The ASVAB Career Exploration Program:

Theoretical and Technical Underpinnings of the Revised Skill Composites and OCCU-Find

ASVAB CAREER EXPLORATION PROGRAM

Introduction

The ASVAB Career Exploration Program (CEP) is one of the largest career exploration programs in the world. Annually, it serves high school and post-secondary students in over 14,000 schools nationwide. Based on internal estimates of market penetration and utilization, it appears that more than one-fourth of all high school seniors will have participated in the ASVAB Program during their high school years (Baker, 2000). Confirming estimates come from independent studies that employ national probability samples of the 16 to 24 year old population (McCloy, DiFazio, & Paul, 1999). The program is designed for flexible use so that it will fit the needs of the schools and the students who participate in the program. Participating in the ASVAB program can reduce career indecision, and increase both job knowledge and career exploration (Baker, 2002). The ASVAB Program can be integrated with other career education and development programs, or it can be the foundation upon which further career education and development activities can stand. Designed for optimal use by high school sophomores, juniors, seniors, and students in postsecondary schools, the program is rooted in a developmental career counseling perspective. In this perspective, students are best served when career exploration is grounded both on an understanding and awareness of their interests, and on the importance placed on different sets of skills and competencies in occupations.

This technical supplement provides the documentation for the creation and initial psychometric evaluation of the ASVAB Career Exploration Program released for the 2002 academic year and updated in 2008. This revised program rests on a new model of career development, employs new methods for linking individuals and careers, and has been reviewed by career development professionals (U.S. Department of Defense, 2005). This document proposes and describes the ASVAB Program model that uses career interests and verbal, mathematics, and science and technical competencies to guide the process of career exploration. It describes the psychometric characteristics of the verbal, math and science and technical competencies, how these are linked to the knowledge, skills and abilities important in various occupations, and demonstrates the outcome of the linkages. This model results in an expanded ASVAB Program that has minimal adverse impact on low-aptitude students by providing equal career opportunities for students from all socioeconomic, racial, and ethnic backgrounds. The model fosters career exploration by focusing students on the occupational importance of verbal, math and science and technical competencies rather than on their own measured skills in these domains. In doing so, it provides students with a set of next steps they can use now to prepare further for careers of their own choosing.

Employing this new model greatly expanded the career offerings of the ASVAB Program, from 201 potential occupations, to over 400. Students also have access to the Department of Labor's (DoL) Occupation Information Network (O*NET), which provides comprehensive information on over 1,000 occupations.). The revised program model is relatively easy to understand and explain to students and their families and is more efficient than the previous ASVAB Program. Conceptually, the revised program is rooted in new developments and the advances in the career development field since the inception of the previous ASVAB Program in the late 1980s and early 1990s. This model provides one way to link individuals to occupations best exemplified by Bloch (1997). Bloch suggested that "the essential tasks of career development are centered on 'self, search, and synthesis'; that is, on identifying the needs, interests, values, and other critical variables of the individual; on understanding the nature of work, occupations, and industries; and on bringing these together" (Bloch, 1997, p. 189). In this perspective, "individuals develop information about themselves, gather information about the world of work appropriate to their current career development needs, and use this information within [their current] framework or to change the framework itself" (Bloch, 1989, p. 122). Accordingly, information is seen as feedback that helps individuals focus on the *construction* rather than on the *acceptance* of career choices. It provides a powerful way to link together important individual and occupational characteristics.

The transition from high school to the world of work can be a difficult challenge. As Chickering and Havighurst (1990, *p*. 32) noted, “choosing and preparing for a career is the most challenging developmental task of all for the late adolescent and young adult. It is essential for achieving emotional independence and for making decisions concerning marriage and family. It is the organizing center for the lives of most men and women.” Clearly, choosing and entering a career is not an easy task. This is because “people must come to grips with uncertainties about their capabilities, the stability of their interests, the current and long-range prospects of alternative occupations, the accessibility of potential careers, and the type of identity they seek to construct for themselves” (Bandura, 1997, p. 422).

Students are called upon to make career related decisions that will have strong and lasting consequences. At the same time that students have access to unprecedented opportunities, they also lack the preparation necessary to take advantage of these opportunities (U.S. Department of Labor [SCANS], 1991, *p.* xv). For example, the SCANS report indicated “more than half our young people leave schools without the knowledge foundation required to find and hold a good job.” The General Accounting Office (GAO, 1992; cited in Isaacson & Brown, 1997) released their own study of the transition from school to work. One of their conclusions was that the nation lacks a coherent strategy for preparing students for work. The necessity for a national coherent strategy is underscored in a study by Bloch (1996), who conducted a multi-state investigation of workforce preparation policies and their implementation in secondary schools. Based on a large national sample ($N = 919$), she reported that many principals and counselors were unfamiliar with national workforce preparation policies and career development programs. Further, she reported that many schools were not committed to providing access to appropriate career development programs for all of their students.

In the career development community, there has always been a deep understanding of the personal significance of work and career. This is because a career provides “a sense of satisfaction and productivity that stems from completing meaningful tasks, a feeling of belonging to a valued reference group, a basis for self-esteem and personal identity, and a way to earn one’s economic place in society” (Moos, 1986, p. 9). As Erik Erikson stated emphatically some 50 years ago, the choice and availability of a career confirm the sense of one’s identity and purpose as a human being: “The sense of ego identity, then, is the accrued confidence that the inner sameness and continuity are matched by the sameness and continuity of one's meaning for others, as evidenced in the tangible promise of a 'career'" (Erikson, 1950, p. 228). The continuing centrality of career and work throughout the life span is well-articulated by Savickas (1997):

> Work provides a major context in which individuals can meet their needs for agency and union. Through work as a productive activity, people can be active agents who advance themselves and improve the world. Through work as a social contribution, individuals can share the fruits of their labor with family, friends, and neighbors. Through working with people, individuals can gratify their needs for cooperation and companionship. Thus, work provides a forum for both individual identity and social significance. Accordingly, individuals can and do use work to develop into the self they want to become as well as manifest that self in social situations. *(p.* 6)

More recently, in his insightful synthesis and analysis of the psychology of work and working, Blustein (2006) offers an integrated functional taxonomy of working that is significant to adolescent career exploration and development. Noting the various trends transforming the current work-related landscape, Blustein argues that individuals use work to (a) attain survival and power, (b) create and maintain social connections, and (c) foster self-determination. In his view, these lie at the heart of the individual's experience of the fusion of self and work. If so, work is not merely a means to several ends, but a powerful vehicle by which we transform ourselves and are transformed from who we are today into who we eventually become. Inviting adolescents, then, to embark in career exploration is to invite them to consider who they are, who they can become, and whom they choose to become. Navigating among these possibilities perhaps is the central task of adolescence, and one that has profound implications both for the adolescent and for all society.

The Creation and Initial Validation of Career Exploration Scores for Use in the ASVAB Career Exploration Program Based on the Profile of American Youth, 1980 (PAY80)

The use of aptitude and achievement measures for career development purposes is standard practice. While many prefer to use a single global aptitude measure, many prefer to use some type of an aptitude profile (*e.g.*, Prediger, 1999). Previously, the ASVAB 18/19 Program employed a single composite measure of aptitude, the Academic Ability Index, that was a simple one digit score that ranged from 1 (high academic ability) to 5 (low academic ability). This index was composed of four ASVAB tests (Word Knowledge, Paragraph Comprehension, Arithmetic Reasoning, and Mathematics Knowledge) and mirrored the Armed Forces Qualification Test score used by the Services to determine whether a military applicant meets the aptitude requirements for entrance into any of the US Military Services (U.S. Department of Defense, 1999).

The ASVAB, however, is able to provide far more career-relevant information than simply an index of general aptitude or academic ability. Most factor analyses of the ASVAB report a four-factor solution (*e.g.*, Ree, Mullins, Mathews, & Massey, 1982; Stoloff, 1983; Waters, Barnes, Foley, Steinhaus, & Brown, 1988). These four factors typically include: (a) a verbal factor composed of Word Knowledge and Paragraph Comprehension; (b) a math factor composed of Arithmetic Reasoning and Mathematics Knowledge; (c) a technical factor that is composed of Auto & Shop, Mechanical Comprehension, and Electronics Information; and, (d) a speeded test factor composed of Coding Speed and Numerical Operations. These findings suggest that the ASVAB could provide far more comprehensive career-related information about students' skills and competencies than simply an estimate of general ability. Optimally, it should be able to provide students with reliable information about their verbal, mathematical, technical skills, and quickness of cognitive response to timed stimuli.

In 2002, Accession Policy decided, and the Services agreed, to drop Numerical Operations and Coding Speed from the ASVAB test battery, leaving eight ASVAB tests intact in a reordered sequence. The remaining eight ASVAB tests administered in the Career Exploration Program are: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Auto & Shop Information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI). Based on prior factor analyses, it seems reasonable to expect that the deletion of the two speeded tests would simply eliminate the speeded factor, leaving the other three factors basically intact. As such, factor analysis of the eight remaining ASVAB tests should reveal the presence of three major factors: a verbal, a mathematical, and a technical factor.

To determine if the remaining eight ASVAB tests would produce such a three-factor solution as expected, an exploratory factor analysis (EFA) was conducted on the 1980 Profile of American Youth (PAY80) data. These data were obtained from the nationally representative sample of 11,914 men and women ages 16 through 23 who took the ASVAB as part of the 1979 National Longitudinal Survey of

Youth Labor Force Behavior (NLSY79). The data from these participants were weighted to be equivalent to the entire population of 16 to 23 year olds in the United States (Bock & Mislevy, 1981). Table 1 reports the correlations among the eight ASVAB tests and their means and standard deviations.

Table 1

Intercorrelations of ASVAB Subtest Standard Scores for the 1980 Youth Population

	GS	AR	WK	PC	AS	MK	MC	EI	Mean	SD
GS	1.00	.74	.82	.71	.66	.71	.71	.77	49.04	10.35
AR		1.00	.73	.70	.56	.83	.70	.68	49.25	10.23
WK			1.00	.81	.57	.70	.63	.71	48.95	10.38
PC				1.00	.47	.67	.56	.61	49.19	10.58
AS					1.00	.45	.75	.76	48.86	10.18
MK						1.00	.62	.60	49.62	10.26
MC							1.00	.76	49.23	10.21
EI								1.00	48.84	10.31

Note. Data downloaded from the Bureau of Labor Statistics website (http://www.bls.gov/nls/nlsy79.htm) on 26 June 2009. N = 11,914. GS = General Science, AR = Arithmetic Reasoning, WK = Word Knowledge, PC = Paragraph Comprehension, AS = Auto & Shop Information, MK = Math Knowledge, MC = Mechanical Comprehension, EI = Electronics Information.

This correlation matrix was submitted to a maximum likelihood factor analysis. (Auto and Shop was not included because of the very large and pronounced gender differences on Auto and Shop scores.) Prior to factoring the seven ASVAB Subtests, the Kaiser-Meyer-Olkin (Kaiser, 1974) measure of sampling adequacy (KMO) and the Bartlett (1950) test of sphericity were calculated. These tests help to assess the degree to which a correlation matrix is suitable for factor analytic exploration (Dziuban & Shirkey, 1974). The values of both indicated that factor analysis was highly appropriate given the correlation matrix. The KMO, which ranges from zero to one, was .90, which Kaiser (1974) describes as "marvelous" *(p.* 33) and the Bartlett test of sphericity yielded a highly significant result $\chi^2(630, N = 11{,}912) = 76681.37, p < .0001$.

Because the matrix was suitable for exploratory factor analyses, the ASVAB correlation matrix was submitted to a maximum likelihood factor analysis. Based on both the Scree test (Cattell, 1966) and an analysis of the residual correlation matrix, three factors, accounting for 89.1% of the variance, were extracted (λ = 5.22, 0.57, and 0.45) and retained for analysis. The residual correlation matrix was calculated based on the three-factor solution. When the factor solution is adequate, the residuals are fairly close to zero in value, indicating that the extracted factors do indeed account for the observed correlations. If the residuals are relatively small, additional factors, even when statistically significant, do not appreciably improve the solution. In the present case, the residual matrix demonstrated that the three-factor solution provided an almost perfect fit. A standard rule of thumb is that fewer than 5% of the residuals should exceed .05. Using absolute values, the average of the residuals was .003, and the largest residual was .004. The very high (.98) Tucker-Lewis reliability coefficient provides substantial evidence that the analysis produced a viable solution accounting for a significant portion of the variance. Table 2 reports the Promax-rotated factor pattern matrix. These factor pattern coefficients express the relationship between the ASVAB test and the factor. The items with coefficients with an absolute value of .45 or higher were used to define the content of each of the three factors. Based on this criterion, the first factor is clearly a verbal factor because of its high loadings from Word Knowledge (.95) and Paragraph

Comprehension (.70). The second factor is clearly a math skills factor, with high loadings from Arithmetic Reasoning (.80) and Math Knowledge (.83). The third factor puts together General Science (.45), Mechanical Comprehension (.72) and Electronics Information (.89) to form a science and technical factor. With only minor variations, these three factors mirror those reported previously, and provide a basis for an expanded use of the ASVAB in the Career Exploration Program. This analysis supports the creation and use of separate scores (verbal, math, and science and technical) for career exploration purposes. The first two factors are the same as the Verbal Ability and Math Ability scores previously employed in the ASVAB 18/19 Program. While students received these scores, they were not used for career exploration purposes. Instead, they were combined together into the overall Academic Ability Index. The third factor, the Science and Technical Factor represents a revised composite for use in career exploration. The high communalities indicate that these three factors account for a substantial proportion of the variance of each of the ASVAB subtests.

Table 2

PAY80 ASVAB Factor Pattern Matrix Coefficients

	Rotated Factor Pattern Coefficients			
ASVAB Test	Verbal	Math	Science and Technical	Communality
GS	.41	.10	**.45**	.80
AR	.04	**.80**	.15	.87
WK	**.95**	-.03	.09	.95
PC	**.70**	.23	.02	.72
MK	.10	**.83**	.04	.80
MC	-.10	.20	**.72**	.73
EI	.10	-.08	**.89**	.82

Note. GS = General Science, AR = Arithmetic Reasoning, WK = Word Knowledge, PC = Paragraph Comprehension, MK = Math Knowledge, MC = Mechanical Comprehension, EI = Electronics Information. Defining factor loadings are bolded.

