

**THE SKILLS SHORTAGE
AND
THE PAYOFF TO VOCATIONAL EDUCATION?**

John Bishop
Cornell University
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Center for Advanced Human Resource Studies
New York State School of Industrial and Labor Relations
Cornell University
Ithaca, New York 14851-0925
607-255-2742

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THE SKILLS SHORTAGE AND THE PAYOFF TO VOCATIONAL EDUCATION

During the 1980s the demand for workers with high levels of skill and education grew more rapidly than the supply. Professional, technical and managerial jobs which accounted for 23.7 percent of jobs in 1978 accounted for 52 percent of job growth between 1978 and 1989. Automation and the transfer of work overseas caused factory operative jobs to fall by 2.2 million. Operative, laborer and service jobs which accounted for 35 percent of jobs in 1978 accounted for only 9 percent of job growth during the subsequent 11 years (Bishop and Carter 1990).

The strong demand for skilled workers and a slow down in growth of the supply of workers with BA and AA degrees helped to cause their wages to rise much more rapidly than the wages of unskilled and semi-skilled workers. Between 1983 and 1989, real weekly earnings rose 16.1 percent for technicians, 12 percent for professional workers, 1.5 percent for managers and clerical workers. In contrast, the real weekly earnings of operators, fabricators and laborers declined 5.3 percent and the real weekly earnings of service workers declined 1.3 percent.¹ Real hourly wages of non-supervisory employees fell 8.1 percent in retailing and 4.4 percent in manufacturing.

Skill demands also appear to be rising within occupations. Increasing numbers of manufacturing workers are working in production cells in which every member of the team is expected to learn every job. Production workers are being given responsibilities--quality checking, statistical process control (SPC) record keeping, resetting machines shown by SPC to be straying from target dimensions, redesigning the layout of the machines in the production cell--that used to be the sole province of supervisors, specialized technicians and industrial engineers.

What implications do these changes in skill demands have for the payoff to high school vocational education? Are workers who develop the technical skills taught in trade and technical programs, in fact, more productive when they get a job in the field? Are the skills taught in these programs still valued by the labor market? Has the payoff to high school vocational training increased along with the payoff to other skills? What changes in the way vocational education is delivered are implied by the tight labor markets for highly skilled workers? This paper attempts to answer these questions by examining four different kinds of evidence on the economic payoffs to occupationally specific training in high school:

- * Comparisons of the training success and job performance of young military recruits who have strong technical competency prior to entering the armed forces to those whose technical competency is weak.
- * Comparisons of job performance in civilian jobs of those who have strong technical competency to those whose technical competency is weak.
- * Comparisons of the job performance of workers who score well on content valid occupational competency tests to those who score poorly.
- * Comparisons of labor market outcomes for young men who have demonstrated competency in the technical arena to the outcomes for those who do not have these competencies.
- * Comparisons of labor market outcomes for those who received vocational education in high school versus the outcomes of those who did not.

The analyses of these five very different types of evidence on the impact of vocational education imply that the skills being taught in the typical vocational program are not obsolete and are valued by the labor market. Young men who have the skills and knowledge that trade and technical programs try to impart are indeed more productive in blue collar and technical jobs, are less likely to be unemployed and obtain higher wage rates and earnings. In addition, during the 1980s non-college bound youth who took 4 or more vocational courses in high school earned substantially more than the non-college bound youth who took no vocational courses in high school.

I. The Effect of Technical Competence on Training Success and Job Performance in the Military

What impact does technical competence have on the ability to learn new tasks and on job performance? The military services have extensively researched this question.

The military uses the Armed Services Vocational Aptitude Battery (ASVAB), a three hour battery of tests, for selecting recruits and assigning them to occupational specialties. The ability of this test battery to predict job performance in a variety of Military Occupational Specialties (MOS) has been thoroughly researched and the battery has been periodically modified to incorporate the findings of this research (Booth-Kewley 1983, Maier and Truss 1983 & 1985, Wilbourn, Valentine & Ree 1984). Most of the research has involved correlating scores on ASVAB tests taken prior to induction with final grades in MOS specific

training courses (generally measured at least 4 months after induction).

The ASVAB test battery is made up of 10 subtests: Mechanical Comprehension, Auto and Shop Knowledge, Electronics Knowledge, Clerical Checking (Coding Speed), Numerical Operations (a speeded test of simple arithmetic), Arithmetic Reasoning, Mathematics Knowledge (covering the high school math curriculum), General Science, Word Knowledge and Paragraph Comprehension. A fuller description of each of these subtests together with sample questions is given in Appendix A. Even though the ASVAB was developed as an "aptitude" test, the current view of testing professionals is that:

Achievement and aptitude tests are not fundamentally different....Tests at one end of the aptitude-achievement continuum can be distinguished from tests at the other end primarily in terms of purpose. For example, a test for mechanical aptitude would be included in a battery of tests for selecting among applicants for pilot training since knowledge of mechanical principles has been found to be related to success in flying. A similar test would be given at the end of a course in mechanics as an achievement test intended to measure what was learned in the course (National Academy of Sciences Committee on Ability Testing, 1982, p.27)."

The universe of skills and knowledge sampled by the mechanical comprehension, auto and shop information and electronics subtests of the ASVAB roughly corresponds to the vocational fields of trades and industry and technical. Some of the material is also covered in physics courses. These subtests have some similarities with the occupational competency examinations developed to assess high school vocational students. However, the ASVAB technical subtests assess knowledge in a much broader domain and the individual items are, consequently, more generic and less detailed. The ASVAB technical composite is interpreted as a measure of knowledge and trainability for a large family of jobs involving the operation, maintenance and repair of complicated machinery and other technically oriented jobs.

