perceived current opportunities and perceived future opportunities
- Higher average sense of efficacy
- Higher average sense of personal control
- Higher rates of parent involvement

SOURCE: Adapted from Task Force (1989).

**Table 3.3** Characteristics of Effective Classrooms

- Frequent use of cooperative learning opportunities
- Frequent use of individualized learning opportunities
- Infrequent use of competitive motivational strategies
- Frequent use of hands-on learning opportunities
- Frequent use of practical problems as assignments
- Active career and educational guidance aimed at broadening students' view of math and physical sciences
- Frequent use of strategies designed to create full class participation

SOURCE: Adapted from Task Force (1989).

**Table 3.4** Interventions to Increase Female and Minority Participation in Mathematics and Science

- Better teaching
- Female-friendly instruction
- Equitable access and experience
- Better counseling
- Course enrollment advice
- Career advice regarding
- Types of occupations
- Need to be self-supporting
- Better linkages with home
- Involve parents
- Inform parents of talents and relevant occupations
- Provide better role models
- Facilitate late reentry into nontraditional fields

**Q:** *I am interested in what you have to say about tracking as well as gifted-and-talented programs.*

**A:** In addition to the summary of findings on ability tracking I gave you, I can tell you that I have been looking at tracking in our data. We have some kids who were tracked in the seventh grade who are now seniors in high school, and we have seen what happens to them as a consequence of having been tracked in math in the seventh grade. It's a very interesting problem because it has a different effect depending on whether you are talking about students at the top or students at the bottom. The general data on tracking—let's leave out the gifted and talented for a moment—suggest the evidence is not very strong that the kids at the top benefit from having been tracked. But the evidence is pretty clear that the kids at the bottom suffer from

having been tracked. There is very little movement across tracks even though we know, for example, that one of the best predictors of being tracked is birth date. So, if you happen to be the youngest kid in your class, you are much more likely to be tracked down than to be tracked up—for developmental reasons. But once you're tracked, it's very difficult for you to move out of the track. Tracking was originally designed to help get kids matched with the material they're capable of dealing with. But what we find is that in the lower tracks, the teachers lower the level of the material and the amount they teach. At the end of the year, those kids are farther behind than they were at the beginning of the year. When we looked at our kids, what we found was that the kids who were doing poorly in the 6th grade and ended up getting tracked in the 7th grade (compared to the kids who were doing poorly who were not tracked in the 7th grade) were more likely to have dropped out of school by the 10th grade, less likely to have any interest any longer in math and science, and more likely to be in a general or vocational track program. Essentially, they were steered out of the college track and were more likely to be involved in all kinds of deviant activities outside of school. So I say that is a cost, and it is one that is too great.

The kids at the top who were tracked did end up looking a bit better for having been tracked. They were slightly more likely to be in science. So is the cost at the bottom end worth the gain at the top end? I think that's the real issue in tracking. What I would suggest instead is contained in the Carnegie (Task Force, 1989) report: Let's do cross-ability, cross-age tutoring because we know that kids gain by teaching someone else. One of the best things you can do for gifted kids is to give them the opportunity to teach kids who need to be taught rather than tracking them and heading them down a different route from their peers. One learns a great deal by teaching. Most of the tutoring evidence suggests that the people who gain the most are the tutors. So we don't have to be concerned that our gifted kids are suffering as a consequence of tutoring other kids.

The other best data are contained in the summary I gave you earlier. Catholic schools on principle do not track, and they try

to keep as high a proportion of their kids on the college track program as possible. They require that their students take college track courses and then require that they learn the material. Those schools have a much higher proportion of kids who end up on the college track when they get to high school, and those students have much lower dropout rates than non-Catholic-school students. And Catholic schools don't necessarily start with a higher caliber of kids. That is, their standardized test scores prior to entering such programs are not different from students who do not enter such programs.

**Q:** *I have believed for quite a while that we are primarily a product of expectations that others have of us.*

**A:** I agree that other people's expectations for us have a big impact. Those expectations come from everywhere—the media, our parents, our peers, our teachers. Comer (1990) specifically focused on the expectations of the schools. He said let's take an inner-city school—a hard-core school, one with a big dropout problem, a drug problem, and kids who are failing. He then tried to change the expectations of that school to see if kids' achievement could be affected. He very successfully did so. I have to emphasize that it does take a major shift in expectations by all authority figures. You really have to change the expectations of the school and of the parents. That really means you have to change the culture of that building. That's what I was talking about earlier. When you convert from a junior high school system to a middle school system, if all you do is shift the grade configuration, you shouldn't expect you are going to get any different outcome.