The Verbal Skills factor comprises both Word Knowledge and Paragraph Comprehension, and appears to be a reading comprehension factor. This factor assesses the degree to which examinees can read, understand and interpret written material correctly. This is clearly seen in the content of the two ASVAB tests:

Word Knowledge assesses an examinee's ability to understand the meaning of words through synonyms - words having the same or nearly the same meaning as other words. The test is a measure of one component of reading comprehension since vocabulary is one of many factors that characterize reading comprehension.

Paragraph Comprehension assesses an examinee's ability to obtain information from written material. Examinees read passages (*i.e.*, expositions, biographies, advertisements, and editorials) of varying lengths and respond to incomplete statements and questions based upon information presented in each passage. The items assess literal comprehension (*i.e.*, identify stated facts and reworded facts and determine sequence of events) and inferential/critical comprehension (i.e., draw conclusions, identify main ideas, determine author's purposes and modes/tones, and identify styles and techniques).

The Mathematics Skills factor comprises both Arithmetic Reasoning and Mathematics Knowledge, and appears to be a mathematics skills factor. This factor assesses examinees' mathematics fluency. This is clearly seen in the content of the two ASVAB tests:

> Arithmetic Reasoning assesses an examinee's ability to solve basic mathematical problems one encounters in everyday life. One-step and multi-step word problems require examinees to add, subtract, multiply, and divide, choosing the correct order of operations when more than one step is necessary. The items include operations with whole numbers, operations with rational numbers, ratio and proportion, interest and percentage, and measurement (*e.g.,* perimeter, area, volume, time/temperature). Arithmetic reasoning is one factor that helps characterize mathematics comprehension and it also provides a valid measure of logical thinking.

> Mathematics Knowledge assesses an examinee's ability to solve mathematical problems by applying knowledge of mathematical concepts and applications. The mathematical problems focus on concepts and algorithms and involve number theory, numeration, algebraic operations and equations, geometry and measurement, and probability. Mathematics knowledge is one factor, which characterizes mathematics comprehension; it also provides a valid measure of logical thinking.

The revised Science and Technical composite for use in the ASVAB CEP consists of General Science, Mechanical Comprehension and Electronics Information. This factor is not as easily defined as were the Verbal and Math Skills factors. This partially is due to the structure of the factor and partially due to the widespread and historical usage of the Verbal and Math Ability factors in the previous ASVAB 18/19 Program. The relatively lower standardized pattern coefficient for GS (.45) suggests that its contribution to this factor is as a general knowledge foundation upon which the more specialized knowledge assessed in MC and EI rest. However, there is still a strong coherence in this third factor that emerges on examination of the content of the three ASVAB tests that comprise this factor:

> General Science assesses an examinee's ability to answer questions on a variety of science topics. The topics are drawn from courses taught in most high schools. The life science items cover the subject areas of botany, zoology, anatomy and physiology, and ecology. The earth/space science items are based on the subject areas of astronomy, geology, and meteorology/oceanography. The physical science items are drawn from force and motion mechanics, energy, fluids, atomic structure, and chemistry.

> Mechanical Comprehension assesses an examinee's aptitude for comprehending the principles of mechanical devices and certain material concepts. Mechanical comprehension topics include simple machines (*e.g*., lever, wedge, pulley), compound machines (*e.g.,* gears, belts, pistons, linkages), mechanical motion (*e.g*., velocity, acceleration, friction), fluid dynamics (*e.g*., atmospheric pressure, hydraulic pressure, "Bernoulli" principle), properties of materials (*e.g.,* expansion, contraction, gravity), and structural support (*e.g.,* trusses, cantilevers, arches).

> Electronics Information assesses an examinee's understanding for electrical current, circuits, devices, and systems. Electronics Information topics include electrical tools, symbols, devices, and materials (*e.g*., soldering irons, transistors, cables); electrical circuits; electrical/electronic systems (*e.g*., generators, radios, TVs, computers); and electrical currents (*e.g*., voltage, resistance, conductivity).

Because the factors were rotated to simple structure by Promax, they are not orthogonal (*i.e*., correlated) to each other. One would expect the Verbal factor to correlate considerably with the other two factors. This is because answering questions correctly on the ASVAB requires first that the questions be read and understood. Only then can the questions be answered correctly. One would also expect the Math factor to correlate substantially with the Science and Technical factor, based on the belief that mathematics is foundational to the understanding of both scientific and technological principles. While all of these correlations are higher than anticipated (Verbal – Math r = .76; Verbal – Science and Technical r = .76; Math – Science and Technical r = .75), they are not inconsistent with expectations.

Because the factor analysis suggested strongly that these three factors could be derived from the ASVAB tests, these three composites were created using the PAY80 data. The reliability of the three composites was calculated separately by grade and gender to determine whether these composites could be used in the revised ASVAB Program. IRT methods determined that the reliability coefficients ranged from a low of .84 to a high of .92 (see Table 3) and were sufficiently high to warrant the creation of the appropriate norms. These three composites are named, respectively, Verbal, Math, and Science and Technical Skills Career Exploration Scales and indicate students' proficiencies in these three broad domains.

Table 3

Reliability Coefficients for the Three Composites by Grade and Gender
Based on PAY80 Sample

	Verbal Skills		Math Skills		Science and Technical Skills	
Grade Level	Males	Females	Males	Females	Males	Females
10th	.93	.92	.92	.90	.91	.84
11th	.93	.92	.93	.92	.91	.85
12th	.92	.92	.93	.92	.91	.86
Postsecondary	.84	.87	.92	.91	.90	.87

Verbal Skills is a general measure of vocabulary and reading skills covered in the Word Knowledge and Paragraph Comprehension tests. People with high scores tend to do well in tasks that require good vocabulary or reading skills, while people with low scores have more difficulty with such tasks. Math Skills is a general measure of mathematics skills covered in the Mathematics Knowledge and Arithmetic Reasoning tests. People with high scores tend to do well in tasks that require knowledge of mathematics, while people with low scores have more difficulty with these kinds of tasks. Science and Technical Skills is a general measure of science and technical skills covered in the General Science, Electronics Information, and Mechanical Comprehension tests. People with high scores tend to do well in tasks that require scientific thinking or technical skills, while people with low scores have more difficulty with such tasks.

The Creation and Initial Validation of Career Exploration Scores for Use in the ASVAB Career Exploration Program Based on the Profile of American Youth (1997)

In 1997, the ASVAB was renormed based on a large representative national probability sample as a part of an updated Profile of American Youth (PAY97) project. This large-scale research project was sponsored by the U.S. Department of Defense (DoD) with the cooperation of the U.S. Department of Labor (DoL). PAY97 was intended to update the older national norms for the ASVAB. The norming samples were drawn to be representative nationally of two groups of American youth and hence to support two programs of interest to DoD: (a) the Enlistment Testing Program (ETP), which provided an assessment of about 6,000 American youth age 18-23 as of June 1, 1997, with oversampling for Hispanic and Non-Hispanic Black youth; and, (b) the Career Exploration Program (CEP), which provided an assessment of approximately 4,700 youth who were expected to be enrolled in grades 10, 11, and 12 as of fall 1997. The ASVAB norms for grades 10, 11, and 12 were derived from CEP data. Norms for students in postsecondary schools (2-year colleges) were derived from the ETP data. All testing was conducted under standardized conditions at Sylvan Learning Centers using a Computerized Adaptive Testing (CAT) version of the ASVAB. Serious efforts were expended to encourage participation in the testing. Respondents who agreed to participate in the approximately 1.5 hours of testing were paid $75 as an incentive. The overall completion rate was about 75 percent of eligible youth, and completion rates were similar for the various grades. The postsecondary sample was part of the larger ETP sample. The test completion rate for this larger sample was 77 percent of eligible youth. The bulk of the sample screening and testing was completed in the summer and fall of 1997, with some testing continuing through April 1998. Additional information on the collection and verification of the norming data can be found elsewhere (Moore, Pedlow, Krishnamurty & Wolter, 2000; Sims & Hiatt, 2001).

Since the existence, scoring and reliability of the three career exploration factors were derived from the 1980 norming of the ASVAB, there was concern that new norms might invalidate the use of the factors. To determine if the ASVAB still produces a three factor solution as expected, a factor analysis was conducted on the 1997 Profile of American Youth (PAY97) data weighted to be equivalent to the entire population of 16 to 23 year olds in the United States. Table 4 reports the correlations among the eight ASVAB tests and their means and standard deviations.

Table 4

Intercorrelations Among ASVAB Subtest Standard Scores for the 1997 Youth Population

	GS	AR	WK	PC	AS	MK	MC	EI	Mean	SD
GS	1.00	.71	.80	.71	.56	.69	.71	.70	47.88	9.90
AR		1.00	.65	.71	.44	.81	.67	.59	47.27	10.01
WK			1.00	.74	.48	.64	.62	.64	47.33	9.38
PC				1.00	.36	.70	.61	.58	45.80	11.64
AS					1.00	.32	.65	.67	42.54	7.72
MK						1.00	.60	.53	51.25	9.64
MC							1.00	.69	45.45	9.74
EI								1.00	43.02	8.94

Note. N = 4,631 weighted to represent the population of 16 to 23 year olds in the United States. GS = General Science, AR = Arithmetic Reasoning, WK = Word Knowledge, PC = Paragraph Comprehension, AS = Auto & Shop Information, MK = Math Knowledge, MC = Mechanical Comprehension, EI = Electronics Information.

A brief inspection of the correlations reported in Table 1 and Table 4 shows relatively small differences between the two sets of correlations. This is easily seen in the two sets of correlations. The pattern of the correlations is quite similar for PAY80 and PAY97-based correlations ($r = .92$, $p < .001$). Further, the absolute difference between the corresponding correlations ranged from .00 to .13. Not surprisingly, the PAY80 and PAY97-based correlations had very similar median correlations of $r = .65$ and $r = .70$ respectively. Even so, because of the large sample sizes, Jennrich's (1970) test of the equality of the two correlation matrices revealed highly significant differences between them χ^2 (28, N = 16,545) = 718.355, $p < .0001$. Cramer's Φ_c, an often used effect size measure for χ^2, revealed a small corresponding effect size ($\Phi_c = .21$). Therefore, while the patterns and median values are similar and only marginally different from each other, the two sets of correlations are not equivalent.

Consequently, one would expect factor analysis results of the PAY97 data to mirror those from the PAY80 data. To confirm this expectation, the PAY97 correlation matrix was submitted to confirmatory factor analysis (CFA). CFA is grounded in a hypothesis testing tradition and tests specific hypothesis about both the number and content of underlying common factors in a test battery. Specifically, CFA was employed to test the three-factor model of the ASVAB common factor variance that emerged from the PAY80 data, again, leaving out AS because of the extreme gender differences on AS that would be a potential confound in the factor analysis. It was hypothesized that the Verbal Skills factor, Mathematics Skill Factor, and Science and Technology factors would account for the intercorrelations found in the PAY97 nationally representative sample as they did in the PAY80 nationally representative sample.

The explicit factor model submitted to CFA (EQS 6.1 for Windows; Bentler, 1995) was that the factors that underlie the ASVAB in this population are the Verbal, Mathematics, and Science and Technical Skills factors composed of the specific ASVAB subtests listed above. The CFA results were as one might expect. Based on standard rule-of-thumb practices, Schumacker and Lomax (2004) suggested three criteria for assessing the adequacy of the model fit to the data. The first criterion is the overall test of significance of the model fit to the data. Nonsignificant results with a corresponding low error term suggest an adequate fit to the data. In the present case, the global index suggested a poor degree of fit of the three-factor model to the data, $\chi^2(11, N = 4{,}631) = 897.57$, $p < .001$. However, because this model fit index is highly sensitive to the sample size, it often is divided by the corresponding degrees of freedom to calculate an adjusted value "free" of the inflation due to sample size. In the present case this adjusted value, $\chi^2 = 81.59$, also was higher than generally hoped for as a measure of good fit. The other major index of overall fit, the root-mean-square-error (RMSE = .132) is higher than the value of .10 advocated as a rule of thumb by Schumacker and Lomax. Their third criteria consists of an examination of various fit indices, with a cutoff value of at least .90 for such indices as the Bentler-Bonet normed fit index (NFI), Tucker-Lewis index (TLI), comparative fit index (CFI), goodness of fit index (GFI), and the adjusted goodness of fit index (AGFI). As reported in Table 5, these values mostly exceeded .90 as recommended by Schumacker and Lomax. Based on these three criteria, the three-factor model can be seen to be a marginally adequate fit to the data.

Such rules-of-thumb, however, have been questioned seriously on both theoretical and empirical grounds. Recently, Hu and Bentler (1999) tested the adequacy of such rules-of-thumb in a large-scale study employing simulated data. They tested how well the various practices were able to detect misspecification errors in model fit using the various rule-of-thumb approaches. Based on their results, the various standard rules (*e*.g., those advocated by Schumacker and Lomax, 2004) had high misspecification errors. That is, the application of these sorts of rules led to relatively high rates of either or both Type I and Type II errors. The results of their large-scale simulations and analyses led them to conclude:

> "we recommend that practitioners use a cutoff value close to .95 for TLI (BL89, RNI, CFI or Gamma Hat [GFI]) in combination with a cutoff close to .09 for SRMR to evaluate model fit. In general, a cutoff value of .96 for TLI, BL89, RNI, CFI or Gamma Hat [GFI], in combination with SRMR < .09 (or .10) resulted in the least sum of Type I and Type II error rates" (*p*. 27).

Since the majority of the fit indices (*e.g.*, NFI, BL89, CFI) mentioned above are at least .95, and the SRMR is less than .06 (see Table 5), the model demonstrates the degree of fit advocated by Hu and Bentler and should be retained.