Since recruits are selected into the army and into the various specialties by a nonrandom process, mechanisms have been developed to correct for selection effects--what I/O psychologists call restriction of range (Thorndike 1949; Lord and Novick 1968; Dunbar and Linn 1986). These selection models assume that selection into a particular MOS is based on ASVAB subtest scores (and in some cases measures of the recruit's occupational interests). For the military environment, this appears to be a reasonable specification of the selection process for attrition is low and selection is indeed explicitly on observable test scores. This

ability to model the selection process is an advantage that validity research in the military has over research in the civilian sector.²

Success in Training

A reanalysis was conducted of data from two large scale studies of Marine recruits (Sims and Hiatt 1981 reprinted in Hunter, Crossen and Friedman 1985; Maier and Truss 1985). These studies were selected because they used versions of the ASVAB that were quite similar to the one administered to the NLS Youth Cohort which will be analyzed in section 3. Correlation matrices which had been corrected (for restriction of range and selection effects) were obtained from the appendices of these studies and LISREL was employed to estimate models in which training grades were regressed on the full set of ASVAB subtests. The standardized regression coefficients from this analysis are reported in table 1.

The first major finding is that technical competency as indexed by the mechanical, auto-shop and electronics subtests had major effects on success in training for all military occupations with the single exception of the clerical occupation (Bishop 1989b). The second major finding was that math knowledge and arithmetic reasoning subtests had substantial effects on training success while computational speed had only modest effects on training success. Both the science and verbal subtests had strong positive impacts on success in training.

Job Performance--Skill Qualification Tests

Since, however, both the criterion--training success--and the predictors--competence in particular areas--are measured by paper and pencil tests, there is a danger that results may be biased by common methods bias. Therefore, it would be desirable to check these findings in a data set in which ASVAB subtest scores predict a hands-on measure of job performance. Maier and Grafton's (1981) study of ASVAB 6/7's ability to predict the hands-on Skill Qualification Test (SQTs) provides such a data set. Maier and Grafton described the hands-on SQTs they used in their study as follows:

SQTs are designed to assess performance of critical job tasks. They are criterion referenced in the sense that test content is based explicitly on job requirements and the meaning of the test scores is established by expert judgment prior to administration of the test rather than on the basis of score distributions obtained from administration. The content of SQTs is a carefully

selected sample from the domain of critical tasks in a specialty. Tasks are selected because they are especially critical, such as a particular weapon system, or because there is a known training deficiency. The focus on training deficiencies means that relatively few on the job can perform the tasks, and the pass rate for these tasks therefore is expected to be low. Since only critical tasks in a specialty are included in SQTs, and then only the more difficult tasks tend to be selected for testing, a reasonable inference is that performance on the SQTs should be a useful indicator of proficiency on the entire domain of critical tasks in the specialty; that is, workers who are proficient on tasks included in an SQT are also proficient on other tasks in the specialty. The list of tasks in the SQT and the measure themselves are carefully reviewed by job experts and tried out on samples of representative job incumbents prior to operational administration. The process of developing SQTs may be characterized as follows:

1. Identify tasks for testing.
2. Identify behaviors or steps essential for performing each task.
3. Develop measures to cover essential behaviors, and have these measures reviewed by job experts.
4. Tryout the measures on representative workers to verify accuracy of measurement; i.e., make sure that measures discriminate between task performers and nonperformers.

After each step, the products are reviewed for content validity. The test content cannot be changed after step 3, when the measures are approved by experts. The tryout of step 4 can be used only to improve the measures, and not to change content. When the development process is followed, the validity of the SQTs as measures of job proficiency is assured by job experts and representative workers.(pp. 4-5)

A more extensive discussion of the procedures for developing SQTs is available in a handbook (Osborn et al, 1977). A thorough discussion of their rationale is provided in Maier and Hirshfeld (1978).

Correlation matrices relating the ASVAB subtests and SQTs were taken from Appendices A and B in Maier and Grafton (1981). The correlation matrices were corrected for selection effects and restriction of range by Maier and Grafton using procedures described in Dunbar and Linn (1986). Regressions were estimated using LISREL for eight major categories of Military Occupational Specialties (MOS): Skilled Technical, Skilled Electronic, General Maintenance, Mechanical Maintenance, Clerical, Operators (of Missile Batteries) and Food, Combat and Field Artillery. Except for combat and field artillery, these MOSs have close counterparts in the civilian sector. The independent variables were the 10 ASVAB 6/7 subtest scores which had counterparts in the ASVAB 8A battery used in the analysis of NLS

Youth presented in section 3 of the paper.

The standardized regression coefficients from this analysis are reported in Table 2. The effects of the four "technical" subtests--mechanical comprehension, auto information, shop information and electronics information--on job performance are substantial in all of the nonclerical occupations. The impact of a one standard deviation increase in all four of these subtests is an increase in the SQT of .415 SD in skilled technical jobs, of .475 SD in skilled electronics jobs, of .316 SD in general maintenance jobs, .473 SD in mechanical maintenance jobs, of .450 SD for missile battery operators and food service workers, of .345 SD in combat occupations and .270 SD in field artillery. Note further that, in standard deviation units, the job performance effects of the technical subtests are much larger than their effects on training grades. Methods bias does seem to be at work. Clearly the technical competencies being measured by the four ASVAB technical subtests are important determinants of worker productivity in these jobs.