You can get kids turned around if you get the expectations changed. Indeed, you can get parents and teachers turned around as well. You can get them all on a track that says, what we're about here is learning math and science. *Everybody* can learn math and science. *Nobody* is not going to learn math and science in this building. Comer is successful at getting this type of change, although he has never focused particularly on math and science (Comer, 1990). But other schools have. There are

good examples of principals around the country who have essentially taken this as their mandate and have turned things around through expectations.

What is interesting about the middle school is one of the things I hope I got across to you: We have these stereotypes about adolescents. Then we put them all in the building and—sure enough—they act just like we think they are going to act. They act out, they are disinterested, they stare off, they can't be trusted, they get in trouble when they go to the bathroom. I think expectations play a big role here. We set up an environment that is very alienating and not very personal at exactly the time when they most need adults, when they most need close contact with people who care about them and will watch them and will help them down a very difficult road. There are people outside the school trying to sell drugs, and it is a really tough developmental period. At this critical time, we withdraw all the supports. Because they function under a different set of expectations, the kids in the old K-8s don't act that way.

**Q:** *Your statistics reflect cultural diversity of the student body, but I don't notice any attention to cultural differences in the recommendations. I wonder what study there has been on that. My impression of many of the school systems these days is that teachers are really kind of reeling. Most of the teachers are from the mainstream, and their student bodies increasingly are recent immigrants, who are increasingly diverse. The teachers are having to deal with these differences in learning styles, languages, and so forth. I wonder to what extent that would affect your research.*

**A:** I don't want to minimize the problems of teachers in the United States today. I just came back from Europe where I looked at some schools in Holland. The fact that we are committed to getting everyone through the school system and through the same school system makes our problem much more difficult and much different than the problems being faced in other countries. I think some of the recommendations that are being suggested by the Carnegie (Task Force, 1989) report will make the job easier. By downscaling, creating cooperative teams, and

moving power back to the teachers and parents, you potentially will be able to produce teams of people who are committed to these kids and are close enough to them to be able to tailor the instruction to their particular needs. That's one of the reasons the Carnegie report in particular didn't say to use this curriculum versus that curriculum. They specifically said that those decisions have to be made locally, taking into account the local needs. But what you have to do is get a team of people together to solve that problem who believe it can be solved.

The issue of getting more people interested in math and science is very different for women than it is for minorities. In the case of minorities, you're not just talking about developing an interest in math and science. You are also facing the more fundamental challenge to get them through the school system. And look at the problems: They attend schools where there is not a lot of money, schools that are beleaguered in other ways as well, schools where the teachers are overwhelmed. The problem in minority education is a much more difficult problem than getting girls interested in math and science. The girls, in many cases, are in the same schools as the White males who traditionally have entered math and science. So we begin with an advantage in solving their problem. We can make great headway just by changing the way math and science are taught in schools that have resources. But to tackle the problems presented by minority and immigrant education, we're going to have to do a lot more work. Not only does teaching have to be changed, but resources have to be allocated differently.

**Q:** *In many K-8 schools, the seventh and eighth grades are still treated as a different group within the institution. Based on your summary of the research, would you say it would be better to treat them just the same as the other classes?*

**A:** I think it is probably better to keep them together as a group so they aren't having different kids in every classroom. I think the critical issue is to let their social network stay together. Don't have them with so many different teachers that the teachers can't get to know them. Try to make it so they can have four



different teachers, but have those teachers, for example, stay with them for the sixth, seventh, and eighth grades. Or instead of having a seventh grade teacher and an eighth grade teacher, get a team of teachers: Have a math specialist, have a science specialist, have a reading specialist, but have them work with those kids for 3 years so they have a chance to know the kids well enough to keep close track of them. The issue is keeping close track of them, monitoring how they are doing both emotionally and academically, so they don't fall behind and feel so alienated that they can't go for help when they need it. That's what you have to do for kids of this age group.