Table 5

Goodness of Model Fit Indices

Overall Model Fit Indices	Value
Bentler-Bonet Normed Fit Index (NFI)	.980
Tucker-Lewis Index (TLI)	.931
Comparative Fit Index (CFI)	.980
Bollen's Fit Index (BL89)	.980
McDonald's Fit Index (MFI)	.909
Goodness of Fit Index (GFI)	.940
Adjusted Goodness of Fit Index (AGFI)	.846
Residual Fit Indices	
Root Mean Square Residual (RMR)	.029
Standardized RMR (SRMR)	.029
Root Mean-Square Error of Approximation (RMSEA)	.132

Since the model seems to fit the data, strongly suggesting that the three skills factors underlie the ASVAB subtests in this population, it is appropriate to examine the resulting standardized regression coefficients. These values ranged between .78 (EI with Science and Technical) to .92 (AR with Mathematics), as reported in Table 6. When the coefficients are close in magnitude, as they are in the present case, it also is appropriate to use unit weighting if constructing scales to represent the underlying factors. Such is clearly the case for the three factors.

Table 6

PAY97 ASVAB CFI Standardized Regression Coefficients

	ASVAB Career Exploration Skill Factors		
ASVAB Test	Verbal	Mathematics	Science and Technical
WK	.87		
PC	.85		
AR		.92	
MK		.89	
GS			.92
MC			.79
EI			.78

Note. GS = General Science, AR = Arithmetic Reasoning, WK = Word Knowledge, PC = Paragraph Comprehension, MK = Math Knowledge, MC = Mechanical Comprehension, EI = Electronics Information.

As in PAY80, the Verbal Skills factor comprises both Word Knowledge and Paragraph Comprehension, and appears to be a reading comprehension factor. This factor assesses the degree to which examinees can read, understand and interpret written material correctly. The Mathematics Skills factor comprises both Arithmetic Reasoning and Mathematics Knowledge, and appears to be a mathematics skills factor.

As in the PAY80 analysis, this new composite for use in the ASVAB Program consists of General Science, Mechanical Comprehension and Electronics Information. This factor is not as easily defined as were the Verbal and Math Skills factors. This partially is due to the structure of the factor and partially due to the widespread and historical usage of the Verbal and Math Ability factors in the previous ASVAB 18/19 Program. In this new factor, GS assesses the general science knowledge foundation upon which the more specialized knowledge assessed in MC and EI rest. As such, there is a strong coherence in this third factor that emerges based on the content of the three ASVAB tests that comprise this factor.

As was the case in the EFA, one would expect the Verbal factor to correlate considerably with the other two factors. This is because answering questions correctly on the ASVAB requires first that the questions be read and understood. Only then can the questions be answered correctly. One would also expect the Math factor to correlate substantially with the Science and Technical factor, based on the belief that mathematics is foundational to the understanding of both scientific and technological principles. While all of these correlations are quite high (Verbal – Math r = .87; Verbal – Science and Technical r = .94; Math – Science and Technical r = .85), they are not inconsistent with expectations, though they are considerably larger than the factor intercorrelations resulting from the EFA of the PAY80 data.[1] There are a number of potential causes for these larger factor intercorrelations. The higher factor intercorrelations in the PAY97 data may reflect the larger intercorrelations in the PAY97 data relative to the PAY80 data (r_{median} = .65 and .70 for the PAY80 and PAY97 data respectively.) Moreover, Lee and Ashton (2007), for example, ague that caution should be employed in the direct comparison of the magnitude of the parameters derived from EFA to those derived through CFA because of the different assumptions of the two forms of factor analysis. Regardless, the CFA and EFA results mirror each other and provide a strong foundation for the creation and use of the Verbal, Math and Science and Technical composites based on the factor analysis results.

Because the factor analysis suggested strongly that these three factors could be derived from the ASVAB tests, these three composites were created using the PAY97 data. The reliability of the three composites was calculated separately by grade and gender to determine whether these composites could be used in the revised ASVAB Program. The IRT-based reliability coefficients ranged from a low of .87 to a high of .97 (see Table 7) and were sufficiently high to warrant the creation of the appropriate norms.

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[1] Given the high factor intercorrelations, a one-factor model composed of the seven ASVAB tests also was tested. This model specifies that it is general intelligence – *g* – that accounts for the intercorrelations among the ASVAB scales. This one-factor model evidenced marginally adequate goodness of fit indices (CFI = .96, NFI = .96, TLI = .82, GFI = .52, AGFI = .05, RMR = .08; SRMR = .08, RMSEA = .168) with a corresponding $\chi^2(14)$ = 1833.58. When compared to the three-factor model, the one-dimensional model was strongly rejected since the three factor model [$\chi^2(11)$ = 897.57] was statistically a much better fitting model, $\chi^2(3)$ = 937.51, p < .0001. Some (*e.g*., Ree & Carretta, 1994) have argued that the structure of the ASVAB is hierarchical in nature, that is general intelligence – *g* - is a higher order construct that is expressed through the first-order factors. In this model, the three skill importance factors are hypothesized to be expressions of one general factor that gives rise to the three skill importance factors. It tests specifically that the three skill importance factors themselves form one general factor. This hierarchical model was tested and provided a marginal fit to the data based on the goodness of fit indices (CFI = .96, NFI = .96, TLI = .96, GFI = .94, AGFI = .83). But it failed to meet the criteria specified by Hu and Bentler (1999), with a SRMR = .154, much larger than the suggested value of .09 - .10, with a corresponding $\chi^2(12)$ = 1140.50. This model was a statistically poorer fit than was the three factor model, $\chi^2(1)$ = 107.81, p < .0001.

These three composites are named, respectively, the Verbal, Math, and Science and Technical Skills Career Exploration Scales and indicate students' proficiencies in these three broad domains.

Table 7

Reliability Coefficients for the Three Composites by Grade and Gender
Based on PAY97 Sample

	Verbal Skills		Math Skills		Science and Technical Skills	
Grade Level	Males	Females	Males	Females	Males	Females
10th	.89	.89	.87	.97	.89	.88
11th	.90	.90	.91	.91	.91	.90
12th	.90	.90	.91	.91	.91	.90

Linking the Three Career Exploration Scales to Occupational Proficiency

O*NET™ is a comprehensive database of worker attributes and job characteristics for over 1,000 occupations in the US (Peterson, Mumford, Borman, Jeanneret, & Fleishman, 1999; online documentation and materials are available at www.onetcenter.org/research.html/O*NET). O*NET™ contains information about the knowledge, skills, abilities, interests, general work activities and labor market information about these occupations.

Of particular importance in the present context are the worker requirements, a category of descriptors that refer to work-related characteristics acquired through experience or education. Chief among these are the approximately 110 KSAs - knowledge (sets of facts and principles needed to address problems and issues that are part of a job), skills (the ability to perform a task well), and abilities (enduring talent that can help a person do a job) - needed to perform successfully in an occupation (O*NET™, 2010). For each of the occupations in the O*NET™ database, either expert job analysts, job supervisors, or job incumbents have rated the degree of importance each of the KSAs hold for a particular occupation. Further, the degree of proficiency needed to perform satisfactorily in the occupation also is rated.

In a number of ways, these KSAs can be considered to encompass the content of an occupation. That is, they provide a key as to what is needed to perform on-the-job functions in a satisfactory fashion. They provide a look into the content of an occupation and describe in concrete terms what workers must know and do to perform the job. In many ways, they are analogous to the item content of a test, since both perform the same function of operationalizing the domain in question. As such, one way to link test content to job performance would be through an analysis of the KSAs in light of test content. In other words, if the KSAs for an occupation indicate that math skills are important and that math proficiency is necessary for job success, job incumbents could be expected – on average – to demonstrate proficiency on math tests. If the KSAs for an occupation indicate that verbal skills and abilities are relatively unimportant, and that successful job performance does not require such verbal ability, job incumbents on average probably will not demonstrate high levels of verbal fluency. As such, it seems a reasonable way to link test content and scores with occupational requirements would be through an analysis of the relationship between test item content and the KSAs that best describe particular occupations.

In an effort to link the three ASVAB Career Exploration Scales (Verbal Skills, Math Skills, and Science and Technical Skills) to the KSAs that describe each of the O*NET™ occupations, each of the 110 O*NET™ KSAs were independently scrutinized by two personnel research psychologists with several years of experience in the career development and industrial/organizational psychology fields. Utilizing the major tenets of the consensual qualitative research paradigm (Hill, Thompson, & Williams, 1997), the judges identified 26 KSAs that had at least a moderately strong probability of being related to the test content of one or more of the ASVAB tests that contributed to the Verbal, Mathematics or Science and Technical Skills composites identified through the factor analyses. These KSAs are reported in Table 9.

Table 9

Initial List of O*NET™ KSAs Potentially Related to ASVAB Test Content

KSA	O*NET™ Scale Name	KSA Text
Knowledge	Biology	Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment
Knowledge	Building and Construction	Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads
Knowledge	Chemistry	Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.
Knowledge	Computers and Electronics	Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming
Knowledge	Engineering and Technology	Knowledge of the practical application of engineering science and technology This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.
Knowledge	English Language	Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar
Knowledge	Mathematics	Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications
Knowledge	Mechanical	Knowledge of machines and tools, including their designs, uses, repair, and maintenance
Knowledge	Physics	Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes
Skill	Equipment Maintenance	Performing routine maintenance on equipment and determining when and what kind of maintenance is needed
Skill	Equipment Selection	Determining the kind of tools and equipment needed to do a

KSA	O*NET™ Scale Name	KSA Text
		job
Skill	Installation	Installing equipment, machines, wiring, or programs to meet specifications
Skill	Mathematics	Using mathematics to solve problems
Skill	Operation and Control	Controlling operations of equipment or systems
Skill	Reading Comprehension	Understanding written sentences and paragraphs in work-related documents
Skill	Repairing	Repairing machines or systems using the needed tools
Skill	Science	Using scientific rules and methods to solve problems
Skill	Technology Design	Generating or adapting equipment and technology to serve user needs
Skill	Trouble Shooting	Determining causes of operating errors and deciding what to do about it
Ability	Deductive Reasoning	The ability to apply general rules to specific problems to produce answers that make sense
Ability	Inductive Reasoning	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events)
Ability	Information Ordering	The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (*e.g.,* patterns of numbers, letters, words, pictures, mathematical operations)
Ability	Mathematical Reasoning	The ability to choose the right mathematical methods or formulas to solve a problem
Ability	Number Facility	The ability to add, subtract, multiply, or divide quickly and correctly
Ability	Oral Comprehension	The ability to listen and understand information and ideas presented through spoken words and sentences
Ability	Written Comprehension	The ability to read and understand information and ideas presented in writing

Note. O*NET™ KSAs judged to be potentially related to the content of the ASVAB Arithmetic Reasoning, Math Knowledge, Paragraph Comprehension, Word Knowledge, General Science, Mechanical Comprehension, or Electronics Information tests.

A set of expert judges was identified and asked to participate in a questionnaire study of the relationship between ASVAB test content and these 26 KSAs. The expert judges were asked to assess how well they thought ASVAB tests could be used to assess the degree to which an individual may have met particular KSAs. Specifically, judges were told:

> "In this survey, we are asking you to assess how well ASVAB subtests could be used to assess the degree to which individuals may have met a number of knowledge, skills, and abilities (KSAs). The 26 KSAs in this survey are a subset of the over 100 KSAs used in the O*NET. In a preliminary study, each of these KSAs was judged to be at least somewhat related to at least one of the ASVAB subtests. In this study, we are interested in refining the list of ASVAB-related KSAs."

Each judge was presented with a list of 26 KSAs from O*NET™ and the test content for particular ASVAB tests. The ASVAB tests assessed in this study were those that define the Verbal, Math, and Science and Technical Skills factors of the ASVAB. Using a six-point scale ranging from *Highly related* to *Not at all related,* the judges were asked to assess the degree to which each individual KSA is related to the particular ASVAB subtest. The relationships between the 26 O*NET™ KSAs and the content of the four ASVAB Verbal and Math Skills tests were assessed by 9 expert judges. These judges included two industrial/organizational psychologists, four other types of psychologists, and three psychometricians. Their years of experience in the field ranged from 1 to 20, averaging 9.0 year (SD = 6.0 years). Seven had Ph.D. degrees while two held MA degrees. The relationships between the 26 O*NET™ KSAs and the content of the three ASVAB Science and Technical tests were assessed by 14 expert judges. These judges included five industrial/organizational psychologists, three other types of psychologists, and four psychometricians. Their years of experience in the field ranged from 1 to 40, averaging 13.5 year (SD = 11.4 years). Twelve had Ph.D. degrees while two held MA degrees. The means and standard deviations of their ratings are reported in Table 10.

Their ratings on the 26 KSAs were assessed for interrater reliability to determine the degree to which the judges agreed that particular KSAs were related to particular ASVAB test content. Given that two judges had already eliminated the 84 KSAs that appeared unrelated to ASVAB test content, the empirical reliabilities generated from the two panels of expert judges represent an underestimate of the true interrater reliability. Even so, the interrater reliability estimates were consistently positive and high at both the scale and composite levels, as reported in Table 11. These high levels of interrater reliability show that the expert judges were able to agree to a large extent that knowing an individual's score on the particular ASVAB test could provide a reliable way to assess the person's degree of mastery of the 26 particular KSAs presented in the questionnaire.

