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## Discussion Papers

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# REFORM OF SECONDARY VOCATIONAL EDUCATION IN THE UNITED STATES

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# Reform of Secondary Vocational Education in the United States

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**Abstract**

Large numbers of courses in vocational education are taken both by high school students who plan to work after graduation and by those planning to continue their education. In fact, more credits were taken in vocational education in 1982 and 1987 than were taken in all other subject areas.

The analysis described here suggests that a majority of those who complete their formal education with graduation from secondary school do not obtain jobs that are directly related to their vocational training. Factors contributing to this underutilization of learned skills are voluntary choices on the part of the individual; inability to find a job related to training; diversified course work--which means that some of the student's training is bound to be unrelated to subsequent work; supply and demand imbalance; and low incidence of jobs requiring occupational skills.

A study of achievement of mathematics skills demonstrates that vocational education can contribute to academic as well as vocational skills. Applied courses evidently enhance proficiency in mathematics.

These findings suggest that vocational education should be restructured to (1) incorporate aggressive job placement with training, for those students ready to commit to an occupational specialty while in high school; (2) provide broad occupational training for those not ready to commit themselves to a specific area while in high school; and (3) integrate vocational training with applied academic instruction.

**Reform of Secondary Vocational Education in the United States**

One of the major issues confronting secondary vocational education in the United States is the extent to which it should emphasize job-specific training as opposed to broad occupational training or even training that is of a very general (or transferable) nature. The case for job-specific training depends in large part upon the performance of secondary vocational education in placing students in jobs that utilize the skills they acquired in training. The case for more general vocational education depends on the currently unknown capacity of vocational education to contribute to the development of mathematics, communications, and other transferable skills.

In this paper, we report the findings of research conducted for the National Assessment of Vocational Education, mandated by the U.S. Congress. The paper is divided into three sections. In the first, we present an analysis of secondary academic and vocational course-taking patterns. In the second, we examine the labor-market utilization of secondary vocational education in the United States. Finally, we assess the potential of vocational education to contribute to the development of academic skills.

## PARTICIPATION IN SECONDARY VOCATIONAL EDUCATION

One of the striking characteristics of secondary vocational education is the breadth of student participation (see Table 1). As one might expect, however, work-bound students (students who expected to complete their education with high school) were the largest consumers of vocational education. Perhaps surprisingly, college-bound students also took substantial amounts of vocational education--not just introductory industrial arts and consumer and homemaking education, but occupationally specific vocational education. In fact, students planning to attend postsecondary vocational-technical training or college (20 percent and 62 percent of 10th-grade students) accounted for the vast majority of vocational credits, 26.5 and

**Table 1**

**Average Course Enrollments in Vocational Education by Postsecondary Plans, 1982 (Credits)**

| | Postsecondary Educational Plans | | | | | |
|---|---|---|---|---|---|---|
| | High School Graduate Only | Vocational/ Technical | Some College | College Graduate | Graduate/ Professional | All Students |
| Consumer and homemaking education | 0.86 | 0.89 | 0.69 | 0.46 | 0.36 | 0.64 |
| General vocational education | 1.20 | 1.07 | 1.06 | 0.85 | 0.72 | 0.98 |
| Occupationally specific vocational education | 4.00 | 3.85 | 2.80 | 1.86 | 1.48 | 2.76 |
| All vocational education | 6.06 | 5.81 | 4.55 | 3.17 | 2.56 | 4.38 |
| Share of all students (percent) | 18.2 | 20.0 | 18.7 | 23.7 | 19.4 | 100.0 |

Source: Gifford et al. (1989).

Note: On average, students take 20 credits in 4 years (9th through 12th grades) to graduate from high school. Each credit is equivalent to a one-hour, five-days-per-week course for a full year.

47.9 percent of all vocational credits, respectively.[1] In contrast, work-bound students (18 percent of 10th-grade students), despite their greater enrollments on average, accounted for only 25.2 percent of all vocational credits and only 26.4 percent of all occupationally specific vocational credits.

Despite a substantial increase in coursework taken in mathematics and science between 1982 and 1987, in both years credits taken in vocational education substantially exceeded credits taken in all other subject areas, including English, the largest academic subject (Table 2). Vocational course work was particularly dominant during the last two years of high school. Among noncollege-bound students in the class of 1982, for example, 11th and 12th grade credits in vocational education exceeded math credits by more than a factor of five. Similarly, college-bound students in the class of 1982 took almost twice as much vocational education as mathematics during the last two years of high school.