Science and word knowledge have significant effects on job performance in skilled technical, general maintenance, clerical, operator/food and combat arms MOSs. With the sole exception of the mechanical maintenance MOS cluster, the two mathematical reasoning subtests have much larger effects on SQTs than the computational speed subtest. A one standard deviation increase in both of the mathematical reasoning subtests raises predicted job performance by .183 SD in skilled technical jobs, .24 SD in skilled electronic jobs, .34 SD in general maintenance jobs, .447 SD in clerical jobs, .22 SD for missile battery operators and food service jobs, .209 SD in combat arms and .416 SD in field artillery. While the effects of the two tests of mathematical reasoning tests on job performance in non-clerical jobs are substantial, their effects are substantially smaller than the effects of the technical composite.

Supervisory Assessments in the Military

Most of the ASVAB validity studies have studied MOS specific measures of performance which reflect the soldier's ability to do the job not their willingness to do it on a regular basis or under adverse conditions. Do the results change when other dimensions of job performance are studied? Project A, a massive study (total costs of more than \$100,000,000) that is developing improved methods for selecting and classifying army personnel, has collected data which allows us to address this issue. Besides the MOS specific SQTs already examined, Project A offers three other performance constructs which have some

applicability to civilian jobs: General Soldiering Proficiency, Effort and Leadership and Maintaining Personal Discipline. General Soldiering Proficiency assesses skills that all soldiers must have (eg. use of basic weapons, first aid, map reading, use of a gas mask) and is a combination of job knowledge tests and hands-on performance tests. This construct is a measure the can do element of job performance.

The other two constructs attempt to measure the will do element of job performance. John P. Campbell (1986) described the constructs and their measurement as follows:

Peer Leadership, Effort, and Self Development: Reflects the degree to which the individual exerts effort over the full range of job tasks, perseveres under adverse or dangerous conditions, and demonstrates leadership and support of peers. That is, can the individual be counted on to carry out assigned tasks, even under adverse conditions, to exercise good judgement, and to be generally dependable and proficient? Five scales from the Army-wide BARS rating form (Technical Knowledge/Skill, Leadership, Effort, Self-development, and Maintaining Assigned Equipment), the expected combat performance rating, and the total number of commendations and awards received by the individual were summed for this factor.

Maintaining Personal Discipline: Reflects the degree to which the individual adheres to Army regulations and traditions, exercises personal self-control, demonstrates responsibility in day-to-day behavior, and does not create disciplinary problems. Scores on this factor are composed of three Army-wide Bars scales (Following regulations, Self-Control, and Integrity) and two indices from the administrative records (number of disciplinary actions and promotion rate). (p. 150)

It had been planned to obtain information on commendations, awards, promotions, and disciplinary actions from administrative records. However, the cost of this approach was extremely high so "everyone crossed their fingers and we collected eight archival performance indicators via a self report questionnaire....Field tests on a sample of 500 people showed considerable agreement between self-report and archival records"(Campbell, 1986, p 144).

These two constructs were related to each other (they correlate .59) but were clearly quite distinct from the two "can do" constructs. Correlations with General Soldiering Proficiency were only .27 for Effort and Leadership and .16 for Personal Discipline. The "can do" constructs were based on ratings made by the same person, so they share some common measurement error. Campbell, consequently, developed residualized "can do" performance constructs by subtracting a ratings method factor from the raw score. With the ratings

methods effect removed, General Soldiering Proficiency (raw) had a correlation of .45 with Effort and Leadership (residual) and .19 with Personal Discipline (residual). In the view of the Project A team, soldiers must have both qualities--the technical competence to do their job and the willingness to do it under stressful circumstances.

Table 3 presents the results of using ASVAB test scores to predict General Soldiering Proficiency (raw), Effort and Leadership (both raw and residualized) and Personal Discipline (raw) (Campbell, 1986, Table 10). The correlation matrices were corrected for range restriction as described by Dunbar and Linn (1986). In this analysis the 10 ASVAB subtests were reduced to four composites: Technical, Speed (Numerical Operations and Clerical Checking), Quantitative (Arithmetic Reasoning and Mathematics Knowledge) and Verbal/Science.

For General Soldiering Proficiency, the results were quite similar to the results obtained predicting hands-on SQTs. The technical and quantitative composites had the largest effects, and the verbal/science composite had a substantial effect. Speed had almost no effect.

The pattern was different for the "will do" performance constructs. The technical composite had large positive effects on both measures of Effort and Leadership. The quantitative composite had a modest positive effect on Maintaining Personal Discipline and the residualized Effort and Leadership. Speed had a modest positive effect on Effort and Leadership. The verbal/science composite had no effect on the residualized Effort and Leadership and a small negative effect on raw score measures of both constructs.³

Eighty percent of the jobs held by enlisted personnel in the military have civilian counterparts so the research on the validity of the ASVAB in military settings just presented should generalize quite well to major segments of the civilian economy (US Department of Defense, 1984). The test is highly correlated with the cognitive subtests of the General Aptitude Test Battery, a personnel selection test battery used by the US Employment Service, the validity of which has been established by studies of over 500 occupations. A validity generalization study funded by the armed forces concluded "that ASVAB is a highly valid predictor of performance in civilian occupations" (Hunter Crossen and Friedman, 1985, p. ix).

Nevertheless, it would be useful to examine civilian data on the effect of technical competence on job performance. It is to the analysis of civilian data we now turn.