Table 10
Expert Judges' Ratings for 26 O*NET™ KSAs by ASVAB Subtests

	ASVAB Test Content Domain													
	Arithmetic Reasoning		Mathematics Knowledge		Word Knowledge		Paragraph Comprehension		General Science		Mechanical Comprehension		Electronics Information	
O*NET™ KSA	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
The ability to add, subtract, multiply, or divide quickly and correctly.	5.67	0.71	5.56	1.33	1.67	1.66	2.22	1.72	3.93	1.69	3.43	1.34	2.86	2.86
The ability to listen and understand information and ideas presented through spoken words and sentences.	3.00	1.94	3.11	2.03	4.22	1.72	4.44	1.74	3.50	1.56	2.57	1.60	2.50	2.50
Knowledge of machines and tools, including their designs, uses, repair, and maintenance.	1.11	0.33	1.67	1.32	1.11	0.33	1.11	0.33	2.43	1.28	5.57	1.16	2.50	2.50
Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.	5.89	0.33	6.00	0.00	1.67	1.66	1.67	1.66	3.71	1.27	3.36	1.55	2.93	2.93
Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.	1.11	0.33	1.13	0.35	1.33	0.71	1.22	0.44	5.71	0.47	1.07	0.27	1.00	1.00
The ability to apply general rules to specific problems to produce answers that make sense.	4.56	1.24	4.22	0.97	2.67	1.66	3.44	1.13	5.07	1.14	4.21	1.58	3.93	3.93
Generating or adapting equipment and technology to serve user needs.	1.44	0.88	1.67	1.00	1.11	0.33	1.11	0.33	2.29	1.49	4.71	0.73	3.93	3.93
The ability to choose the right mathematical methods of formulas to solve a problem.	5.78	0.44	5.89	0.33	1.89	1.69	2.22	1.72	3.71	1.68	3.64	1.69	2.79	2.79
Knowledge of the structure and content of the English language including the meaning and spelling	2.22	1.30	2.89	1.76	5.67	0.71	5.78	0.44	1.79	0.89	1.57	0.85	1.43	1.43

	ASVAB Test Content Domain													
	Arithmetic Reasoning		Mathematics Knowledge		Word Knowledge		Paragraph Comprehension		General Science		Mechanical Comprehension		Electronics Information	
O*NET™ KSA	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
of words, rules of composition, and grammar.														
The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).	3.67	1.73	4.33	1.32	3.11	1.62	4.89	1.05	4.57	1.22	3.71	1.54	3.14	3.14
Using scientific rules and methods to solve problems.	3.78	1.64	4.22	1.09	1.78	0.97	2.67	1.00	5.71	1.07	4.07	1.73	3.29	3.29
The ability to read and understand information and ideas presented in writing.	4.11	1.36	3.44	1.88	6.00	0.00	5.89	0.33	4.21	1.25	3.07	1.54	3.29	3.29
Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.	1.78	1.39	2.00	1.73	1.56	1.33	1.56	1.33	1.79	0.80	2.57	1.79	5.29	5.29
Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.	1.67	1.12	2.11	1.27	1.22	0.67	1.56	0.73	3.08	1.61	5.07	1.38	3.79	3.79
Installing equipment, machines, wiring, or programs to meet specifications.	1.22	0.44	1.11	0.33	1.44	1.01	1.22	0.44	1.64	1.01	4.71	1.33	4.29	4.29
Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and	1.22	0.67	1.33	0.71	1.11	0.33	1.11	0.33	5.29	0.91	1.43	.76	1.29	1.29

	ASVAB Test Content Domain													
	Arithmetic Reasoning		Mathematics Knowledge		Word Knowledge		Paragraph Comprehension		General Science		Mechanical Comprehension		Electronics Information	
O*NET™ KSA	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.														
Determining causes of operating errors and deciding what to do about it.	1.56	0.73	1.44	0.73	1.56	0.88	1.44	0.53	2.50	1.45	4.36	1.34	3.93	3.93
Determining the kind of tools and equipment needed to do a job.	1.56	0.73	1.22	0.44	1.33	0.71	1.22	0.44	2.14	1.35	4.50	1.51	3.36	3.36
Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes.	2.00	1.23	2.11	1.76	1.33	0.50	1.22	0.44	5.86	0.36	4.79	1.93	3.43	3.43
Using mathematics to solve problems.	6.00	0.00	6.00	0.00	2.00	1.66	1.78	1.64	3.86	1.29	3.57	1.34	3.29	3.29
Performing routine maintenance on equipment and determining when and what kind of maintenance is needed.	1.00	0.00	1.33	0.50	1.11	0.33	1.22	0.44	1.43	0.85	3.43	1.91	3.00	3.00
Repairing machines or systems using the needed tools.	1.11	0.33	1.11	0.33	1.11	0.33	1.11	0.33	1.14	0.53	3.57	1.79	3.00	3.00
The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (*e.g.,* patterns of numbers, letters, words, pictures,	4.22	1.39	4.56	1.01	3.56	1.42	3.78	1.48	3.50	1.09	2.86	1.51	3.14	3.14

	ASVAB Test Content Domain													
	Arithmetic Reasoning		Mathematics Knowledge		Word Knowledge		Paragraph Comprehension		General Science		Mechanical Comprehension		Electronics Information	
O*NET™ KSA	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
mathematical operations).														
Understanding written sentences and paragraphs in work-related documents.	2.44	1.67	2.56	1.88	5.78	0.44	5.67	0.50	3.07	1.64	2.85	1.46	2.71	2.71
Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads.	1.22	0.44	1.22	0.44	1.11	0.33	1.22	0.44	1.29	0.83	4.07	1.90	1.71	1.71
Controlling operations of equipment or systems	1.11	0.33	1.11	0.33	1.11	0.33	1.11	0.33	3.93	1.09	4.29	1.49	3.71	3.71

Table 11

O*NET™ Composite Reliability (α) Based on KSAs Judged Related to ASVAB Test Content

ASVAB Composite or Scale	α
Verbal Composite	.94
Word Knowledge	.88
Paragraph Comprehension	.86
Math Composite	.87
Arithmetic Reasoning	.84
Mathematics Knowledge	.80
Science and Technical Composite	.94
General Science	.93
Mechanical Comprehension	.79
Electronics Information	.90

Judges' six-point ratings were averaged together for each of the 26 KSAs. Any KSA that had an average of 4.00 or greater was retained, while those KSAs with an average lower than 4.00 were discarded. This meant that KSAs for which the judges' collective (average) judgment was that the KSA was highly related, moderately highly related, or moderately related were retained for further analysis. Those KSAs for which the judges' collective (average) judgment was that the KSA was somewhat related, slightly related, or not at all related were discarded. This procedure led to the retention of 5 KSAs that were related to the Verbal Composite, 9 KSAs related to the Math Composite, and 16 KSAs related to the Science and Technical Composite (see Table 12).

Table 12

Retained O*NET™ KSAs Related to ASVAB Test Composite Content Based on Judge's Ratings

ASVAB Verbal Composite	KSA	KSA Text
Inductive Reasoning	A	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
Written Comprehension	A	The ability to read and understand information and ideas presented in writing.
Oral Comprehension	A	The ability to listen and understand information and ideas presented through spoken words and sentences.
English Language	K	Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.
Reading Comprehension	S	Understanding written sentences and paragraphs in work-related documents.
ASVAB Math Composite		
Deductive Reasoning	A	The ability to apply general rules to specific problems to produce answers that make sense.
Inductive Reasoning	A	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among

		seemingly unrelated events).
Written Comprehension	A	The ability to read and understand information and ideas presented in writing.
Number Facility	A	The ability to add, subtract, multiply, or divide quickly and correctly.
Mathematical Reasoning	A	The ability to choose the right mathematical methods of formulas to solve a problem.
Information Ordering	A	The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (*e.g.,* patterns of numbers, letters, words, pictures, mathematical operations).
Mathematics	K	Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.
Science	S	Using scientific rules and methods to solve problems.
Mathematics	S	Using mathematics to solve problems.
ASVAB Science and Technical Composite		
Deductive Reasoning	A	The ability to apply general rules to specific problems to produce answers that make sense.
Inductive Reasoning	A	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
Written Comprehension	A	The ability to read and understand information and ideas presented in writing.
Mechanical	K	Knowledge of machines and tools, including their designs, uses, repair, and maintenance.
Biology	K	Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.
Computers and Electronics	K	Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.
Engineering and Technology	K	Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.
Chemistry	K	Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.
Physics	K	Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes.

Building and Construction	K	Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads.
Technology Design	S	Generating or adapting equipment and technology to serve user needs.
Science	S	Using scientific rules and methods to solve problems.
Installation	S	Installing equipment, machines, wiring, or programs to meet specifications.
Trouble Shooting	S	Determining causes of operating errors and deciding what to do about it.
Equipment Selection	S	Determining the kind of tools and equipment needed to do a job.
Operation and Control	S	Controlling operations of equipment or systems

Note. A = ability; K = knowledge; S = skill.

The goal at this step of the process was to combine the KSAs together such that for each of the three ASVAB composites, there would be a corresponding maximally correlated O*NET™ KSA composite (see Table 12.) So, the ASVAB composites are defined by summing scores received on the subtest listed in Table 13 under each ASVAB composite. The corresponding O*NET™ composite would be defined by combining together the ratings on the particular KSAs listed in Table 13 under each O*NET™ composite.

Table

Retained O*NET™ KSAs Related to ASVAB Test Composite Content

ASVAB Verbal Composite		O*NET™ Verbal Composite	
WK	Word Knowledge	A	Inductive Reasoning
PC	Paragraph Comprehension	A	Written Comprehension
		A	Oral Comprehension
		K	English Language
		S	Reading Comprehension
ASVAB Math Composite		**O*NET™ Math Composite**	
AR	Arithmetic Reasoning	A	Deductive Reasoning
MK	Math Knowledge	A	Inductive Reasoning
		A	Written Comprehension
		A	Number Facility
		A	Mathematical Reasoning
		A	Information Ordering
		K	Mathematics
		S	Science
		S	Mathematics

ASVAB Science and Technical Composite		O*NET™ Science and Technical Composite	
GS	General Science	A	Deductive Reasoning
MC	Mechanical Comprehension	A	Inductive Reasoning
EI	Electronics Information	A	Written Comprehension
		K	Mechanical
		K	Biology
		K	Computers and Electronics
		K	Engineering and Technology
		K	Chemistry
		K	Physics
		K	Building and Construction
		S	Technology Design
		S	Science
		S	Installation
		S	Trouble Shooting
		S	Equipment Selection
		S	Operation and Control

Note. A = ability; K = knowledge; S = skill.

The next step was to decide on the appropriate O*NET™ criterion variable to relate to the ASVAB Career Exploration Composites. Figure 1 displays two examples taken directly from the data collection questionnaires used by O*NET™. The first is for Information Ordering, while the second is from Multilimb Coordination, both Ability items. As can be seen, there are two types of KSA ratings in the O*NET™ database: importance and performance level. The KSA importance rating asked "How important is {KSA} to the performance of this job?" and performance level rating asked "What level of {KSA} is needed to perform this job?" Importance was assessed on a standard five-point scale ranging from 1 (not important) to 5 (extremely important). Level was assessed via seven-point behaviorally anchored rating scales (BARS) that provided the raters with anchors specifically related to the particular KSA being rated. As might be expected, importance and level ratings are highly correlated. For these 26 KSAs across the 1,018 O*NET™ occupations, the correlations (uncorrected for unreliability) ranged in magnitude from .75 to .97. The average correlation between the importance and level ratings was .91, with a standard deviation of .06. When this correlation is corrected for unreliability in the ratings, it increases to .97 suggesting that for these KSAs, the level of knowledge, skill or ability needed to perform the job activity is almost perfectly predicted by the level of importance of the job activity for the occupation. One conclusion is that in the O*NET™ database, the importance of any of these particular KSAs for an occupation is highly predictive of the performance level of the KSA needed to perform the job.

In determining whether to use importance or performance level ratings for the KSAs hinged on two important considerations, one psychometric and the other developmental in nature. Performance level was assessed in terms of the descriptors provided to "anchor" ratings to particular performance levels. To combine performance level ratings together would require that a rating have the same meaning across all of the KSAs. For example, a rating of "6" would have to be commensurate across all of the KSAs that would be combined together. Often, this is not the case because the nature of behaviorally-anchored ratings scales makes such additivity suspect (Kinicki & Bannister, 1988). Consider the ratings for performance in Figure 1. For Information Ordering "Assembling a nuclear warhead" is rated 6; for Multilimb Coordination a 6 refers to "Play a drum set in a jazz band." Conceptually, since both are rated as a 6, one could argue that they represent the same level of performance in their respective domains. While this may be true, it seems disingenuous on its face. It would be difficult to make sense of any type of score created by summing or averaging together such ratings. Consequently, from a psychometric perspective, it would be difficult to construct a meaningful scale by combining such ratings together (Kinicki & Bannister, 1988).

10. Information Ordering — **The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations).**

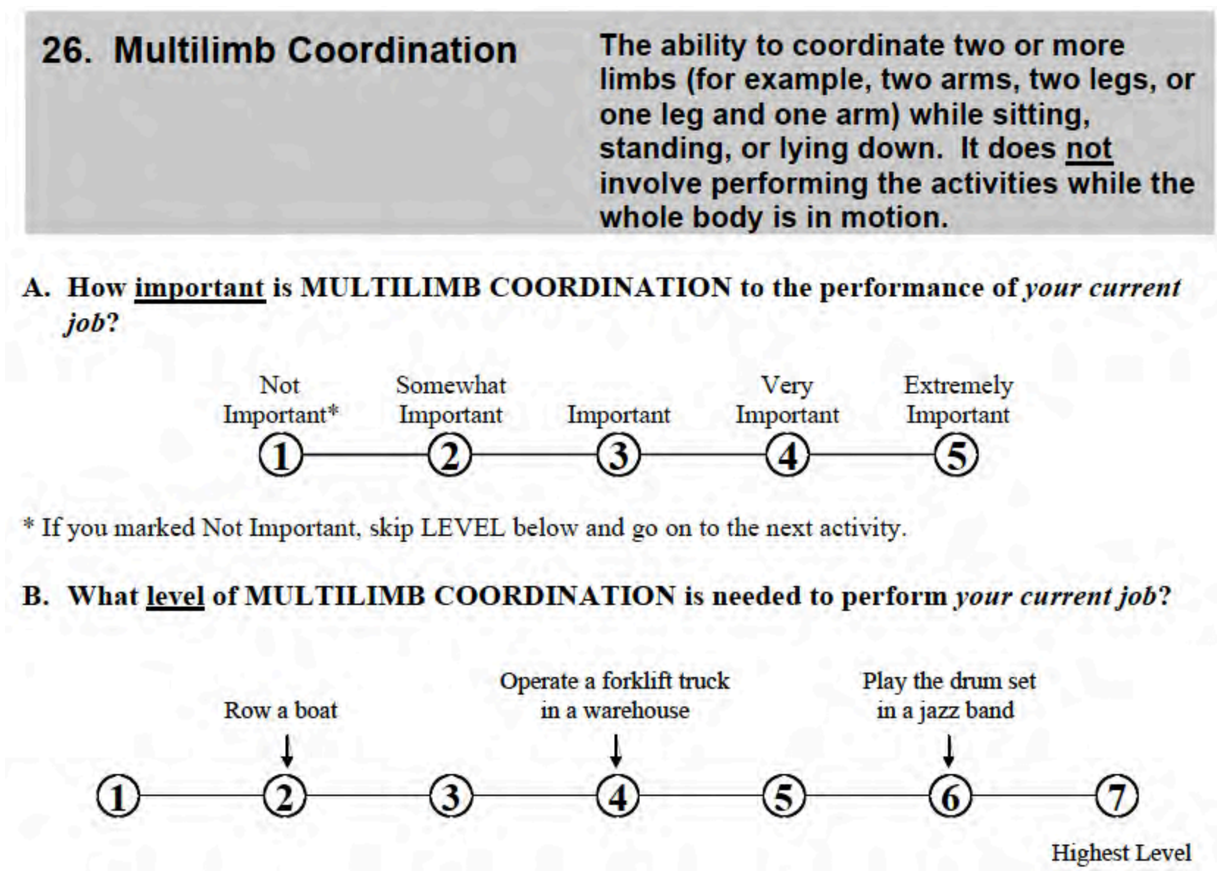
A. How important is INFORMATION ORDERING to the performance of *your current job*?