The large amount of vocational education taken by students with different educational and work goals presents two major challenges for secondary vocational education and federal policy. One challenge is adapting the secondary school vocational curriculum to provide a range of programs and courses offering different mixes of job-specific and transferable occupational skills to meet the needs of different students. A second major challenge invited by the large amount of vocational education taken by both work-bound students and students planning further education is expanding the contribution of vocational education to the academic education of students.

## THE UTILIZATION OF VOCATIONAL SKILLS

In this section we examine the extent to which occupationally specific vocational education is used by students in subsequent employment. The analysis is confined to students who terminated their formal education with graduation from secondary school. The analysis employs two new

**Table 2**

**Average Course Enrollments in Major Subject Areas 1982 and 1987**

| | Grades 11 and 12 | | Grades 9 through 12 | | | |
|---|---|---|---|---|---|---|
| | Noncollege-Bound Graduates 1982 | College-Bound Graduates 1982 | Noncollege-Bound Graduates 1982 | College-Bound Graduates 1982 | All Graduates 1982 | All Graduates 1987 |
| Vocational education | 3.77 | 2.04 | 5.82 | 3.24 | 4.38 | 4.21 |
| Math-related | 0.58 | 0.51 | 0.91 | 0.70 | 0.78 | [a] |
| Non-math-related | 3.19 | 1.53 | 4.91 | 2.54 | 3.60 | [a] |
| Mathematics | 0.56 | 1.26 | 2.18 | 3.16 | 2.62 | 3.07 |
| Science | 0.39 | 1.08 | 1.81 | 2.66 | 2.21 | 2.54 |
| English | 1.81 | 1.96 | 3.92 | 4.08 | 3.90 | 4.02 |
| Social studies | 1.81 | 1.89 | 3.25 | 3.34 | 3.21 | 3.33 |
| Fine arts | 0.64 | 0.72 | 1.38 | 1.51 | 1.43 | 1.40 |
| Foreign languages | 0.13 | 0.56 | 0.46 | 1.58 | 1.09 | 1.45 |
| Personal and other | 1.04 | 1.16 | 2.84 | 3.00 | 2.75 | 2.80 |
| All subjects | 10.14 | 10.66 | 21.67 | 22.57 | 21.61 | 22.84 |

Sources: Data from 1982 are from Horn and Meyer (1990a); data from 1987 are from Gifford et al. (1989).

[a]Data unavailable.

Columns may not add to totals due to rounding.

measures of skill use. The course utilization rate (CUR) measures the share of all vocational courses taken by students that are related to jobs that they eventually obtain. The skilled-jobs course utilization rate (skilled-jobs CUR) measures the share of all vocational courses that are related to the jobs that the students obtain only when those jobs require more than minimal skills (jobs requiring three or fewer months of total in-school or on-the-job training time). By definition, vocational courses that are related to occupations in the low-skill category are not considered as matched or utilized courses in the skilled-jobs CUR.

Only 38 percent of all occupationally specific vocational courses were utilized in skilled jobs during the fall of 1983 (see Table 3), approximately 16 months after graduation. For all jobs--not just skilled ones--the rate of course utilization is approximately 10 percentage points higher than the skilled-job rate.

Over time, the skilled-jobs CUR increased while the simple CUR remained stable. Comparing fall 1983 and fall 1985, the simple CUR increased by only two percentage points but the skilled-jobs CUR increased from 38 to 44 percent. Thus, the skilled-jobs CUR reflects the fact that, over time, students obtained jobs with greater skills, an issue that we will discuss later.

At both points in time, rates of skilled-jobs course utilization were substantially higher for women than for men--46 versus 33 percent in 1983, and 53 versus 38 percent in 1985. The higher skilled-jobs CUR for women was due, in large part, to their extensive enrollment in business education (56 percent of all their occupationally specific training) and the relatively high rate at which business graduates obtained skilled, business-related jobs: 53 percent in 1983 and 65 percent in 1985. For women, rates of skilled-jobs course utilization were also relatively high in health (71 percent in 1983) and occupational home economics, the second largest vocational subject for women (51 percent in 1983). By 1985, however, the skilled-jobs CUR in occupational home economics had declined to 32 percent.