II. The Effect of Technical Competence on Supervisory Assessments of Job Performance in the Civilian Sector

Over the last 50 years, industrial psychologists have conducted hundreds of studies, involving many hundreds of thousands of workers, on the relationship between supervisory assessments of job performance and various predictors of performance. In 1973 Edwin Ghiselli published a compilation of the results of this research organized by type of test and occupation. Table 4 presents a summary of the raw validity coefficients (correlation coefficients uncorrected for measurement error and restriction of range) for six types of tests: mechanical comprehension tests, "intelligence" tests, arithmetic tests, spatial relations tests, perceptual accuracy tests and psychomotor ability tests. As pointed out earlier, mechanical comprehension tests assess material that is covered in physics courses and applied technology courses such as auto mechanics and carpentry.

For craft occupations and semi-skilled industrial jobs, the mechanical comprehension tests are more valid predictors of job performance than any other test category. For protective occupations, mechanical comprehension tests tie intelligence tests for top rank in the validity sweepstakes. For clerical jobs, mechanical comprehension tests are not as good predictors of job performance as tests of intelligence, arithmetic and perceptual accuracy. This result is consistent with the analysis of job performance in the military data reported in Table 2.

It appears that measures of generic technical competence are highly correlated with job performance in technical and blue collar jobs. What about paper and pencil occupational competency tests for specific occupations? How highly do they correlate with job performance.

III. The Relationship between Occupational Competency Tests and Job Performance

Meta-analyses of the hundreds of studies of the validity of occupational competency tests have found that content valid occupational competency tests are highly valid predictors of job performance. Dunnette's (1972) meta-analysis of 262 studies of occupational competency tests found that their average correlation with supervisory ratings was .51. This correlation was higher than the correlation of any other predictor studied including cognitive ability tests (.45), psychomotor tests (.35), interviews (.16) and biographical inventories (.34).

Vineberg and Joyner's (1982) meta-analysis of military studies found that grades in training school (which were based on paper and pencil tests of occupational competency) had a higher correlation (.27) with global performance ratings by immediate supervisors than any other predictor. The correlations for the other predictors were .21 for ASVAB ability composites, .14 for years of schooling, .20 for biographical inventory and .13 for interest. Hunter's (1982) meta-analysis found that content valid job knowledge tests had a correlation of .48 with supervisory ratings and an even higher correlation of .78 with work sample measures of job performance. Consequently, for training program graduates who are employed in the occupation for which their competency was assessed, scores on these competency exams are highly valid predictors of job performance and promotion probabilities.

It has also been established that vocational education programs have substantial effects on occupational competency test results. The findings of two studies comparing students at various stages of their training are reported in Table 5. The first column of the table reports the differences between trained and untrained students on the occupational competency tests developed by American Institutes of Research (1982) under a contract with the Office of Vocational and Adult Education. The second column reports the difference between Ohio high school juniors and seniors on most of the competency tests available from the Ohio Vocational Education Achievement Test Program. Since the tests are normally given in the spring, this column is an estimate of the gain in competency that occurs between the end of the first and the end of the second year of a high school vocational program (Instructional Materials Laboratory 1988). Mean differences have been put into a common metric by dividing them by the sample standard deviation of the program completers who took the test. While some of the mean differences are less than a third of a standard deviation, most are over half of a standard deviation and some are substantially greater than one standard deviation. The difference between sophomores and juniors and between juniors and seniors on academic achievement tests are generally between 20 and 30 percent of a standard deviation in the final years of high school. Thus, when test standard deviations are the metric of comparison, vocational education appears to produce larger gains (on a narrower front to be sure) than the academic side of high school.

Selective attrition and maturation effects are probably contributing to the differences in competency between trained and untrained individuals (and also between sophomores and

seniors on academic achievement tests). Consequently, the true value added of vocational programs is probably somewhat less than the numbers reported.

When occupational competency tests appropriate for the job compete with academic ability tests in predicting job performance measured either by supervisory ratings or actual work samples, the occupational competency tests have about twice as large an effect as ability tests (Hunter, 1983). Since large improvements in job knowledge appear easier to achieve than equivalent (in proportions of a standard deviation) improvements in verbal and mathematical skills, occupationally specific training would appear to be highly desirable if the student is likely to put the knowledge to use by working in the occupation.

Thus workers who score well on paper and pencil assessments of specific occupational competency and generic technical competence are indeed more productive on the job. Does this result in young men with technical competencies getting better jobs and spending less time unemployed? It is to this question we now turn.

IV. The Effect of Technical Competence on the Wages, Earnings and Unemployment of Young Men

A study was conducted to determine to what degree achievement in the various subjects taught in high school were rewarded by the labor market during the 1980s. This was accomplished by estimating models predicting wage rates, earnings and unemployment as a function of competence in the academic fields of mathematics, science and language arts and in the trade/technical arena while controlling for years of schooling, school attendance, ethnicity, age, work experience, marital status and characteristics of the local labor market.

The data set for this analysis was the Youth Cohort of National Longitudinal Survey (NLS)--all eight waves from 1979 to 1986. At the time of the 1986 interview the NLS Youth ranged from 21 to 28 years of age. The measures of achievement were derived from the ASVAB 8A. During the summer of 1980 all members of the NLS Youth sample were asked to take this test battery and, with the inducement of a \$50 honorarium, the battery was successfully administered to 94 percent of the sample. The ASVAB 8A test battery has 10 subtests: Mechanical Comprehension, Auto and Shop Knowledge, Electronics Knowledge, Clerical Checking (Coding Speed), Numerical Operations (a speeded test of simple arithmetic), Arithmetic Reasoning, Mathematics Knowledge (covering the high school math curriculum),

General Science, Word Knowledge and Paragraph Comprehension.