**Q:** *You mentioned something about giving power back to the teachers. I wonder what you mean by that. I am one of those in a beleaguered school. I find that power is not being translated down into having teachers give more hours to instruction and less time to police duty. The community's interest doesn't seem to be in that direction. So I'm wondering what you mean by giving the power back to the teachers. It's hard to be a good teacher if you don't have the time to teach well. I wonder if perhaps the community just doesn't trust that teachers would use time to improve their teaching if they were given freedom from having to be cops.*

**A:** As one teacher to another, I'm sure that trust is lacking. The president of my university doesn't trust his faculty to use its time wisely! Again, the best example I can give you of giving power to the teachers is the Comer (1990) schools. What he means by it is literally to give the power back to the teachers. He creates teacher-parent-principal management teams. Not only is the team given the problems of the school, but they are also given the responsibility to deal with them—and the resources to take action. You don't have to increase the resources, but you have to give the management team access to the resources. The teams identify what the problems in the school are and what it will take to solve them. Clearly, this approach will initially take more time than teachers normally now spend. But once it is in place, it should be a lot more fun and rewarding than when someone else was calling the shots. You really have

to be willing to let go and let it happen. It's going to fail in some cases. But what more and more people are suggesting is that it is worth the risk because what we're doing right now is not working very well either.

There are a lot of barriers, and the Carnegie report (Task Force, 1989) does deal with some of these things. A whole set of these barriers has to do with trust—who trusts or does not trust whom. I think we have to break down barriers between teachers and parents because I think teachers don't want parents meddling in the schools just as parents don't want teachers meddling in the home. The first thing that always comes up is that one group wants to blame the other: The teachers blame the parents or the administrators, the parents blame the teachers or the administrators, the administrators blame the teachers and parents. At some point, you have to have these groups come together. They all have a vested interest—the kids. We can't worry about who is responsible for what. We have to solve the problem now, together. The other thing that the Carnegie report really talks about is breaking down the barrier between the school and the informal learning community. Learning doesn't start at the school gate. What you really have to do is get the community involved, which may eventually help solve the problem of the people who say, "I don't have anything to do with school so why should I put my money there." If they themselves are invested in what is going on at the school building, maybe they will be more sympathetic when it comes to voting. But it also means you can take advantage of some other resources. One tactic, for example, that the Carnegie report suggests is to have every child in the middle school involved in some kind of community service. Learning occurs on the job as well as at school. Schools need to work to get that coordinated.

**Q:** *Have you looked at the number of women who go into math and science who come out of single-sex schools? Is there a difference?*

**A:** Yes, there is a difference for women in the United States as shown in the data. But I should note that the sociology of single-sex schools is unusual in this country compared to other coun-

tries. So we have real problems trying to understand what the selection process was that got kids into the single-sex schools in the first place in the United States. In fact, the best studies on single-sex schools are done in Australia and to some extent England, where such schools are more clearly an option. Because they are a more routine option there, they don't produce a very biased, skewed sample as is the case here. And what those studies suggest is that girls are more likely to go on in atypical fields if they are in single-sex schools than if they are in coed schools. Males from single-sex schools, however, are more likely to come out sex typed and to hold more sexist attitudes than they would had they gone to a coed school. So the best option is to let girls go to single-sex schools but make all boys go to coed schools, if we go strictly by the data! I don't think we should go strictly by the data. The point I want to make is that we know enough now about how to teach math and science that we don't need to have single-sex schools. What seems to happen in single-sex schools is that those girls are more likely to get mentored and less likely to be hassled by their male peers about what they're doing. You can create an environment in a coed school that produces that effect for both the males and the females if you work at it. We can take what we learned from single-sex schools to design better programs in coed schools. For example, we can make sure there is an adequate number of females in classes—that is, no one is scheduled for isolation. We can make it clear to the teacher that equal amounts of time are to be spent with the boys and the girls, and that doesn't mean spending the time with the girls patting them on the back and spending the time with the boys giving them experiences with the equipment. We can make sure girls get leadership roles.

**Q:** *How do we compare internationally other than by achievement exam—for example, attitudes toward math and science?*

**A:** There is that same old problem of different studies using different measures, which makes it difficult to make comparisons across nations. We do know that the amount of sex difference in performance varies across countries, and we're not exactly sure

why. We only have the data; we haven't looked at the classrooms to see what is going on. We know that some cultures have a higher proportion of both males and females who go on in math and sciences than in the United States, and there clearly are differences in the expectations. For example, in many countries, it is expected that everyone will take physics; it's not an option, whereas in our schools it is. In some countries, one is expected to take 4 years of math, whereas here one is expected to take only 2 years to graduate.