**Table 3**

**Rates of Vocational Course Utilization by Subject Area**

| Vocational Subject | Share of All Specific Coursework | Skilled-jobs CUR | | CUR | |
|---|---|---|---|---|---|
| | | Fall 1983 | Fall 1985 | Fall 1983 | Fall 1985 |
| **Women** | | | | | |
| Agriculture | 2.9% | 40.0% | 26.9% | 40.0% | 26.9% |
| Business | 55.96 | 52.6 | 65.4 | 62.7 | 70.7 |
| Marketing | 9.85 | 22.5 | 38.3 | 63.8 | 46.3 |
| Health | 3.40 | 70.7 | 78.8 | 73.5 | 81.0 |
| Occupational home economics | 18.06 | 51.4 | 31.5 | 79.6 | 64.4 |
| Construction | 0.42 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mechanics and repairers | 0.94 | 7.0 | 35.2 | 7.0 | 35.2 |
| Precision production | 6.32 | 11.6 | 17.8 | 15.3 | 17.8 |
| Transportation | 0.03 | 0.0 | -- | 0.0 | -- |
| Technical and communications | 2.05 | 6.1 | 31.6 | 6.1 | 31.6 |
| All women | 100.00 | 45.9 | 53.0 | 61.1 | 61.8 |
| Sample size | | 699 | 667 | 699 | 667 |
| **Men** | | | | | |
| Agriculture | 8.70% | 45.5% | 43.6% | 47.0% | 45.1% |
| Business | 6.09 | 30.1 | 32.4 | 42.5 | 46.7 |
| Marketing | 4.75 | 35.5 | 20.9 | 45.2 | 27.5 |
| Health | 0.51 | 11.8 | 7.5 | 11.8 | 9.9 |
| Occupational home economics | 2.00 | 21.3 | 14.4 | 27.3 | 18.9 |
| Construction | 12.01 | 34.0 | 42.0 | 34.0 | 42.0 |
| Mechanics and repairers | 26.25 | 38.7 | 45.5 | 46.4 | 51.6 |
| Precision production | 37.43 | 27.1 | 36.0 | 34.5 | 41.8 |
| Transportation | 0.22 | 32.1 | 6.2 | 32.6 | 6.2 |
| Technical and communications | 2.04 | 8.3 | 22.1 | 20.1 | 22.4 |
| All men | 100.00 | 32.6 | 38.0 | 39.0 | 43.2 |
| Sample size | | 702 | 699 | 702 | 699 |
| Total | | 38.4 | 44.2 | 48.7 | 50.9 |
| Sample Size | | 1,401 | 1,366 | 1,401 | 1,366 |

Source: Meyer and Horn (1990).

Note: See Horn and Meyer (1990b) for a description of the crosswalk used to measure the relatedness of vocational courses and occupations.

In the marketing area, the third largest vocational subject for women, the skilled-jobs CUR was quite low, 23 percent in 1983 and 38 percent in 1985. A major reason for these low rates is that a large share of marketing students initially worked in low skilled-jobs. This explanation is evident from comparing the simple and skilled-jobs CURs for marketing. In 1983, the skilled-jobs CUR was less than the simple CUR by over 40 percentage points.

Uniformly low rates of course utilization were found for women in the traditionally male trades and industry subjects, substantially less than 20 percent in most cases. These courses accounted for only 8 percent of all vocational enrollments among women. This finding means that the few women who completed nontraditional training generally failed to obtain related jobs.

Low to moderate rates of course utilization were observed for men in all vocational subject areas (Table 3). Skilled-jobs CURs were less than 50 percent in all areas. In precision production, the largest vocational education area for men, the rate of skilled-jobs course utilization was 27 percent in 1983 and 36 percent in 1985. In mechanics and repairers, the second largest vocational area among men, the skilled-jobs CUR was significantly higher, 39 percent in 1983 and 46 percent in 1985.

In comparing rates of skilled-job course utilization among men and women, three points stand out. First, as previously mentioned, overall course utilization was much higher for women than for men. Second, course utilization among women tended to be highest in traditionally female subject areas: business, health, and occupational home economics, and lowest in traditionally male subject areas. Conversely, course utilization among men tended to be lowest in the traditionally female subject areas. Third, skilled-jobs course utilization increased over time for both men and women.