The mechanical comprehension, auto and shop information and electronics subtests of the ASVAB assess acquisition of knowledge in the trades and industry and technical field. These subtests were aggregated into a single composite which is interpreted as an indicator of competence in the "technical" arena.

Two dimensions of mathematical achievement were measured: the speed of doing simple mathematical computations is measured by a three minute 50 problem arithmetic computation subtest which will be referred to as computational speed. Mathematical reasoning ability was measured by a composite of the mathematics knowledge and arithmetic reasoning subtests. Science achievement was indexed by the ASVAB's General Science subtest. This test focuses on science definitions and has minimal coverage of higher level scientific reasoning. Verbal achievement was measured by a composite made up of the word knowledge and paragraph comprehension subtests.

Four measures of labor market success were studied: the log of the hourly wage rate in the current or most recent job, the log of calendar year earnings if they exceed \$500, earnings in dollars (with nonworkers over age 16 included in the sample) and the share of labor force time that the individual was unemployed (defined only for people who were in the labor force for at least 8 weeks during the calendar year).

The model estimated assumed that technical and academic competencies have linear and additive effects on labor market outcomes:

$$(1) \underline{Y}_t = a_t A + b_t C + c_t T + e_t S + g_t Z_t + u_t \quad \text{for } t = 1979 \dots 1986$$

where \underline{Y}_t is a vector of labor market outcomes (wage rates, earnings and unemployment) for year t .

A is a vector of test scores measuring competence in mathematical reasoning, reading and vocabulary and science knowledge.

C is a measure of speed in simple arithmetic computation.

T is the technical composite measuring mechanical comprehension and electronics, auto and shop knowledge.

S is clerical checking speed.

Z_k is a vector of control variables such as age, work experience, schooling, school attendance, marital status, parenthood, minority status, past and current military service, region, residence in an SMSA and local unemployment rate.

u_t is a vector of disturbance terms for each year.

An extensive set of controls was included in the estimating equations. Reports of weeks spent in employment are available all the way back through 1975. For each individual, these weeks worked reports were aggregated across time and an estimate of cumulated work experience was derived for January 1 of each year in the longitudinal file. This variable and its square was included in every model as was age and its square. School attendance was controlled by four separate variables. The first variable indicated whether the youth is in school at the time of the interview. The second was a dummy variable indicating whether the youth has been in school since the last interview. The third was a dummy variable indicating whether the student is attending school part time. The fourth variable was a measure of the share of the calendar year that the youth reported attending school derived from the NLS's monthly time log. Years of schooling was also controlled for by four variables: years of schooling, a dummy for high school graduation, years of college education completed, and years of schooling completed since the ASVAB tests were taken. The individual's family situation was controlled by dummy variables for being married and for having at least one child. Minority status was controlled by a dummy variable for Hispanic and two dummy variables for race. Characteristics of the local labor market were held constant by entering the following variables: dummy variables for the four Census regions, a dummy variable for rural residence and for residence outside an SMSA and measures of the unemployment rate in the local labor market during that year.

The results of the estimations are presented in Tables 6, 7, 8, and 9. **Technical competence has large and significant positive effects on wage rates and earnings and negative effects on unemployment.** The F tests indicate that in all eight years analyzed, technical competence had significantly more positive effects on wage rates and earnings than the aggregated academic tests. A one population standard deviation increase in the technical composite increased wage rates by 5.6 percent and yearly earnings by \$1065 (12.5 percent) and reduced the rate of unemployment by 1.9 percentage points. This is a very substantial return to technical achievement.

The second major finding is that **high level academic competencies do not have positive effects on wage rates and earnings.** The mathematics reasoning, verbal and science composites all had negative effects on wage rates and earnings and often positive effects on unemployment. In the wage rate models, 23 of 24 coefficients were negative. F tests on the sum of the coefficients on the three academic composites were calculated. This sum was significantly (at the 5 percent level) negative in 5 of the 8 years. In the log earnings models, 20 of 21 coefficients were negative. In the dollar earnings models, 19 of 21 coefficients were negative. F tests on the sum of the coefficients on academic tests in the dollar earnings models find they are significantly negative in 5 of the 7 years. In the unemployment models, about half of the coefficients were positive and the F test on the sum of the coefficients was never significantly different from zero at even the 10 percent level.

Speed in arithmetic computation had substantial positive effects on labor market success of young men. A one population standard deviation increase in computational speed raised wage rates by 5.3 percent and earnings by \$837 (10.4 percent) on average. The wage and earnings effects grew over time. The unemployment effects, in contrast, diminished with time. They were significant in 1979-80 but not later. In all eight of the years studied, computational speed had a significantly larger impact on wage rates and earnings than the aggregated academic tests. Computational speed, however, is something that calculators do better than people and is not viewed by most educators as an appropriate goal for a high school mathematics curriculum (National Council of Teachers of Mathematics 1989). Being able to do clerical checking rapidly significantly lowered unemployment in 4 of the 7 years, significantly increased dollar earnings in 6 of 7 years but had no effect on wage rates.

In sum, analysis of labor market data for young males finds strong evidence that measures of technical competence are strongly related to higher wages, greater earnings and lower rates of unemployment. Since competence in this arena is the primary objective of trade and technical vocational programs, it would be reasonable to hypothesize that students who participate in trade and technical programs should be receiving higher earnings than students who take no vocational courses in high school and fail to go to college. It is to this question we now turn.