Not Important*	Somewhat Important	Important	Very Important	Extremely Important
1	2	3	4	5

* If you marked Not Important, skip LEVEL below and go on to the next activity.

B. What level of INFORMATION ORDERING is needed to perform *your current job*?

Put things in numerical order	Follow the correct steps to make changes				Assemble a nuclear warhead	
1	2	3	4	5	6	7
						Highest Level



26. Multilimb Coordination

The ability to coordinate two or more limbs (for example, two arms, two legs, or one leg and one arm) while sitting, standing, or lying down. It does not involve performing the activities while the whole body is in motion.

A. How important is MULTILIMB COORDINATION to the performance of *your current job*?

Not Important* (1) — Somewhat Important (2) — Important (3) — Very Important (4) — Extremely Important (5)

* If you marked Not Important, skip LEVEL below and go on to the next activity.

B. What level of MULTILIMB COORDINATION is needed to perform *your current job*?

(1) — (2) Row a boat — (3) — (4) Operate a forklift truck in a warehouse — (5) — (6) Play the drum set in a jazz band — (7) Highest Level

Figure 1. O*NET™ rating form for Ability KSAs Information Ordering and Multilimb Coordination.

Conversely, the importance ratings appear to be commensurate as the scale anchors are the same for all of the KSAs, ranging from “Not Important” to “Extremely Important.” As such, a rating of 3 – “Important” - whether for Information Ordering or for Multilimb Coordination has the same connotation and underlying meaning. Therefore, these could be combined together in a meaningful way. Scores on such a scale would indicate the degree of importance those particular KSAs have for satisfactory performance in the particular occupation. If so, it would argue that adolescents could gauge the desirability of such occupations based on the degree of importance placed on the particular KSAs for successful job performance. Second, utilizing importance rather than performance level is consistent with a number of models of adolescent career exploration. Expanding on Jordaan’s (1963) view of exploration, Grotevant (1987) argues that adolescent investment of time, energy and affect in a domain is proportional to the importance placed on that domain. So, if adolescents find math important they are likely to explore potential careers in which math is important. If they find math unimportant, they are unlikely to invest time exploring such occupations.

Consequently, it was decided to use the KSA importance ratings because they are on a common scale, they are additive, they correlate substantially with the level ratings, and they facilitate career exploration.

The appropriate KSA (Table 12) importance ratings were averaged together to create the three O*NET™ composite variables that correspond to the ASVAB Verbal, Math, and Science and Technical Skill composites. Table 14 reports basic descriptive information about these three O*NET™ composites. The reliability estimates (α) range from .82 to .91. ANOVA revealed that the three composites differ in importance $F(2, 1015) = 442.43$, $p < .0001$, with each significantly different from the other $p < .0001$. Clearly, the O*NET™ occupations differ systematically in the importance ratings for the three composite areas. Overall, it appears that verbal skills are judged more important than are either math or science and technical skills. Further, it appears that the three composites are significantly and positively correlated with each other. Only the high correlation between the Verbal and the Math composite ($r = .77$) appears problematic because it suggests that occupations with high importance ratings on the Verbal composite may also have high importance ratings on the Math composite. If so, it may be difficult to find occupations with high importance ratings on the Verbal composite and low importance ratings on the Math composite, or vice versa.

Table 14

O*NET™ Occupation Verbal, Math and Science and Technical Composite Descriptive Information

O*NET™ Composite	Mean	SD	α	Correlations V	M	ST
Verbal (V)	2.93	.75	.91	1.00	.77	.13
Math (M)	2.72	.75	.90		1.00	.47
Science/Technical (ST)	2.20	.48	.82			1.00

Note. N = 1,108 occupations listed in the O*NET™ database. Means, standard deviations and correlations based on a five-point scale from 1 (Not Important) to 5 (Extremely Important) in the performance of the occupation. All correlations significant at the .01 level.

To facilitate the use of these composite ratings, the occupations needed to be classified into a small number of clusters that would reflect the relative importance of Verbal, Math and Science and Technical KSAs. It was decided that a three-cluster solution would be appropriate for exploration purposes. This would essentially place each occupation into a High, Medium or Low cluster on each of the three KSA importance composites. In doing so, it was important to ensure that within-cluster occupations were maximally similar in their importance ratings, and the between-cluster similarity was minimized. One way to accomplish this task is through cluster analysis employing Ward's (1963) method to simultaneously minimize within-cluster variance and maximize between-cluster variance. Ward's method was set to determine three levels of importance (high, medium, and low) for each of the three importance composites. In these types of situations, Ward's method generally tends to produce clusters with approximately equal number of elements. This will be essential if these composites are to be useful for career exploration, as it will provide a large number of potential occupations in each of the high, medium and low importance clusters. While Ward's method does not create specific cut-points that differentiate among the high, medium and low importance clusters, it can be used to determine those cut-points. This was accomplished by finding the midpoint between the element with the smallest score in the high importance cluster and the element with the highest score in the medium importance cluster, repeating the procedure with the medium and low importance clusters. The cut-points and number of occupations in each of the importance clusters, as defined by the results of the cluster analysis employing Ward's method, are reported in Table 15.

Table 15

O*NET™ Occupation Composite Index Cut Points

	Range Cut-Points			Number of Occupations		
O*NET™ Composite	Low	Medium	High	Low	Medium	High
Verbal	1.29 – 2.67	2.68 – 3.44	3.45 – 4.66	407	318	293
Math	1.17 – 2.26	2.27 – 3.17	3.18 – 4.63	267	494	257
Science/Technical	1.13 – 1.77	1.78 – 2.44	2.45 – 3.79	223	492	303

Note. *N* = 1,108 occupations listed in the O*NET™ database. Range cut-points based on a five-point scale from 1 (Not Important) to 5 (Extremely Important) in the performance of the occupation.

One of the strong motivations for revising the ASVAB Program was to provide expanded career exploration opportunities for all students who participate in the revised program regardless of the academic capability of the participant. It was hoped that linking together three ASVAB composites to their corresponding KSA-based 'footprints' in the O*NET™ 3.1 database would broaden participants' horizons beyond that which was available under the older *g*-based system. This could only be the case if the placement of occupations in one composite (*e.g*., high) is not matched by its placement in other composites (*e.g*., also high). To assess this possibility, a series of cross tabulations were conducted to see how many occupations were designated in the same importance level across the three composites. Tables 16 through 18 report these two-way cross-tabulations. In each case, every cell of the resulting 3 X 3 table was populated with at least some occupations. Consistent with the high correlation between the Verbal and Math composites (r = .77), there were only 19 occupations with a grouping of High on one composite and low on the other.

Table 16

O*NET™ Occupations: Verbal by Math Importance Cluster

Verbal	Mathematics Importance Cluster			
Importance Cluster	Low	Medium	High	Total
Low	222	177	8	407
Medium	34	216	68	318
High	11	101	181	293
Total	267	494	257	1018

Table 17

O*NET™ Occupations: Verbal by Science and Technical Importance Cluster

Science and Technical	Verbal Importance Cluster			
Importance Cluster	Low	Medium	High	Total
Low	65	92	66	223
Medium	251	118	123	492
High	91	108	104	303
Total	407	318	293	1018

Table 18

O*NET™ Occupations: Math by Science and Technical Importance Cluster

Science and Technical	Mathematics Importance Cluster			
Importance Cluster	Low	Medium	High	Total
Low	87	110	26	223
Medium	165	234	93	492
High	15	150	138	303
Total	267	494	257	1018

The next step was to determine the relationship between the skill importance ratings and career interests. To do so, a series of cross tabulations was conducted that compared the importance clusters with the O*NET-assigned RIASEC code for each of the 1,018 occupations. It was hoped that for each of the RIASEC dimensions, there would be a corresponding set of occupations in the high, medium, and low importance clusters. These cross-tabulations, reported in Tables 19 – 21, reveal only a few instances where there are no occupations. For example, there are no O*NET™ occupations that are typed as Investigative and have low importance in Verbal or Math Skills. While this could be an artifact of the methodology, it seems reasonable that given the nature of Investigative occupations, there would be few – if any -occupations that rate verbal or math skills as relatively low in importance.

Table 19

Verbal Importance Cluster by RIASEC Domain

	Verbal Importance Cluster			
RIASEC Domain	Low	Medium	High	Total
Realistic	370	132	23	525
Investigative	0	18	88	106
Artistic	9	27	22	58
Social	11	33	47	91
Enterprising	7	47	71	125
Conventional	10	61	42	113
Total	407	318	293	1018

Table 20

Math Importance Cluster by RIASEC Domain

	Math Importance Cluster			
RIASEC Domain	Low	Medium	High	Total
Realistic	202	260	63	525
Investigative	0	19	87	106
Artistic	25	30	3	58
Social	19	55	17	91
Enterprising	8	66	51	125
Conventional	13	64	36	113
Total	267	494	257	1018

Table 21

Science and Technical Importance Cluster by RIASEC Domain

	Science and Technical Importance Cluster			
RIASEC Domain	Low	Medium	High	Total
Realistic	40	290	195	525
Investigative	3	27	76	106
Artistic	30	20	8	58
Social	26	57	8	91
Enterprising	49	67	9	125
Conventional	75	31	7	113
Total	223	492	303	1018

Determining Final Occupations for the OCCU-Find

Now that the O*NET™ occupations were successfully linked to the ASVAB content through the three career exploration factors, it was time to determine which of the 1,018 O*NET™ occupations would be included in the OCCU-Find. The OCCU-Find is a career exploration tool that display and organizes occupational information to facilitate career exploration. For each occupation listed, the OCCU-Find contains the occupational title, RIASEC interest codes, and the importance level for the three importance clusters. It was determined that the OCCU-Find should include enough occupations to facilitate career exploration and development, yet not so many that it would overwhelm participants with too many potential choices. Based on these considerations, it was decided that the final OCCU-Find should contain between 400 and 500 occupations.

In selecting occupations, a number of criteria were deemed important. Some of these criteria pertained to occupational characteristics, and some pertained to the characteristics of the final list of occupations. In selecting occupations, a 'representative sampling' approach was employed that was designed to select occupations such that the final list would be similar in nature and content to the entire list of occupations in the O*NET™ database. In doing so, two personnel research psychologists with several years of experience in the career development and industrial/organizational psychology fields considered the entire set of O*NET™ occupations for inclusion. Each analyst sought to provide a final list that contained both civilian and military occupations, occupations with large numbers of employees, occupations with a high expected growth rate over the next ten years, and occupations with relatively good socioeconomic status. Of paramount importance was for each to select occupations with a mix of high, moderate, and low importance ratings for each of the three composites in each of the RIASEC domains.

An iterative consensus procedure was employed (Hill, Thompson, & Williams, 1997) to determine the final list of OCCU-Find occupations. In the first phase, the two analysts independently selected the occupations they believed met the specified criteria, as well as the additional criteria each believed important based on their experience and judgment. As Table 22, reports, these initial lists were quite similar. The analysts agreed on 295 occupations that should be included and on 560 occupations that should not be included in the OCCU-Find. Given the task, this high level of agreement (84%) and reliability ($\kappa = .66$, $p < .001$) was fairly surprising.

Table 22

Initial OCCU-Find Analyst Agreement Matrix

	First Analyst		Analyst
Second Analyst	Exclude Occupation	Include Occupation	Totals
Exclude Occupation	560 (55.0%)	102 (10.0%)	662 (65.0%)
Include Occupation	61 (6.0%)	295 (29.0%)	356 (35.0%)
Analyst Totals	621 (62.0%)	397 (39.0%)	1018 (100/0%)

The analysts then discussed the occupations, paying special attention to the 163 occupations for which there was disagreement. After considerable discussion, the two analysts came to consensus over all 1,018 occupations in the O*NET™ database. They decided that 431 (42%) of the occupations met the specified occupational criteria to be included in the OCCU-Find, while the remaining 587 occupations failed to meet the specified criteria for inclusion.

The final list of OCCU-Find occupations was scrutinized to ensure that it covered sufficiently the three importance domains. To assess this, a series of cross tabulations were conducted to ensure that every cell of the resulting 3 X 3 tables contained at least some occupations. Tables 23 - 25 report these two-way cross-tabulations. In only one cell was there no occupations: Low Verbal Importance by High Math Importance. As such, it appears the process was quite successful in identifying occupations in all of the possible configurations.

Table 23

OCCU-Find Occupations: Verbal by Math Importance Matrix

Verbal Importance Cluster	Mathematics Importance Cluster: Low	Medium	High	Total
Low	58	35	0	93
Medium	21	110	31	162
High	10	58	108	176
Total	89	203	139	431

Table 24

OCCU-Find Occupations: Verbal by Science and Technical Importance Matrix

Science and Technical Importance Cluster	Verbal Importance Cluster: Low	Medium	High	Total
Low	33	53	46	132
Medium	41	63	74	178
High	19	46	56	121
Total	93	162	176	431

Table 25

OCCU-Find Occupations: Math by Science and Technical Importance Matrix

Science and Technical Importance Cluster	Math Importance Cluster: Low	Medium	High	Total
Low	51	65	16	132
Medium	33	90	55	178
High	5	48	68	121
Total	89	203	139	431

Similarly, the OCCU-Find occupations also need to cover the RIASEC domains with regard to the three importance clusters as well. To assess this, a series of cross tabulations were conducted to see how many occupations were designated in each RIASEC domain. It was hoped that for each of the RIASEC dimensions, there would be a corresponding set of occupations in all three levels of the Verbal, Math and Science and Technical importance clusters. These cross-tabulations are reported in Tables 26 – 28, and show only few instances where there are no occupations.