Although it would be unrealistic (and even undesirable) to expect percentage rates of course utilization to approach 100 percent, the estimates reported in some fields are low enough to call into question the efficacy of occupationally specific training in some subject areas.

## Incidence of Skilled Jobs by Occupation

Before examining the factors that contribute to skill underutilization, it is important to examine the incidence of low-, medium-, and high-skill jobs by occupational area. The incidence of low-skill jobs in fall 1983 was very high, particularly for young women (see Table 4). Thirty-four percent of all jobs held by women 16 months out of high school were in low-skill occupations, as compared with 22 percent for men. By the fall of 1985 (40 months out of high school), the incidence of low-skill jobs had fallen dramatically for women, to 22 percent. The incidence of low-skill jobs also declined for men, to 17 percent. For both men and women, the decline in low-skill jobs was matched by growth in high-skill jobs. In 1985, 38 percent of women and 44 percent of men worked in high-skill occupations.

The distribution of medium- and high-skilled jobs differed significantly, however, between men and women. A single occupational area dominated the skilled labor market for women: business. In 1983, medium- and high-skill business occupations accounted for 24 percent of all jobs among the women. By 1985, this figure had risen to 35 percent. In fact, virtually all of the growth in skilled jobs for women between 1983 and 1985 was due to the growth in skilled business jobs. In both 1983 and 1985, skilled jobs in marketing plus occupational home economics accounted for a total of 24 and 20 percent, respectively, of all jobs among women. Precision production, health, and technical and communications accounted for most of the remaining jobs.

Jobs for men were spread more evenly across all occupational areas but were more concentrated in areas that accounted for few of the jobs held by women, in particular, agriculture

**Table 4**

**The Distribution of Jobs by Occupational Area and Skill Level, 1983 and 1985**

| | Low Skill | | Medium Skill | | High Skill | | Medium Plus High Skill | |
|---|---|---|---|---|---|---|---|---|
| Occupational Area | Fall 1983 | Fall 1985 | Fall 1983 | Fall 1985 | Fall 1983 | Fall 1985 | Fall 1983 | Fall 1985 |
| **Women** | | | | | | | | |
| Agriculture | -- | -- | 0.98% | 0.81% | 0.25% | 0.25% | 1.23% | 1.06% |
| Business | -- | -- | 9.83 | 13.32 | 14.02 | 21.97 | 23.85 | 35.29 |
| Marketing | -- | -- | 11.05 | 7.74 | 1.33 | 1.93 | 12.38 | 9.67 |
| Health | -- | -- | 3.18 | 2.89 | 1.69 | 2.29 | 4.87 | 5.18 |
| Occupational home economics | -- | -- | 6.49 | 5.82 | 5.28 | 4.38 | 11.77 | 10.20 |
| Construction | -- | -- | 0.63 | 0.21 | 0.00 | 0.00 | 0.63 | 0.21 |
| Mechanics and repairers | -- | -- | 1.15 | 0.43 | 0.71 | 1.14 | 1.86 | 1.57 |
| Precision production | -- | -- | 6.22 | 7.74 | 1.42 | 1.84 | 7.64 | 9.58 |
| Technical and communications | -- | -- | 0.00 | 0.00 | 0.97 | 4.14 | 0.97 | 4.14 |
| Nonvocational | -- | -- | 0.23 | 0.43 | 0.50 | 0.38 | 0.73 | 0.81 |
| All areas | 34.05 | 22.31 | 39.78 | 39.39 | 26.17 | 38.30 | 65.95 | 77.69 |
| Sample size | | | 699 | 667 | 699 | 667 | 699 | 667 |