V. Have the Economic Benefits of Vocational Education Increased ?

The Payoff during the 1970s

There have been quite a few studies of the impact of high school vocational education on labor market success of non-college bound youth. Most of the studies analyzing data collected during the 1970s used student reports of their track to define participation in vocational education (Grasso and Shea 1981, Gustman and Steinmeier 1981, Woods and Haney 1981). When, however, these student reports of track were cross checked against transcripts, it was found that some of the self-identified vocational students had only a few vocational courses on their transcript and many "general track" students had taken 3 or 4 vocational courses (Campbell, Orth and Seitz 1981). Since it is the number and types of courses taken which are influenced by school policy, studies of the impact of vocational education need to employ objective measures of participation and not self-assessments of track, which apparently measure the student's state of mind as much as they measure the courses actually taken.

The solution to this problem is to use transcripts or reports of actual courses taken to measure participation in vocational education. In his analysis of longitudinal data on approximately 3500 men and women who graduated from high school in 1972, Meyer (1981) used school reports of the number of courses taken in vocational and nonvocational fields to define a continuous variable: the share of courses that were vocational. He found that females who devoted one-third of their high school course work to clerical training earned 16 percent more during the seven years following graduation than those who took no vocational courses (see Table 10). Those who specialized in home economics or other non-clerical vocational courses did not obtain higher earnings. Males who specialized in trade and industry earned 2.8 percent more than those in the general curriculum. Males in commercial or technical programs did not earn significantly more than those who pursued a general curriculum.

Rumberger and Daymont (1982) used transcripts to define variables for the share of course work during the 10th, 11th and 12th grades that was vocational and the share that was neither academic nor vocational. Analyzing 1979/80 data on 1161 young adults in the National Longitudinal Survey (NLS) who were not attending college full time and had attended high school during the early and middle 1970s, they found that males who devoted one-third of their time to vocational studies instead of pursuing a predominantly academic

curriculum spent about 12 percent more hours in employment, but experienced slightly greater unemployment and received a 3 percent lower wage. Females who similarly devoted one-third of their time to vocational studies at the expense of academic course work were paid the same wage but spent about 8 percent more time in employment and 1.6 percent less time unemployed.

The Payoff during the 1980s

Studies of vocational education that have used more recent data sets have obtained much more positive results. Kang and Bishop's (1986) study of 2485 men and women who graduated from high school in 1980 and did not attend college full-time used student reports [transcripts were not available] of courses taken in three different vocational areas--business and sales, trade and technical, and other--and five academic subjects--English, math, science, social science and foreign languages--as measures of curriculum. Males who took 4 courses (about 22 percent of their time during the final three years of high school) in trade and technical or other vocational subjects by cutting back on academic courses were paid a 7 to 8 percent higher wage, worked 10 to 12 percent more, and earned 21 to 35 percent more during 1981, the first calendar year following graduation. Males who took commercial courses did not have higher earnings or wage rates. Females who substituted 4 courses in office or distributive education for 4 academic courses were paid an 8 percent higher wage, worked 18 percent more, and earned 40 percent more during 1981. Females who took trade and technical courses did not receive higher wage rates and earned 6 percent more than those who pursued an academic curriculum. The benefits probably diminish in later years, but this is of little consequence since the incremental costs of four vocational courses can be recovered in just one or two years at this rate.

Joseph Altonji's (1988) study of the NLS Class of 72 followup surveys for 1973 through 1986 found modest positive effects of vocational coursework on hourly wage rates. Holding years of further education constant, four trade and technical courses substituted for a mix of academic courses (English, foreign language, social studies, science and mathematics) raised wage rates by 5 to 10.3 percent depending on specification. Substituting four commercial courses for a mix of academic courses had no effect on wages in OLS models but raised wage rates by 3 percent in instrumental variable models intended to correct for selection bias.

Recent studies of students who graduated in the late 1970s and early 1980s by Paul Campbell and his colleagues at the National Center for Research on Vocational Education also obtained very positive findings. Controlling for test scores and past and present enrollment in higher education, their analysis of 1983 and 1985 National Longitudinal Survey data on 6953 young men and women between the ages of 19 and 28 found that graduates of vocational programs had 16.5 percent higher earnings than those who had specialized in academic courses [comparison is made with academic rather than general track students because most general track students take one or two vocational courses]. A parallel analysis of High School and Beyond data on 6098 students who graduated in 1982 (which also controlled for test scores and college attendance) found that the vocational graduates were 14.9 percent more likely to be in the labor force in 1983/84, were one percentage point less likely to be unemployed, and were paid about 9 percent more per month than the academic graduates. The overall earnings effect was 27 percent. The differential between vocational and general curriculum graduates [who generally took 1 to 2 vocational courses] was generally about half the size of the differential between vocational and academic graduates (Campbell et. al., 1986, 1987).

These positive results contrast markedly with the negative findings regarding CETA's classroom occupational skills training programs for youth and the Supported Work Demonstration (see the right hand side of Table 10). Only the Job Corps, a considerably more costly training program, has positive impacts that even approach these results.

Why did the Payoff Increase?

There are three reasons for viewing the more recent studies as more accurate descriptions of the current impacts of vocational education than the studies published prior to 1983. First, vocational education has been changing rapidly. During the 1970s, competency based instruction tied to competency profiles certifying the skills learned became common practice, career education courses preceding the selection of an occupational specialty were introduced, job search skills were added to the curriculum of most vocational programs, home economics was reoriented from a focus on home making to a focus on preparation for work, and the content of many individual programs was upgraded and updated. Consequently, the data on the younger members of the NLS Youth sample and on High School and Beyond students, who received their vocational instruction between 1978 and 1982, is much more

relevant to vocational education as it is now practiced than the Class of 1972 data analyzed by Meyer, Gustman/Steinmeier and Woods/Haney.