**Q:** *Are you saying that if we make the change at the end of the 8th grade instead of at the end of the sixth, we'll minimize the change and not just delay it? And have you looked at all at the change from junior high school to high school?*

**A:** The data (Blyth, Simmons, and Bush 1978; Blyth, et al., 1983) clearly suggest that some of the negative consequences of the transition to junior high school are repeated at the transition to high school. What you have to realize is that kids who go to middle school or junior high school essentially have two transitions. They have to make a second transition when they go into high school. The Blyth, Simmons and Bush data suggest that K-8 kids maintain their advantage through the high school years. There is a transition effect, but they continue to maintain their advantage. It also appears that some of the kids who made the junior high school transition react even worse to the high school transition.

I would like to argue that it is not the transition that is most damaging. I don't think that whether kids stay in the same building or go to a different building is really what matters. What matters is what happens in those buildings. K-8s look better because seventh and eighth grades in K-8s are a better environment than seventh and eighth grades in junior highs. But you can produce a seventh and eighth grade experience in a junior high school building that has the positive aspects of the seventh and eighth grade experience in the K-8s. So again, what is important is the environment they move from and the environment they move to; it's not the transition. I don't think it

matters whether they make it in sixth grade, whether they make it in fifth grade, or whether they make it at eighth grade. All these arguments about how much it is in sync with puberty I think are probably missing the point.

**Q:** *Would you argue that high school students would also do better in a smaller environment?*

**A:** Yes. Don't we? And it's true for the transition into college. You would be surprised at how many people I talk to who have a child in a high school with 3,000 kids who tell me they want their child to go to a small liberal arts college so they can have close contact with their teachers. That's a transition at age 18 or 19 years, and they want to put their kids in a college that is smaller than the high school they had no objection to. Down-sized environments, we know from organizational psychology, are much easier to deal with. What is interesting is that we have known this for a long time. For example, we know that in organizations where someone has to manage many, many people that what seems to happen fairly regularly is that the manager begins to lose trust in the people he or she manages and assumes the workers are likely to try to get away with things and to try to make the manager look bad—exactly the things the 7th and 8th-grade teachers tell us about their kids. We shouldn't be surprised that we see these effects in adolescents because we know they are true for adults. Why would we expect anything more mature to happen?

**Q:** *My daughter went from a K-8 program into high school. The K-8 was good, but being a 9th grader in the same building with seniors (who are 18 or 19 years old) was enormously overwhelming for her. I think she would have been better off if she had one more year before the transition.*

**A:** I think it's amazing how many people think however they have it now is exactly the way it should be. My daughter switched from a junior high to a middle school, and she told me how awful it was going to be to have 6th-grade kids in her school! I really don't think the timing is all that critical. What is critical

is what happens on both sides of that shift. We need to make an environment that is on a human scale, that gives teachers and students an opportunity to know each other well enough that they can trust each other, especially given our stereotypes.

I go out and talk to people in school districts on a fairly regular basis. A lot of districts are trying to make a decision now whether to move to the middle school concept and so forth. It is a big issue, even more so now that the Carnegie report (Task Force, 1989) has come out. I am a sociologically oriented psychologist, so I think the structure of the environment has a tremendous impact. I think if I had to gamble on an environment that is likely to work, it would be the K-8. It has an environment that can't be produced in a middle school or a junior high school. The K-8 has the right structure. It's a smaller group of people. You don't have the same chances of it going wrong. You don't have so many things you have to watch for. But I tell people that and, amazingly enough, parents say to me I don't want 7th and 8th graders in the same building as my fourth grader. I remind them that their 4th grader is going to be a 7th and 8th grader someday and ask them if they don't want their child at that time to be in the best possible environment. But they still have this tremendous sense of protectiveness—to protect against the corruptive nature of those older children. Again, there is the stereotype that adolescents are somehow going to undermine and lead these kids down a bad path. The data don't suggest that is true. In fact, kids in 7th and 8th grades become a wonderful resource. They can do cross-age tutoring. They can have this really active role and feel they are cooperating with the teachers and administration, so they don't have to do graffiti on the walls. They really can become a resource and an asset to the building.

**Q:** *Why should the transition to middle school be more debilitating in math than in English or history?*

**A:** I think it's because the transition in the way math and science are taught is more dramatic than for English or history. My perception is that the way math is taught in the seventh grade—



◆ MINORITIES AND GIRLS IN SCHOOL ◆

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