table continued

**Table 4, continued**

| Occupational Area | Low Skill Fall 1983 | Low Skill Fall 1985 | Medium Skill Fall 1983 | Medium Skill Fall 1985 | High Skill Fall 1983 | High Skill Fall 1985 | Medium Plus High Skill Fall 1983 | Medium Plus High Skill Fall 1985 |
|---|---|---|---|---|---|---|---|---|
| **Men** | | | | | | | | |
| Agriculture | -- | -- | 9.45% | 7.10% | 1.56% | 2.60% | 11.01% | 9.70% |
| Business | -- | -- | 5.26 | 5.96 | 5.23 | 8.50 | 10.49 | 14.46 |
| Marketing | -- | -- | 6.70 | 5.19 | 1.47 | 3.03 | 8.17 | 8.22 |
| Health | -- | -- | 0.23 | 0.23 | 0.26 | 0.27 | 0.49 | 0.50 |
| Occupational home economics | -- | -- | 1.04 | 1.64 | 5.69 | 2.60 | 6.73 | 4.24 |
| Construction | -- | -- | 6.86 | 5.89 | 3.22 | 5.86 | 10.08 | 11.75 |
| Mechanics and repairers | -- | -- | 3.46 | 2.94 | 8.13 | 7.66 | 11.59 | 10.60 |
| Precision production | -- | -- | 8.37 | 8.29 | 8.50 | 12.18 | 16.87 | 20.47 |
| Technical and communications | -- | -- | 0.00 | 0.00 | 0.47 | 1.58 | 0.47 | 1.58 |
| Nonvocational | -- | -- | 2.32 | 1.75 | 0.19 | 0.10 | 2.51 | 1.85 |
| All areas | 21.58 | 16.63 | 43.69 | 38.99 | 34.73 | 44.38 | 78.42 | 83.37 |
| Sample size | | | 702 | 699 | 702 | 699 | 702 | 699 |

Source: Meyer (1990b).

Note: The distribution of low-skill jobs by occupational area is not reported, since the specific occupational content of low-skill jobs is minimal.

(11 percent of skilled jobs in 1983), construction (10 percent in 1983), mechanics and repairers (12 percent in 1983), and precision production (17 percent in 1983). Business and marketing were important job areas for men as well as women. They accounted for 10 and 8 percent, respectively, of all skilled jobs among men in 1983.

In summary, among women, business dominated both the supply of occupationally specific training and the distribution of skilled jobs. Among men, enrollments tended to be highest in the following areas: agriculture, construction, mechanics and repairers, and precision production, areas that also accounted for a large share of jobs.

## Factors Contributing to Skill Underutilization

Five factors together account for the underutilization of vocational training: (1) voluntary nonplacement--students choose to work in occupations unrelated to their specific occupational training; (2) frictional nonplacement--students accept work in unrelated occupations because they are unable to find available training-related jobs; (3) enrollment nonconcentration (diversification)--if students take some coursework in unrelated vocational subjects, part of their training will always remain unutilized; (4) aggregate supply and demand imbalance--if the number of students trained in a particular field or subject area exceeds the number of job openings (at the market wage), some students will be denied access to training-related jobs; (5) low-skill job incidence--jobs that require only minimal occupational skills provide no opportunity for utilization of job-related occupational skills.

Our analysis reveals that voluntary and frictional nonplacement (we were unable to distinguish between the two with our data) was the major cause of training underutilization in 1983 and 1985, particularly among men (Table 5). For men in 1983, the estimates indicate that even if enrollment nonconcentration, supply and demand imbalance, and low-skill

**Table 5**

Factors that Account for Underutilization of Occupationally Specific Vocational Education

| Factor | Women Fall 1983 | Women Fall 1985 | Men Fall 1983 | Men Fall 1985 |
|---|---|---|---|---|
| Voluntary and frictional nonplacements[a] | 25.35% | 31.53% | 44.24% | 37.89% |
| Enrollment nonconcentration[a] | 13.78 | 14.29 | 22.88 | 22.07 |
| Aggregate supply and demand imbalance and low-skilled job incidence[a] | 28.68 | 9.68 | 24.18 | 21.50 |
| Aggregate supply and demand imbalance[b] | 7.52 | 3.27 | 10.60 | 11.41 |
| Low-skilled job incidence[b] | 21.16 | 6.41 | 13.58 | 10.09 |
| Skilled-jobs CUR | 45.90 | 53.00 | 32.60 | 38.00 |

Source: Meyer (1990b).

[a]The factor aggregates in rows 1, 2, and 3 interact in the determination of the skilled-jobs CUR. Specifically, the product of one minus each of the three factors (dividing each of the factors first by 100) equals the skilled-jobs CUR. For example, for Fall 1983 (1 - .2535) * (1 - .1378) * (1 - .2868) = .4590 = 49.5%. See Meyer (1990b) for further discussion.

[b]The aggregate factor in row 3 is the sum of the factors in rows 4 and 5.

job incidence had been eliminated, course underutilization would still have been great. Unrelated placements were also large for women, and rose over time.