Second, the labor market reward for the skills taught in high school appears to be experiencing secular growth. The 1980s were a period of dramatic increases in all kinds of skill premiums. Rewards for work experience and for college degrees rose substantially. Between 1979 and 1988 the real wage of male college graduates with fewer than 10 years of work experience increased by 5.5 percent while the real wage of high school graduates with fewer than 10 years of post-school work experience declined by 20 percent (Kosters 1989). High school graduates with vocational training suffered a decline in their real wage during this period but those without any vocational training suffered even bigger declines.

Third, large samples are preferable to small samples. In the four year interval between the Rumberger/Daymont analysis of NLS youth data and Campbell et al's analysis, the number of graduates for which high school transcript data was available nearly doubled. This makes the findings in Campbell et al's 1986 and 1987 papers a more reliable estimate of vocational education's effect than those provided by Rumberger/Daymont's 1982 study and the early studies of NLS data done by Mertens and Gardner (1982) and others.

V. Summary and Implications

Applied technology courses taken in high school significantly increase the wages and earnings of graduates who do not go to college. Tests assessing technical competence are powerful predictors of wage rates and earnings of young males and highly valid predictors of training success and job performance in technical, craft and industrial occupations. A one population SD increase in technical competence raises the average earnings (regardless of occupation) of young men by \$1333. per year in 1985 dollars. Averaging over the six non-clerical non-combat occupations, and assuming that the standard deviation of true productivity is 30 percent of the wage, a one population SD increase in all four of the technical subtests raises productivity by about 11.5 percent of the wage or about \$2875. per year in 1985 dollars.⁴ With a working life of 40 years and a real discount rate of 5 percent, the present discounted value of such a learning gain is about \$50,000. **These results imply that broad technical literacy is essential for workers who use and/or maintain equipment that is similar in complexity to that employed in the military.**

The skills taught in typical trade and technical programs raise productivity and yield substantial labor market benefits if jobs are found in a related field. These benefits alone are sufficient to justify trade and technical programs (Bishop 1989a).

The A Nation at Risk report recommendation that all students take a course in computers recognizes the need for technology education. High school students see the usefulness of these courses. Sophomores taking such courses described them as "Very Useful" for their career 53 percent of the time and as of "No Use" only 6 percent of the time (LSAY, Q. AACOMF)(see Table 11). However, computers are only one of the technologies we interact with on a daily basis. The findings just reviewed suggest that students headed into technical training programs or directly into a job should receive a thorough technology education.

An example of the kind of course that is needed is the Principles of Technology (PT) course developed by a consortium of vocational education agencies in 47 states and Canadian provinces in association with the Agency for Instructional Technology and the Center for Occupational Research and Development. This 2 year applied physics course is both academically rigorous and practical. Each six day subunit deals with the unit's major technical principle (eg. resistance) as it applies to one of the four energy systems--mechanical (both rotational and linear), fluid, electrical and thermal. A subunit usually consists of two days of lectures/discussion, a math skills lab, two days of hands-on physics application labs, and a subunit review. This approach appears to be quite effective at teaching basic physics concepts. When students enrolled in regular physics and Principles of Technology courses were tested on basic physics concepts covered in the PT course at the beginning and end of the school year, the PT students started out behind the regular physics students but obtained an average score of 81 at completion as compared to an average of 66 for those completing a physics course (Perry 1989). Another study by John Roper (1989) comparing PT and physics students obtained similar results. In 29 states students get science and/or math credit when they take PT. Courses in applied biology/chemistry and in applied mathematics are currently being field tested. This is an area of study that needs much more attention than it has been getting from educational reformers and curriculum developers.

An argument that is often made for vocational education is that it helps motivate students who have been doing poorly in core academic subjects to apply themselves to

learning English and mathematics by showing its applications in a real work setting. It is also argued that, by offering opportunities for more concrete/hands-on type of learning, vocational education reduces dropout rates of at-risk students. Indeed, there is research support for this claim. Mertens, Seitz and Cox (1982) analysis of NLS Youth data found that taking and passing a vocational course in 9th grade reduced the dropout rate for dropout prone youth during 10th grade from 9 percent to 6 percent. Taking and passing vocational courses in 9th, 10th and 11th grade also significantly reduced dropping out during 12th grade.

One possible explanation of this dropout reducing effect is that students may view these courses as more relevant to their career plans. When 10th graders were asked to rate career utility on a five point scale, "very useful" was the description given by 58 percent of business/vocational classes, by 28 percent of science students in science courses and 47 percent of math students (see Table 11). Another possible explanation is that at risk students find vocational courses to be easier for them than academic courses. When asked "How difficult or easy is ____ course?," 54 percent characterize their vocational course as "very easy," while only 20-23 percent so characterize their science and mathematics courses. When asked to respond to "How much does the ____ course challenge you to use your mind?" on a 5 point scale ranging from "challenges a lot" to "never challenges", 16 percent of the vocational courses were placed in the bottom response category while only 6-7 percent of the mathematics and science courses were so classified. Sixty percent of business and vocational classes appear to assign no homework.

In my view these statistics imply that despite the demonstrated success of vocational education in helping students get better jobs, that vocational education is not now achieving its promise. It is well known that achievement levels in most high school academic subjects are very low.⁵ What this data implies is that the expectations placed on vocational students are too low, not just in their academic classes but in their vocational classes as well. As a consequence, many graduates of high school vocational programs do not have the occupational skills that employers are seeking and some employers are turning to post-secondary voc-tech institutions to meet their needs for technically qualified workers.