Table 26

OCCU-Find Occupations: Verbal Importance Cluster by RIASEC Domain Matrix

	Verbal Importance Cluster			
RIASEC Domain	Low	Medium	High	Total
Realistic	67	44	12	123
Investigative	0	15	50	65
Artistic	9	22	22	53
Social	7	28	31	66
Enterprising	5	18	37	60
Conventional	5	35	24	64
Total	93	162	176	431

Table 27

OCCU-Find Occupations: Math Importance Cluster by RIASEC Domain Matrix

	Math Skill Composite			
RIASEC Domain	Low	Medium	High	Total
Realistic	40	60	23	123
Investigative	0	15	50	65
Artistic	23	27	3	53
Social	14	37	15	66
Enterprising	6	29	25	60
Conventional	6	35	23	64
Total	89	203	139	431

Table 28

OCCU-Find Occupations: Science and Technical Importance Cluster by RIASEC Domain Matrix

	Science and Technical Skill Composite			
RIASEC Domain	Low	Medium	High	Total
Realistic	15	50	58	123
Investigative	3	19	43	65
Artistic	28	17	8	53
Social	20	39	7	66
Enterprising	25	33	2	60
Conventional	41	20	3	64
Total	132	178	121	431

2008 Revision of the OCCU-Find

It is cliché to point out that the American occupational landscape has experienced considerable change over the last two decades. This change, fueled by technological innovation, changing workforce demographic characteristics, immigration and globalization, and employer needs and wants, necessitates periodic revision of career exploration programs and materials (Brown, 2006). Consequently, the ASVAB CEP decided to revise the OCCU-Find in 2008 to keep it fresh, up to date, current, and useful for adolescents engaging in career exploration and development.

This section describes the changes reflected in the 2008 revision of the OCCU-Find. The 2008 OCCU-Find includes revisions in two critical areas. First, a new methodology for generating the importance ratings was developed, tested and validated. Second, this new methodology was employed to select occupations for inclusion in an updated and expanded OCCU-Find that would provide even more opportunities for adolescents' occupational and career exploration than was available in the 2002 OCCU-Find.

Development of the New Methodology for Deriving Skill Importance Ratings

As discussed previously, the 2002 OCCU-Find Importance Ratings originally were derived from the knowledge, skills and ability (KSAs) ratings in the O*NET™ 3.1 database. In revising and updating these ratings, it seemed natural to turn to the O*NET™ database, which itself had gone through a continuing process of development and revision. This seemed to be the natural place to begin the OCCU-Find revision process. Unfortunately, because of the changing nature of the O*NET™, reliance on the KSAs seemed inadvisable for three reasons.

First, the nature of the KSA ratings in O*NET™ had changed from 2002 to 2008 in ways that made them less suitable for the purposes of the ASVAB Program. Since the release of the first complete database in 2002 (O*NET™ 4.0), the O*NET™ database has been updated eight times. Due in part to the large number of occupations, the database was updated in phases, with updates to a subset of occupations accomplished in each phase. Such a process would result in KSAs that would be updated for some of the occupations, but not for others in the O*NET™ database. This meant that some of the KSAs would be based on more current information than other ratings, which could lead to unpredictable importance ratings. As such, the uneven process used to update the database could prove insufficient to form the strong foundation needed to support high quality career exploration. Moreover, while the initial O*NET™ KSA ratings were generated primarily by occupational analysts, subsequent ratings were provided by both occupational analysts and job incumbents. These differential sources of KSA ratings for the updated occupations did not seem equivalent to the analyst ratings of the non-updated occupations.

Second, while O*NET™ does include military occupations that have civilian counterparts (*e.g.*, dental hygienists, clerks, bookkeepers, psychologists), it does not include military-specific occupations (*e.g.,* special forces, artillery crew members). Because of this, independent analysts rated the 15 military-specific occupations in the 2002 OCCU-Find using the same definitions of the Verbal, Math, and Science and Technical importance composites. While the ratings appeared to have consistency and to portray accurately the military occupations, the process was costly and time-consuming. Because it was unwieldy it would make little sense to adapt the process for large-scale use. Further, the process could potentially lead to unpredictable skill importance ratings since the analysts could not apply the same criteria to the military occupations as did the O*NET™ analysts in their ratings of the similar civilian occupations. As Brown (2006) has pointed out, not including military-specific occupations in adolescent career exploration hampers exploration by giving adolescents an incomplete picture of their potential occupational opportunities.

Finally, the O*NET™ KSAs were not developed specifically for career exploration purposes. While they can be used to support adolescent career exploration under very defined and specific conditions, there may be more suitable and useful kinds of ratings that can be used in this regard. For example, the 2002 Verbal Importance Composite focused solely on reading comprehension and written communication skills. High school students, in reviewing the skill requirements of occupations, are likely to consider Verbal Skills in a broader context. As such, the O*NET™ -derived OCCU-Find ratings might not satisfactorily address the career exploration purposes of the ASVAB Program.

Methodology Selection

Consequently, several alternatives to relying solely on O*NET™ data for the OCCU-Find KSA ratings were proposed and investigated. A new methodology for generating Skill Importance Ratings could allow consistent ratings to be given both to military and civilian occupations and could lessen the dependence on O*NET™. In selecting a new methodology for deriving Skill Importance Ratings, three options were considered:

Option 1: Develop interim ratings using the same O*NET™ -derived approach.

Option 2: Conduct independent analysis of occupational information, using O*NET™ data as part of a more comprehensive set of information to establish ratings.

Option 3: Conduct independent analysis with review and validation conducted by subject matter experts (SMEs) and job incumbents.

These three options are described below, along with the rationale for selection of the final methodology to update and revise the OCCU-Find skill importance ratings.

*Option 1: Develop Interim Ratings Using O*NET™ -Derived Approach*. The first approach was to use the updated data in O*NET™ to generate new Skill Importance Ratings. Using the same KSAs as were used in the 2002 OCCU-FIND, this approach would have involved the following five steps:

1. Identify which of the OCCU-Find occupations had been updated in the O*NET™ database.
2. Using the 2002 OCCU-Find, conduct statistical analyses to determine if statistically significant KSA differences existed between the occupations updated in the current O*NET™ database and those that were not updated. If such difference were found, derive statistical formulae to model and "equate" for these differences.
3. Using the same algorithm from the 2002 OCCU-Find, calculate updated Skill Importance Ratings for the updated occupations. Then, compare these updated ratings with those from the 2002 OCCU-Find to determine how they differ and to derive statistical formulae to model those differences.
4. Using the formulae derived in the previous steps, transform the "Old Ratings" into "New Ratings" for those OCCU-Find occupations not yet updated in O*NET™.
5. Determine reliability and validity indices for the entire set of current O*NET™ occupations. These would be compared with the indices derived from the previous O*NET™ database. This

would act both as a measure of quality control and as a way to help ensure continuity among the occupations selected for inclusion into the OCCU-Find.

This approach would rely almost entirely on statistical criteria to make sure that the new KSA ratings were consistent with and derivable from the ratings in the 2002 O*NET™ database. Unfortunately, such consistency could not be guaranteed; even if it existed, it would be potentially volatile because it would need to be reestablished every time new occupations were added or updated in the O*NET™ database. Moreover, this approach would not address the issue for military-specific occupations, requiring a separate process for generating Skill Importance Ratings for military-specific occupations. Therefore, after consideration, this approach was rejected.

*Option 2: Conduct independent analysis of occupational information using O*NET™ data as part of a more comprehensive set of information to establish ratings.* Next, a methodology that would rely on independent analysis of occupational information was considered. Rather than statistically transforming O*NET™ KSA ratings into Skill Importance Ratings, occupational analysts would generate Skill Importance Ratings based on a review of the appropriate occupational information. The primary focus of the analysis would be on evaluating job task information to determine the importance of Verbal Skills, Math Skills, and Science and Technical Skills. In this approach, O*NET™ KSA data would be used to inform the rating process, but would not be the sole information source on which ratings are based.

In this approach, different teams of two analysts would make the ratings. Within each team, each analyst would independently rate the importance of Verbal Skills, Math Skills, and Science and Technical Skills for the OCCU-Find occupations. Rules for identifying rater consistency and reliability, the magnitude of acceptable differences between the raters, and deciding how these differences would be dealt with would be established prior to the rating process. These rules would help to ensure that the ratings would be of sufficient quality to support the OCCU-Find. Analysts' ratings would be compared, and an initial estimate of interrater reliability would be derived based on the independent ratings. The two analysts would then identify the occupations in which they disagreed and employ the specified procedure to reach consensus. Ultimately, the final ratings would be the consensus-based team ratings based on the skills definitions and rating scales as a basis for determining the importance of Verbal, Math, and Science and Technical Skills for the OCCU-Find occupations.

Option 3: Conduct independent analysis with review and validation conducted by subject matter experts (SMEs) and job incumbents. The third approach would be similar to Option 2, with the primary difference being that SMEs or job incumbents would review the ratings developed by independent analysts. This would act as a check on the accuracy of the ratings provided by the analysts. As in the previous case, a set of rules would be created to handle situations in which discrepancies existed between the ratings provided by the analysts and those provided by the subject matter experts. This validation approach, while providing additional evidence for the validity of ratings, would also require a significant investment in time and energy. Moreover, it is doubtful that such an approach would be necessary or even useful for a system designed to inform and support adolescent career exploration.

After careful consideration, Option 2 was selected because it provided a consistent, replicable approach for generating Skill Importance Ratings for military-specific and civilian OCCU-Find occupations. In addition, it affords the opportunity and the discretion to provide Skill Importance Ratings that meet the intent of the ASVAB Career Exploration Program.

Development of Rating Materials

A thorough review of occupational data from O*NET™ and military sources prior to developing the materials needed to implement the new methodology was conducted. Current O*NET™ KSA data was provided as a reference, as were the O*NET™ KSA composites that comprised the existing Skill Importance Ratings for Verbal Skills, Math Skills, and Science and Technical Skills.

Development of Skills Definitions and Task Statements

The first step in developing rating materials was to operationally define the Verbal, Math and Science/Technical Skills dimensions in terms of the KSAs available in O*NET™. To do this, the tests that comprise the ASVAB Verbal, Math and Science and Technical skill composite dimensions were reviewed. Based on the content of the tests, four or five key sub-categories were identified for each skill composite dimension (see Table 29). Each of these further included several corresponding sample task statements covering a variety of occupations. Many of these task statements were based on the O*NET™ KSA questionnaires (O*Net Resource Center, 2010). This process was designed to align the tasks to the content of the ASVAB tests that define the Verbal, Math and Science and Technical skill composite dimensions.

Since analysts would be basing their ratings primarily on job and task descriptions, sample task statements were created for each of the Skill sub-categories. Analysts used these sample statements as a guideline to determine the degree to which successful completion of the specific occupational tasks required the skills and competencies implied by the content of the ASVAB tests that define the Verbal (WK, PC), Math (AR, MK), and Science and Technical Skills (GS, MC, EI) composites. These sample task statements were largely based on examples used in the O*NET™ KSA questionnaires. (O*NET Resource Center, 2010) The comprehensive set of Skills Definitions Sample Task Statements can be found in Appendix A.

Table 29
Definitions of the Three Skill Importance Dimensions

Verbal Skill Importance Dimension	
ASVAB Subtests	Content Sub Categories
<u>Word Knowledge</u> assesses an examinee's ability to understand the meaning of words through synonyms - words having the same or nearly the same meaning as other words. The test is a measure of one component of reading comprehension since vocabulary is one of many factors that characterize reading comprehension. <u>Paragraph Comprehension</u> assesses an examinee's ability to obtain information from written material. Examinees read passages (*i.e.*, expositions, biographies, advertisements, and editorials) of varying lengths and respond to incomplete statements and questions based upon information presented in each passage. The items assess literal comprehension (*i.e.*, identify stated facts and reworded facts and determine sequence of events) and inferential/critical comprehension (i.e., draw conclusions, identify main ideas, determine author's purposes and modes/tones, and identify styles and techniques).	Understand the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar. Communicate information and ideas effectively using written, oral, and visual media as appropriate for the needs of the audience. Organize ideas in a logical sequence (e.g. using correct grammar, syntax, punctuation, and spelling). Understand information and ideas presented through spoken words (listening) and written sentences (reading). Use logic and reasoning to identify: (a) main ideas; (b) patterns; (c) the strengths and weaknesses of alternative solutions; or, (d) approaches to problems.
Math Skill Importance Dimension	
ASVAB Subtests	Content Sub Categories
<u>Arithmetic Reasoning</u> assesses an examinee's ability to solve basic mathematical problems one encounters in everyday life. One-step and multi-step word problems require examinees to add, subtract, multiply, and divide, choosing the correct order of operations when more than one step is necessary. The items include operations with whole numbers, operations with rational numbers, ratio and proportion, interest and percentage, and measurement (e.g., perimeter, area, volume, time/temperature). Arithmetic reasoning is one factor that helps characterize mathematics comprehension and it also provides a valid measure of logical thinking. <u>Mathematics Knowledge</u> assesses an examinee's ability to solve mathematical problems by applying knowledge of mathematical concepts and applications. The mathematical problems focus on concepts and algorithms and involve number theory, numeration, algebraic operations and equations, geometry and measurement, and probability. Mathematics knowledge is one factor, which characterizes mathematics comprehension; it also provides a valid measure of logical thinking.	Compute and calculate: Add, subtract, multiply, or divide quickly and correctly. Choose the right mathematical methods or formulas to solve a problem involving number theory, numeration, algebraic operations and equations, geometry and measurement, and probability. Compile, interpret, evaluate, categorize, tabulate, audit, or verify information or data. Arrange things in a certain order or pattern according to a specific rule or set of rules (*e.g.,* patterns of numbers, mathematical operations). Identify, interpret, and use patterns, diagrams, or relationships among objects or items.