But low-skill job incidence, enrollment nonconcentration, and supply and demand imbalance also contributed to course underutilization, although the magnitude of these factors differed significantly for men and women and over time. For women, for example, low-skill jobs was a major reason for course underutilization in 1983 (21 percent), but a relatively modest reason by 1985 (6 percent). For men, enrollment nonconcentration (not taking a coherent group of courses) was a consistently large source of course underutilization (23 percent in 1983). For men and women, the least important source of course underutilization was aggregate match of training supply and available jobs.

Our diagnosis of the sources of course underutilization leads to the following immediate conclusions. First, the fact that unrelated placements appear to have been so pervasive indicates that schools and employers need to do a much better job of placement, helping students get skilled, training-related jobs. If this proves to be an impossible task, then secondary vocational education will need to assess carefully the degree to which it should offer occupationally specific training, as opposed to more general occupational preparation.

Second, the fact that voluntary nonplacements appear to be so large indicates that many students enroll in occupationally specific training without a strong commitment to use their training in subsequent employment. It is likely that these students are not yet ready to select a specific area of skill specialization. Students should have additional vocational options from which to choose or should postpone selecting an occupational specialty. Ideally, students who are ready to select a specific area of skill specialization should have access to high-quality occupationally specific training coupled with aggressive assistance in job placement. Students who are not yet ready to specialize should have access to equally high-quality broad occupational and general vocational education. The general point is that secondary vocational education needs to provide an array of curriculum options that reflect the diverse needs and interests of its clientele.

Finally, schools need to take steps to accelerate the placement of high school youth into skill-demanding occupations. We believe that students would be much more likely to obtain skill-demanding jobs if they had strong academic and occupational skills. Further, it is likely that students would be stimulated to work harder and learn more if they faced the prospect of obtaining jobs that made full use of their academic and vocational skills right out of high school. If so, schools should approach the challenge of raising the skill levels of youth jobs by: (1) improving the academic and vocational rigor of vocational education; (2) ensuring that all high school students, even those ready to select an occupational specialty, develop strong academic skills; (3) working with employers to place adequately prepared students in skilled jobs; and (4) designing vocational programs to meet the needs of skill-demanding employers.

## DEVELOPING ACADEMIC SKILLS THROUGH VOCATIONAL EDUCATION

This section examines the role of vocational education in the provision of mathematics skills. The belief that vocational education can contribute to students' academic skills is based on the observation that the applied, often "hand-on" approach to instruction in vocational education stimulates student interest in school. If they are effective, applied courses could complement or substitute for traditional academic courses as a means to learn basic academic skills. We focused on mathematics learning not only because labor market studies have shown that mathematics proficiency is a major determinant of productivity, but also because mathematics achievement for all students is a high priority for American education policymakers (Bishop, 1988).

The analysis examines the growth of mathematics proficiency among students in the last two years of high school, depending on the credits they earned in 19 different mathematics and math-related courses. In addition to traditional mathematics courses, such as algebra and geometry, these courses include applied math, math-related vocational education (e.g., electronics, drafting, accounting, and agricultural science), and math-related science courses (chemistry and physics). The 19 courses span a continuum that includes standard mathematics as well as a wide range of courses that may involve applications of mathematical tools and concepts.

As we discussed earlier, enrollments in vocational education differed significantly between college-bound and other students, although both groups took more vocational education than mathematics. Vocational enrollments were especially large for students not bound for college. Math-related vocational courses accounted for approximately 18 percent of all vocational courses for all students (Table 2).

The fact that noncollege-bound students enrolled in few math courses raises a concern about whether these students developed adequate mathematics skills while in high school. In fact, college-bound students, on average, scored nearly twice as high as noncollege-bound students on a national standardized math test (Horn and Meyer, 1988). In addition, between 1980 and 1982, college-bound students increased their math scores substantially more than non-college-bound students (2.71 versus 1.08 gain points).