Identifying problems, however, is a lot easier than solving them. American senior high school students average only 3.8 hours of homework a week while their Japanese counterparts average over 19 hours a week (Juster and Stafford 1990). Unfortunately, the sentiment

expressed by one student, "You're going to work your whole life,..[High school should be a place to] enjoy life and have fun" (Powell et al, 1985, p 43) is quite common. Sixty-two percent of 10th graders agree with the statement, "I don't like to do any more school work than I have to" (Longitudinal Survey of American Youth or LSAY, Q. AA37N). Some of these students end up in vocational courses. When one asks vocational teachers to raise their standards, many complain that students will not take their courses if they set the expectations too high. Principles of Technology is a very demanding course. Student fear of its heavy work demands has been a major barrier to its spread. Powell describes "An angry math teacher [who remembering] the elimination of a carefully planned program in technical mathematics for vocational students simply because not enough signed up for it,...[said] Its easy to see who really makes decisions about what schools teach: 'the kids do.'(p. 9)"

How then can students be convinced to choose rigorous technical and occupational programs and work hard to excel in them? The answer is by **(1) developing rigorous courses that teach students concepts and material that they will use after leaving high school, (2) defining accomplishment in a way that students who work hard will perceive themselves as successful, (3) measuring the student's performance using a valid external assessment and then (4) insuring that accomplishment is recognized and rewarded by the labor market.**

Usefulness is essential for three reasons. First, the social benefits of learning derive from the use of the knowledge and skills not from the fact they are in someone's repertoire. Secondly, skills and knowledge that are not used deteriorate very rapidly. In one set of studies, students tested 2 years after taking a course had forgotten 1/2 of the college psychology and zoology, 1/3 of the high school chemistry, and 3/4 of the college botany that had been learned (Pressey and Robinson, 1944). Skills and knowledge that are used are remembered. Consequently, if learning is to produce long term benefits, the competencies developed must continue to be used after the final exam (either in college, the labor market or somewhere else). Finally, usefulness is essential because students are not going to put energy into learning things they perceive to be useless. Furthermore, the labor market is not in the long run going to reward skills and competencies that have no use. Indeed, selecting workers on the basis of competencies that are not useful in the company's jobs is in most

circumstances a violation of Title VII of the Civil Rights Act.

It is also essential that the occupational competencies developed by students be assessed not just by the teacher but by some external group--local employers, the state department of vocational education or the National Occupational Competency Testing Institute. This simultaneously accomplishes three goals: it helps to insure that the curriculum is both up to date and rigorous, it signals to prospective employers the skills that the student has developed and generates stronger economic incentives for the student to put greater effort into the course.

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ENDNOTES

1. Employment and Earnings, January 1984 and January 1990, Table 56 and Table 60. Nominal weekly earnings figures were deflated by the CPI for all urban consumers which rose 24 percent between 1982-84 and 1989.
2. If hiring selections are based entirely on X variables included in the model, unstandardized coefficients are unbiased and simple correction formulas are available for calculating standardized coefficients and validities. Unfortunately, in the civilian sector incidental selection based on unobservables such as interview performance and recommendations is very probable (Thorndike 1949; Olson and Becker 1983; Mueser and Maloney 1987). Consequently, in a sample of accepted applicants for a civilian job, one cannot be confident that these omitted unobservable variables are uncorrelated with the included variables that were used to make initial hiring decisions and, therefore, that coefficients on included variables are unbiased.
3. The very small effects of competency in mathematics, English and science on supervisory ratings in the military needs to be viewed with some caution for four reasons: the information on commendations, awards, promotions and disciplinary actions was self reported, a ratings method effect was clearly visible in the data, other researchers have expressed skepticism about the validity of military ratings (Vineberg and Joyner 1982), and there appears to be major differences between the civilian and military sectors in the effect of verbal and mathematics achievement on supervisory ratings (with the effects much larger in the civilian sector)(Hunter 1986).
4. In 1985 the mean full time compensation of operatives, craft workers and technicians was approximately \$25,000 a year. Studies that measure output for different workers in the same job at the same firm, using physical output as a criterion, can be manipulated to produce estimates of the standard deviation of non-transitory output variation across individuals. It averages about .14 in operative jobs, .28 in craft jobs, .34 in technician jobs, .164 in routine clerical jobs and .278 in clerical jobs with decision making responsibilities (Hunter, Schmidt & Judiesch 1988). Because there are fixed costs to employing an individual (facilities, equipment, light, heat and overhead functions such as hiring and payrolling), the coefficient of variation of marginal products of individuals is assumed to be 1.5 times the coefficient of variation of productivity. Because about 2/3rds of clerical jobs can be classified as routine, the coefficient of variation of marginal productivity for clerical jobs is 30 % [$1.5 * (.33 * .278 + .67 * .164)$]. Averaging operative jobs in with craft and technical jobs produces a similar 30% figure for blue collar jobs. The details and rationale of these calculations are explained in Bishop 1988b.

5. According to the National Assessment of Educational Progress (1988), 93 percent of 17 year olds do not have "the capacity to apply mathematical operations in a variety of problem settings (p. 42)." "In persuasive writing, students had difficulty providing evidence for their points of view....Even in 11th grade, only 28 percent wrote **adequate** or **elaborated** responses to the least difficult persuasive task (1986, p. 9). The 25 percent of the Canadian 18 year olds studying chemistry know as much chemistry as the top 1 percent of American high school graduates taking their second year of chemistry, most of whom are in Advanced Placement classes (International Association for the Evaluation of Educational Achievement, 1988).