Science and Technical Skill Importance Dimension	
ASVAB Subtests	Content Sub Categories
General Science assesses an examinee's ability to answer questions on a variety of science topics. The topics are drawn from courses taught in most high schools. The life science items cover the subject areas of botany, zoology, anatomy and physiology, and ecology. The earth/space science items are based on the subject areas of astronomy, geology, and meteorology/oceanography. The physical science items are drawn from force and motion mechanics, energy, fluids, atomic structure, and chemistry. Mechanical Comprehension assesses an examinee's aptitude for comprehending the principles of mechanical devices and certain material concepts. Mechanical comprehension topics include simple machines (e.g., lever, wedge, pulley), compound machines (e.g., gears, belts, pistons, linkages), mechanical motion (e.g., velocity, acceleration, friction), fluid dynamics (e.g., atmospheric pressure, hydraulic pressure, "Bernoulli" principle), properties of materials (e.g., expansion, contraction, gravity), and structural support (e.g., trusses, cantilevers, arches). Electronics Information assesses an examinee's understanding for electrical current, circuits, devices, and systems. Electronics Information topics include electrical tools, symbols, devices, and materials (e.g., soldering irons, transistors, cables); electrical circuits; electrical/electronic systems (e.g., generators, radios, TVs, computers); and electrical currents (e.g., voltage, resistance, conductivity).	Apply principles, techniques, procedures, and equipment to the design and production of equipment and technology to serve user needs. Install, perform maintenance, and repair equipment, machines, wiring, or programs to meet specifications. Conduct tests and inspections of people, products, machines, services, or processes to evaluate health/quality, diagnose diseases, or determine causes of operating errors. Perform experiments, develop theories, and predict outcomes using knowledge of one of the following: a) physical principles and laws; b) life science principles and laws; c) electrical principles and laws; d) earth science principles and laws; e) social science principles. Select and operate machines, vehicles, and equipment adjusting controls to exact positions when necessary.

An example would be useful to clarify the relationship between the skill dimension content and the occupational tasks. The first sub-category for the Verbal Skills Dimension was: "Understand the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar." Operationally, the issue becomes "How would one determine if this skill was important in carrying out the duties of an occupation? In what occupational tasks and activities would we expect to see evidence for the importance of this skill?" The importance of this skill would be relatively evident in occupations, for example, in which it was important to: (a) proofread and correct a memo or report; (b) write a memo or report using proper grammar and syntax; (c) transcribe dictation from a medical report; (d) identify mistakes in technical reports and check with specialists to obtain correct information, or (e) type reports and other written material from rough drafts. As such, the degree to which these and similar occupational tasks were required would also be the degree to which verbal skills would be important for carrying out the duties of that occupation and for being successful in that occupation.

For each of the sub-categories within each of the skill composites, several appropriate task statements were created, with many based on the O*NET™ KSA questionnaires (O*NET Resource Center, 2010). Keeping this test content in mind, Table 30 reports the definitions and task statements provided for the Verbal Skills Composite. The complete set for all three skill composite dimensions along with their respective sample task statements is reported in Appendix A.

Table 30

Definitions and Sample Task Statements for the Verbal Skills Composite

Subcategory	Task Statements
Understand the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.	Proofread and correct a memo or report. Write a memo or report using proper grammar and syntax. Transcribe dictation from a medical report. Identify mistakes in technical reports and check with specialists to obtain correct information. Type reports and other written material from rough drafts.
Communicate information and ideas effectively using written, oral, and visual media as appropriate for the needs of the audience. Organize ideas in a logical sequence (e.g. using correct grammar, syntax, punctuation, and spelling.)	Written media Write a report to staff outlining new directives. Create a presentation. Write a newspaper article or book. Convince a superior in writing to buy a new copy machine. Write a detailed report following an investigation of a fire. Compose a letter in response to a customer complaint. Write technical documentation for software. Write a report outlining the results of a medical test. Oral media Conduct workshops. Deliver a presentation. Instruct a patient about using a medical device. Preside as judge or facilitate a dispute. Greet or guide tourists. Interview patients to obtain medical history. Argue a case in a courtroom. Present a strategic plan to upper management. Solicit donations for a charity. Counsel a student and/or athlete about college. Advise a patient about treatment options. Explain scientific principles to students. Interview applicants to obtain personal and work history. Answer customer questions and/or complaints about products and/or services. Visual Media Design a marketing brochure. Develop imagery for an advertising campaign, including graphics, photographs, animation, and video. Create graphics to best convey a message. Design a website. Develop multimedia presentation for a new product. Create training video.

Understand information and ideas presented through spoken words (listening) and written sentences (reading).	Listen to a patient and prepare treatment plan. Conduct a job interview. Read trade journals and convey information to coworkers. Take a customer's order. Follow verbal instructions. Read and follow step-by-step instructions. Read a memo from management. Understand an instruction book on repair and maintenance.
Use logic and reasoning to identify: (a) main ideas; (b) patterns; (c) the strengths and weaknesses of alternative solutions; and/or, (d) approaches to problems.	Analyze a new product/service through comparison and contrast. Determine whether a subordinate has a good excuse for being late. Evaluate customer complaints and determine appropriate responses. Write a legal brief challenging a federal law. Identify an alternative approach to help trainees who are having difficulties. Write a soil comparison study for a state agency. Determine leads in a case based on evidence; solve crimes. Diagnose a disease using results of many different tests.

Identification of O*NET™ KSAs

In the proposed methodology, O*NET™ KSA information supplemented the task information used by the raters. While not the sole basis for the Skill Importance Ratings, the information included in O*NET™ was extremely useful for the rating process. Raters would review the O*NET™ KSAs that were important for each occupation. This information would factor into the overall Skill Importance Ratings assigned to the occupation. As a starting point, the O*NET™ KSAs included as part of each skill composite in the 2002 OCCU-Find was used. From a content validity perspective, and as might be expected given the changing occupational landscape, these original 2002 O*NET™ KSAs did not address fully the occupational requirements for today's world of work. As such, 11 additional O*NET™ KSAs were included to more fully represent today's occupational tasks and thus to enhance the quality and usefulness of the ASVAB Program for adolescent career exploration. In the 2002 OCCU-Find, some O*NET™ KSAs were included in more than one skill composite. While this is in some ways reasonable in that it may more adequately represent the world of work for some occupations, it tends to decrease parsimony and the discriminant validity of the three composites. As such, a strong attempt was made to remove duplicates to improve parsimony and the discriminant validity of the three skill composites without an appreciable loss in reliability. This process led to the elimination of three duplicated KSAs, while retaining three (Skill – Science, Inductive Reasoning and Written Comprehension – Abilities.) The list of potential KSAs for inclusion in the new skills dimension composites, reported in Table 30, were submitted to a reliability analysis using the O*NET™ 3.1 database.

Standard reliability techniques were employed to decide which of these 41 potential KSAs would be retained as part of the final 2008 OCCU-Find skill dimensions composites. Based on these analyses, 10 KSAs were retained for the Verbal Composite ($\alpha = .96$), 9 KSAs were retained for the Mathematics Composite ($\alpha = .90$), and 17 KSAs were retained for the Science and Technical Composite ($\alpha = .88$). The retained KSAs are starred in Table 31.

Table 31

Initial List of O*NET™ KSAs Potentially Related to ASVAB Test Content: 2008 OCCU-Find

Verbal Composite	**KSA**	**KSA Text**
Inductive Reasoning*	A	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
Oral Comprehension*	A	The ability to listen and understand information and ideas presented through spoken words and sentences.
Oral Expression*	A	The ability to communicate information and ideas in speaking so others will understand.
Written Comprehension*	A	The ability to read and understand information and ideas presented in writing.
Written Expression*	A	The ability to communicate information and ideas in writing so others will understand.
Communications and Media*	K	Knowledge of media production, communication, and dissemination techniques and methods. This includes alternative ways to inform and entertain via written, oral, and visual media.
English Language*	K	Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.
Reading Comprehension*	S	Understanding written sentences and paragraphs in work-related documents.
Speaking*	S	Talking to others to convey information effectively.
Writing*	S	Communicating effectively in writing as appropriate for the needs of the audience.
Math Composite		
Deductive Reasoning*	A	The ability to apply general rules to specific problems to produce answers that make sense.
Inductive Reasoning*	A	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
Information Ordering*	A	The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (*e.g.,* patterns of numbers, letters, words, pictures, mathematical operations).
Mathematical Reasoning*	A	The ability to choose the right mathematical methods of formulas to solve a problem.
Number Facility*	A	The ability to add, subtract, multiply, or divide quickly and correctly.
Written Comprehension*	A	The ability to read and understand information and ideas presented in writing.
Mathematics*	K	Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.
Mathematics*	S	Using mathematics to solve problems.
Science*	S	Using scientific rules and methods to solve problems.
Science and Technical Composite		
Control Precision*	A	The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.
Deductive Reasoning	A	The ability to apply general rules to specific problems to produce answers that make sense.
Inductive Reasoning	A	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).

Spatial Orientation	A	The ability to know your location in relation to the environment or to know where other objects are in relation to you.
Written Comprehension	A	The ability to read and understand information and ideas presented in writing.
Biology*	K	Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.
Building and Construction*	K	Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads.
Chemistry*	K	Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.
Computers and Electronics*	K	Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.
Design	K	Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.
Engineering and Technology*	K	Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.
Mechanical*	K	Knowledge of machines and tools, including their designs, uses, repair, and maintenance.
Physics*	K	Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes.
Equipment Selection*	S	Determining the kind of tools and equipment needed to do a job.
Installation*	S	Installing equipment, machines, wiring, or programs to meet specifications.
Operation and Control*	S	Controlling operations of equipment or systems
Operation Monitoring*	S	Watching gauges, dials, or other indicators to make sure a machine is working properly.
Operations Analysis*	S	Analyzing needs and product requirements to create a design.
Quality Control Analysis*	S	Conducting tests and inspections of products, services, or processes to evaluate quality or performance.
Science*	S	Using scientific rules and methods to solve problems.
Technology Design*	S	Generating or adapting equipment and technology to serve user needs.
Trouble Shooting*	S	Determining causes of operating errors and deciding what to do about it.

Note. A = ability; K = knowledge; S = skill. Three KSAs appear in two composites – Science (S), Inductive Reasoning (A), and Written Comprehension (A). *Retained KSA.

Updates to the OCCU-Find Taxonomy

The occupations included in the OCCU-Find were updated to provide the most current set of occupations for career exploration purposes. The OCCU-Find titles were updated to reflect the updated O*NET™-SOC 2006 Taxonomy, to incorporate high demand occupations, and to reduce redundancy of occupational information. This section describes the process that was followed to update the OCCU-Find taxonomy.

O*NET™ completed a comprehensive update of its taxonomy in 2006. This update involved aggregating occupations, merging occupations, and subsuming some occupations under others in order to reflect the world-of-work more consistently and accurately. Taking advantage of this work, analysts reviewed all O*NET™ changes relevant to the OCCU-Find, and incorporated the same types of changes to the OCCU-Find taxonomy. In order to provide students with the most current list of occupational titles possible, the O*NET™ list of "In Demand" occupations was reviewed and incorporated. These occupations, according to O*NET™, are found within National High Growth Industries that are "are economically critical, projected to add substantial numbers of new jobs, and are being transformed by technology and innovation" (North Carolina Resource Network, 2008). In reviewing these occupations, the focus was on occupations that met three important criteria: (a) an average or better projected growth over the period 2004-2014; (b) projected need remained constant or increased; and (c) not already incorporated in the OCCU-Find. Then, all OCCU-Find titles were reviewed in order to reduce or eliminate occupational title redundancies and to provide a parsimonious set of occupations for students to explore. Similar to the O*NET™ updating process, this led to the merging of some occupations that had overlapping titles, job tasks, or KSAs.

One of the primary objectives of the ASVAB CEP is to provide a sufficient number of occupations for students with differing abilities and interests to explore. The process employed to update the OCCU-Find resulted in a decrease in the number of potential OCCU-Find occupations from 474 to 451, about a 15% decrease. This change was not uniform across the six RIASEC domains, with only slight changes in the Investigative (+5%), Social (+4%), Enterprising (-2%) and Conventional (-3%) arenas. The two largest areas of change were in the Realistic (-15%) and Artistic (-16%) domains. Since there were still a large number of Realistic occupations, this reduction appeared not to be problematic. However, the reduction in the number of Artistic occupations was deemed problematic, and additional Artistic occupations were sought by researching both the O*NET™ database and the US Department of Education's Classification of Instructional Programs Website (NCES, 2000) for additional Artistic occupations and instructional programs. This procedure led to the inclusion of one additional Artistic occupation. After further discussion and consensus building, the final list of OCCU-Find occupations was created, with a total of 452 occupations distributed across the RIASEC domain, with 130 Realistic, 73 Investigative, 46 Artistic, 71 Social, 66 Enterprising, and 66 Conventional occupations. This entire list of occupations appears in Tables 32-37. As with the 2002 version of the OCCU-Find, the number of Realistic occupations was a little less than double of that for any other RIASEC domain. Such a distribution is reasonable, since there are more Realistic occupations in the world-of-work than for any other RIASEC domain.