Our analysis found convincing evidence that mathematics skills can be learned outside of traditional mathematics courses (see Table 6).[2] While the effects of applied mathematics and specific vocational math are substantially higher for the college-bound than for the noncollege-bound group, the contributions of traditional math and math-related science courses are nearly identical for both groups. (Although the contribution of traditional math courses to math gain varies by type of math course, such as pre-algebra, algebra I, or geometry, the average credit-weighted contribution of all traditional math courses is approximately 1.4 for noncollege-bound and 1.5 for college-bound students.) The disparity in the effects of applied math courses for

**Table 6**

Estimates of the Contribution of Traditional Mathematics and Applied Mathematics Courses to Growth in Mathematics Proficiency

| | Noncollege-Bound Students | College-Bound Students |
|---|---|---|
| Traditional Mathematics | | |
| Basic math | ª | ª |
| General math | 0.26 | 0.96 |
| Pre-algebra | 2.12** | 1.45** |
| Algebra I | 2.47** | 2.29** |
| Geometry | 2.07** | 1.15** |
| Algebra II | 1.96** | 1.76** |
| Pre-calculus | 1.53** | 1.24** |
| Calculus | ª | 1.21 |
| Math Applications | | |
| Applied math | 0.63* | 1.36** |
| Specific vocational math | 0.03 | 1.70** |
| Chemistry/physics | 0.88** | 0.80** |
| Math-related vocational education | 0.22* | -0.04 |
| Sophomore mathematics test | 0.93 | 1.00** |
| Sample size | 4,448 | 6,513 |

Source: Horn and Meyer (1990a).

Note: The values reported in the table represent the number of additional points a student earns on the 38-point math test, on average, for each credit taken in the course category indicated.

ªThe number of participants was too small to generate statistically reliable estimates.

*Estimates statistically significant at the 0.05 level or higher.
**Estimates statistically significant at the 0.01 level or higher.

college and noncollege-bound students may mean that the applied math courses taken by noncollege-bound students are pitched at too elementary a level.

Math-related science courses (chemistry and physics) make surprisingly large contributions to math proficiency for both noncollege and college-bound students: on the order of half the effect of geometry or advanced algebra. These results provide the strongest evidence that mathematics can be learned through application.

The results for math-related vocational education also provide support for learning through application, although the effectiveness of these courses was limited to noncollege-bound youth. We estimate that five credits of math-related vocational education would increase the mathematics proficiency of noncollege-bound students by 1.10 points. An increase of this size would double the average two-year increase in math scores for the noncollege-bound group. Enrolling in five math-related vocational courses is not unrealistic given that noncollege-bound students in our sample took an average total of 5.7 credits in vocational education between grades 9 and 12. Of course, since these courses comprise only 18 percent of the current vocational curriculum, a major expansion of math-related vocational courses would be needed to enable most noncollege-bound youth to take a program rich in math-related vocational education. The lack of effects on math achievement of math-related vocational classes for college-bound youth suggests that math-related vocational courses, as structured in the early 1980s, provided fairly low-level applications of mathematics.

In summary, our findings provide strong support for the idea of applied learning in mathematics. They also demonstrate, however, that major changes are needed to enable high school vocational education to contribute substantially to the development of students' mathematics skills.

## CONCLUSIONS

The evidence presented in this paper strongly suggests to us that American secondary vocational education needs to be restructured in order to pursue the following four missions. First, occupationally specific training with aggressive job placement should be available to those students who are ready to commit to a specific area of skill specialization such as business, construction, or health. Training of this type should generally be deferred until the last one or two years of high school in order to provide students with an opportunity to develop the academic and broad occupational competencies needed to master advanced occupational skills, and to provide students with as much time as possible to select an occupational specialty while in high school (if they select one at all).

This type of training would generally be appropriate primarily for students intending to work after completing high school and ready to commit to an area of skill specialization. Hence, we expect that occupational-specific training would not be the dominant form of vocational education in most high schools. On the other hand, we believe that a slimmed-down program of occupational-specific training, with a clear mission to prepare and place students in training-related, skill-demanding jobs, would be more effective than the present programs, on average.

Programs of occupationally specific training should maintain close ties with prospective employers. In fact, it would seem desirable to offer (or require) students enrolled in occupationally specific training the opportunity to actually work in training-related jobs during the summer between their junior and senior years and during their senior years, perhaps as part of structured work experience/cooperative education courses. As is the case of apprenticeships, some students may naturally obtain jobs as a result of structured work experiences. To facilitate the placement of other occupationally trained students, schools must make job placement a major priority. This is essential because the best evidence to date indicates that the value of occupational-specific training is considerable if it is "used" in training-related jobs, but limited if it is not. In order for occupationally specific training to exist as an attractive option for students, the probability of subsequently utilizing the training must be reasonably high--substantially higher than the estimated skilled-course utilization rates reported earlier.

Finally, many schools, even those with access to area vocational centers, lack the students to be able to offer a full range of occupational specialties, particularly if, as suggested, occupationally specific training is not the dominant form of high school vocational education. This suggests the importance of exploiting economies of scale through shared training programs among different high schools (e.g., area vocational-technical centers), joint high school and postsecondary programs (joint with proprietary and public vocational-technical schools, community colleges, four-year institutions, and adult education programs), and cooperative training programs with business and labor (e.g., apprenticeships). Cooperative ventures of this type are not uncommon in vocational education. Flexible financing schemes, such as student vouchers for occupationally specific training, could help to facilitate these training alternatives when needed.

Second, <u>broad occupational training</u> should be available to students as preparation for subsequent occupationally specific training at the secondary or postsecondary levels and as a job-oriented alternative to high school specific occupational training. Although our evidence indicates that many high school students are not yet ready to commit to an occupationally specific area while in high school, it seems likely that at least some of them would be prepared to select a broad occupational area, for example: business, management, and marketing; manufacturing and machine operations; or services. There is a need to develop new broad occupational courses that distill and unify the common skills shared by jobs within such broad occupational areas. The popular "Principles of Technology" course may be a good example of a broad occupational course that fits within the "manufacturing and machine operations" area.

Third, integrated vocational and academic courses should be expanded and further developed to provide high school students with the opportunity to learn academic skills in an alternative, applied context. The statistical evidence discussed earlier demonstrates the feasibility of using high school vocational education as a potent instrument for developing academic skills. In light of the large number of college-bound students in vocational education and the large number of work-bound students not ready to commit to a specific area of skill specialization, we believe that integrated vocational and academic education should eventually emerge as the dominant form of high school vocational education.

Finally, given the fact that approximately three-quarters of all high school vocational education is taken by students bound for college or postsecondary vocational-technical school, it is important to structure high school vocational courses, particularly those that provide broad occupational training and those that are integrated with academic courses, so that maximum continuity is provided between training in high schools and training in postsecondary schools. The emerging "2 + 2" programs are one example of this type of education.[3]

**Notes**

[1]The share of credits accounted for by a particular group, say group j, is given by P(j)*Mean(j)/Mean, where P(j) = the share of the population in group j, Mean (j) = average vocational credits taken by group j, and Mean = overall mean vocational credits.

[2]See Meyer (1990a) for a discussion of the issues involved in estimating a curricular production function.

[3]The "2 + 2" programs span the last two years of high school and the first two years of community college or college. In "2 = 2" programs the high school coursework is generally broad and technical, rather than occupationally specific.

**References**

Bishop, John. 1988. "The Productivity Consequences of What Is Learned in High School." Working Paper no. 88-18, Center for Advanced Human Resource Studies, Cornell University, Ithaca, NY, December.

Gifford, A. G., Dean Harde, E. Gareth Hoachlander, Robert H. Meyer, and John E. Tuma. 1989. "Course Enrollments in Secondary Education," NAVE Contractor Report, MRP Associates, Berkeley, Calif., April.

Horn, Robin S., and Robert H. Meyer. 1990a. "Mathematics Learning for the Noncollege-Bound Student: The Role of Vocational Education." National Assessment of Vocational Education (NAVE) Report. Institute for Research on Poverty, University of Wisconsin-Madison, forthcoming.

Horn, Robin S., and Robert H. Meyer. 1990b. "Occupational Training and Occupational Demand: A User's Guide." National Assessment of Vocational Education (NAVE) Report, Vocational Studies Center, University of Wisconsin-Madison.

Meyer, Robert H. 1990a. "The Production of Mathematics Skills: Theory vs. Application." Institute for Research on Poverty, University of Wisconsin-Madison. Photocopy.

Meyer, Robert H. 1990b. "Supply and Demand Revisited: An Analysis of the Skill Mismatch Between Vocationally Trained Workers and Jobs." Institute for Research on Poverty, University of Wisconsin-Madison, forthcoming.

Meyer, Robert H., and Robin S. Horn. 1990. "The Human Capital Utilization Rate: Do Students Use Their Training in Subsequent Employment?" Institute for Research on Poverty, University of Wisconsin-Madison, forthcoming.