Table 32

Final List of Realistic OCCU-Find Occupations

Agricultural and Food Science Technicians	Electric Motor, Power Tool, and Related Repairers	Motorboat Operators
Agricultural Engineers	Electrical and Electronic Engineering Technicians	Motorcycle Mechanics
Agricultural Inspectors	Electrical Engineers	Musical Instrument Repairers and Tuners
Air Crew Members	Electricians	Nuclear Power Reactor Operators
Air Crew Officers	Electro-Mechanical Technicians	Nuclear Technicians
Aircraft Launch and Recovery Specialists	Elevator Installers and Repairers	Nursery Workers
Aircraft Mechanics and Service Technicians	Emergency Management Specialists	Operating Engineers and Other Construction Equipment Operators
Aircraft Structure, Surfaces, Rigging, and Systems Assemblers*	Explosives Workers, Ordnance Handling Experts, and Blasters	Ophthalmic Laboratory Technicians
Airline Pilots, Copilots, and Flight Engineers	Farmers and Ranchers	Outdoor Power Equipment and Other Small Engine Mechanics
Amusement and Recreation Attendants	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	Packers and Freight, Stock, and Material Movers
Architectural and Civil Drafters	Fire Investigators	Painters and Paperhangers
Armored Assault Vehicle Crew Members	Firefighters	Parking Lot Attendants
Artillery and Missile Crew Members	Fish and Game Wardens	Pest Control Workers
Automotive Body and Related Repairers	Food Preparation Workers	Petroleum Engineers
Automotive Mechanics and Service Technicians	Forest and Conservation Workers	Plasterers and Stucco Masons
Aviation Inspectors	Foresters and Conservation Technicians	Plumbers, Pipefitters, and Steamfitters
Avionics Technicians	Geological and Petroleum Technicians	Police Patrol Officers
Bakers	Hazardous Materials Removal Workers	Power Plant Operators
Biological Technicians	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Printing Machine Operators
Brickmasons and Blockmasons	Highway Maintenance Workers	Pump Operators
Broadcast Technicians	Housekeeping and Janitorial Workers	Radar and Sonar Technicians
Bus and Truck Mechanics and Diesel Engine Specialists	Industrial Machinery Mechanics	Radiologic Technologists and Technicians
Bus Drivers	Industrial Truck and Tractor Operators	Refuse and Recyclable Material Collectors
Cabinetmakers	Infantry	Roofers
Carpenters	Inspectors, Testers, Sorters, Samplers, and Weighers	Sailors and Marine Oilers
Carpet Installers	Jewelers and Precious Stone and Metal Workers	Ship and Boat Captains
Chemical Technicians	Landscape Architects	Ship Engineers
Civil Engineering Technicians	Landscaping and Groundskeeping Workers	Ship Pilots
Civil Engineers	Laundry and Drycleaning Workers	Sound Engineering Technicians
Cleaners of Vehicles and Equipment	Lifeguards, Ski Patrol, and Other Recreational Protective Service Workers	Special Forces
Command and Control Center Specialists	Locksmiths and Safe Repairers	Surgical Technologists
Commercial Divers	Logging Equipment Operators	Surveying Technicians
Computer Hardware and Business Machine Technicians	Machinists	Taxi Drivers and Chauffeurs
Computer Hardware Engineers	Maintenance and Repair Workers, General	Telecommunications Line Installers and Repairers
Computer Software Engineers, Applications	Marine Engineers and Naval Architects	Tree Trimmers and Pruners
Cooks	Meat, Poultry, and Fish Cutters and Trimmers	Truck Drivers
Correctional Officers and Jailers	Mechanical Engineering Technicians	Umpires, Referees, and Other Sports Officials
Couriers and Messengers	Mechanical Engineers	Upholsterers
Crane and Tower Operators	Medical and Clinical Laboratory Technicians	Veterinary Assistants and Animal Caretakers

Dental Laboratory Technicians	Medical Appliance Technicians	Water and Liquid Waste Treatment Plant and System Operators
Desktop Publishers	Medical Equipment Preparers	Welders, Cutters, Solderers, and Brazers
Diagnostic Medical Sonographers	Medical Equipment Repairers	

Table 33

Final List of Investigative OCCU-Find Occupations

Aerospace Engineering and Operations Technicians	Electronics Engineers	Nuclear Medicine Technologists
Aerospace Engineers	Environmental Engineers	Operations Research Analysts
Anesthesiologists	Environmental Science and Protection Technicians, Including Health	Optometrists
Anthropologists and Archeologists	Environmental Scientists and Specialists, Including Health	Oral and Maxillofacial Surgeons
Archivists	Epidemiologists	Orthodontists
Astronomers	Family and General Practitioners	Pediatricians, General
Atmospheric and Space Scientists	Financial Analysts	Pharmacists
Biochemists and Biophysicists	Food Scientists and Technologists	Physician Assistants
Biologists	Forensic Science Technicians	Physicists
Biomedical Engineers	Geographers	Political Scientists
Cardiovascular Technologists and Technicians	Geoscientists	Psychiatrists
Chemical Engineers	Health and Safety Engineers	Range Managers
Chemists	Historians	Respiratory Therapists
Chiropractors	Hydrologists	Social Science Research Assistants
Clinical and School Psychologists	Industrial Engineering Technicians	Sociologists
Compensation, Benefits, and Job Analysis Specialists	Industrial-Organizational Psychologists	Soil and Plant Scientists
Computer Programmers	Logisticians	Soil and Water Conservationists
Computer Security Specialists	Management Analysts	Statisticians
Computer Support Specialists	Market Research Analysts	Surgeons
Computer Systems Analysts	Mathematical Technicians	Surveyors
Criminal Investigators and Special Agents	Mathematicians	Urban and Regional Planners
Database Administrators	Medical and Clinical Laboratory Technologists	Veterinarians
Dentists, General	Medical Scientists	Zoologists and Wildlife Biologists
Dietitians and Nutritionists	Network Systems and Data Communications Analysts	
Economists	Nuclear Engineers	

Table 34		
Final List of Artistic OCCU-Find Occupations		
Actors	Dancers	Museum Technicians and Conservators
Advertising and Promotions Managers	Directors, Stage, Motion Pictures, Television, and Radio	Music Composers and Arrangers
Architects	Editors	Music Directors
Art Directors	English Language and Literature Teachers, Postsecondary	Musicians, Instrumental
Art, Drama, and Music Teachers, Postsecondary	Fashion Designers	Painters, Sculptors, and Illustrators
Broadcast News Analysts	Film and Video Editors	Photographers
Camera Operators, Television, Video, and Motion Picture	Floral Designers	Photographic Process Workers
Cartoonists	Foreign Language and Literature Teachers, Postsecondary	Producers
Choreographers	Graphic Designers	Radio and Television Announcers
Commercial and Industrial Designers	Interior Designers	Reporters and Correspondents
Copy Writers	Interpreters and Translators	Set and Exhibit Designers
Costume Attendants	Librarians	Singers
Court Reporters	Makeup Artists, Theatrical and Performance	Talent Directors
Craft Artists	Merchandise Displayers and Window Trimmers	Technical Writers
Creative Writers, Poets, and Lyricists	Models	
Curators	Multi-Media Artists and Animators	

Table 35

Final List of Social OCCU-Find Occupations

Adult Literacy, Remedial Education, and GED Teachers and Instructors	Funeral Attendants	Probation Officers and Correctional Treatment Specialists
Ambulance Drivers and Attendants	Health Educators	Psychiatric Aides
Animal Control Workers	Home Health Aides	Psychiatric Technicians
Animal Trainers	Instructional Coordinators	Radiation Therapists
Athletic Trainers	Kindergarten Teachers	Recreation Workers
Audiologists	Licensed Practical and Licensed Vocational Nurses	Recreational Therapists
Bailiffs	Massage Therapists	Registered Nurses
Child Care Workers	Medical and Public Health Social Workers	Rehabilitation Counselors and Specialists
Child, Family, and School Social Workers	Medical Assistants	Residential Advisors
Clergy	Mental Health and Substance Abuse Social Workers	Secondary School Teachers
Counseling Psychologists	Mental Health Counselors	Security Guards
Dental Assistants	Middle School Teachers	Sheriffs and Deputy Sheriffs
Dental Hygienists	Nursing Aides, Orderlies, and Attendants	Social and Community Service Managers
Dietetic Technicians	Nursing Instructors and Teachers, Postsecondary	Social and Human Service Assistants
Directors, Religious Activities and Education	Occupational Health and Safety Specialists	Special Education Teachers, Secondary School
Education Administrators, Elementary and Secondary School	Occupational Therapist Aides	Speech-Language Pathologists
Education Administrators, Preschool and Child Care Center/Program	Occupational Therapists	Substance Abuse and Behavioral Disorder Counselors
Educational, Vocational, and School Counselors	Orthotists and Prosthetists	Teacher Assistants
Elementary School Teachers	Park Naturalists	Tour Guides and Escorts
Eligibility Interviewers	Personal and Home Care Aides	Training and Development Specialists
Emergency Medical Technicians and Paramedics	Personal Financial Advisors	Vocational Education Teachers
Employment Interviewers	Physical Therapist Aides	Waiters and Waitresses
Equal Opportunity Representatives and Officers	Police, Fire, and Ambulance Dispatchers	
Fitness Trainers and Aerobics Instructors	Preschool Teachers	

Table 36		
Final List of Enterprising OCCU-Find Occupations		
Administrative Services Managers	Financial Examiners	Opticians, Dispensing
Advertising Sales Agents	Financial Managers	Paralegals and Legal Assistants
Aircraft Launch and Recovery Officers	Flight Attendants	Parts Salespersons
Appraisers and Assessors of Real Estate	Food Service Managers	Personnel Recruiters
Aquacultural Managers	Funeral Directors	Private Detectives and Investigators
Arbitrators, Mediators, and Conciliators	Hairdressers, Hairstylists, and Cosmetologists	Property, Real Estate, and Community Association Managers
Armored Assault Vehicle Officers	Hosts and Hostesses, Restaurant, Lounge, and Coffee Shop	Public Relations Specialists
Artillery and Missile Officers	Human Resources Managers	Purchasing Agents and Buyers
Athletes and Sports Competitors	Industrial Engineers	Purchasing Managers
Chefs and Head Cooks	Industrial Production Managers	Real Estate Sales Agents
Chief Executives	Infantry Officers	Retail Salespersons
Coaches and Scouts	Insurance Adjusters, Examiners and Investigators	Sales Managers
Command and Control Center Officers	Insurance Sales Agents	Sales Representatives
Compensation and Benefits Managers	Judges, Magistrate Judges, and Magistrates	Securities, Commodities, and Financial Services Sales Agents
Computer and Information Systems Managers	Lawyers	Special Forces Officers
Construction Managers	Loan Officers	Telemarketers
Criminal Investigators and Special Agents	Lodging Managers	Training and Development Managers
Crop and Livestock Managers	Manicurists and Pedicurists	Transit and Railroad Police
Demonstrators and Product Promoters	Marketing Managers	Transportation Vehicle, Equipment and Systems Inspectors
Detectives and Criminal Investigators	Medical and Health Services Managers	Transportation, Storage, and Distribution Managers
Driver/Sales Workers	Meeting and Convention Planners	Travel Guides
Education Administrators, Postsecondary	Nursery and Greenhouse Managers	Treasurers, Comptrollers, and Chief Financial Officers

Table 37		
Final List of Conventional OCCU-Find Occupations		
Accountants and Auditors	Electrical Drafters	Multimedia Equipment Technicians
Actuaries	Executive Secretaries and Administrative Assistants	Municipal Clerks
Air Traffic Controllers	File Clerks	Office Clerks, General
Assessors	Fire Inspectors	Order Fillers, Wholesale and Retail Sales
Bill and Account Collectors	Freight and Cargo Inspectors	Parking Enforcement Workers
Bookkeeping, Accounting, and Auditing Clerks	Hotel, Motel, and Resort Desk Clerks	Pharmacy Technicians
Brokerage Clerks	Human Resources Assistants, Except Payroll and Timekeeping	Police Identification and Records Officers
Budget Analysts	Immigration and Customs Inspectors	Postal Service Clerks
Cargo and Freight Agents	Insurance Appraisers, Auto Damage	Postal Service Mail Carriers
Cartographers and Photogrammetrists	Insurance Claims and Policy Processing Clerks	Production, Planning, and Expediting Clerks
Cashiers	Legal Secretaries	Proofreaders and Copy Markers
City and Regional Planning Aides	Library Assistants, Clerical	Receptionists and Information Clerks
Claims Examiners, Property and Casualty Insurance	Library Technicians	Reservation and Transportation Ticket Agents and Travel Clerks
Construction and Building Inspectors	License Clerks	Secretaries
Correspondence Clerks	Licensing Examiners and Inspectors	Shipping, Receiving, and Traffic Clerks
Cost Estimators	Loan Interviewers and Clerks	Statistical Assistants
Counter and Rental Clerks	Mail Clerks and Mail Machine Operators	Stock Clerks
Court Clerks	Mapping Technicians	Tax Examiners, Collectors, and Revenue Agents
Credit Analysts	Medical Records and Health Information Technicians	Tax Preparers
Credit Authorizers, Checkers, and Clerks	Medical Transcriptionists and Secretaries	Telephone Operators
Customer Service Representatives	Meter Readers, Utilities	Tellers
Dispatchers, Except Police, Fire, and Ambulance	Multimedia Collections Specialists	Title Examiners, Abstractors, and Searchers

Pilot Validation and Reliability Study of the Skill Composite Dimensions

Next, a group of 17 occupations were selected for inclusion in a pilot study designed to test the feasibility of the new methodology and the use of these new Skill Composites. These 17 pilot occupations (see Table 38) were selected to be representative of RIASEC codes, including two military-specific occupations. For each of these occupations, O*NET™ and military job descriptions were collected and given to occupational analysts who comprised the expert raters in this pilot study. In this test, pairs of analysts were assigned to one of two 'teams' with each team rating the 17 occupations on the final 17 KSAs that comprised the Verbal, Math, and Science and Technical Skills dimensions.

Table 38
Occupations Included in Pilot Study

Occupation		Occupation	
R	Automotive Mechanics and Service Technicians	A	Advertising and Promotions Managers
R	Computer Hardware and Business Machine Technicians	A	Graphic Designers
R	Computer Hardware Engineers	A	Musicians, Instrumental
R	Medical Appliance Technicians	S	Physical Therapist Aides
R	Special Forces	S	Radiation Therapists
I	Computer Security Specialists	E	Armored Assault Vehicle Officers
I	Computer Support Specialists	E	Computer and Information Systems Managers
I	Physician Assistants	E	Marketing Managers
		C	Medical Transcriptionists and Secretaries

Note. R = Realistic, I = Investigative, A = Artistic, S = Social, E = Enterprising, C = Conventional.

Following O*NET™, a 5-point Likert Scale from 1 (Not Important) to 5 (Extremely Important) was viewed as the most appropriate scale from which to assess and judge the importance of each of the KSAs for the occupations being rated. The anchors for the scale were the same as those used in the O*NET™ KSA questionnaires. Appropriate definitions and examples were developed for the 1 (Not Important), 3 (Important), and 5 (Extremely Important) points on the rating scale to provide rating guidance for the analysts (see Table 39). The raters were instructed to give ratings of 2 or 4 if the job information indicates that the importance falls somewhere between the anchors.

Table 39
KSA Rating Scale Anchors Descriptions

Value	Anchor	Anchor Description
1	Not Important	These skills are not needed to perform the core job tasks. An individual could perform the job without using these skills. These skills are rarely used in the job. Related O*NET™ KSAs are not included in job information. Core job tasks do not require these skills.
2	Somewhat Important	*na [Somewhere between "Not Important and Important".]*
3	Important	These skills are necessary for successful performance on the job. The incumbent uses these skills on a regular basis. The incumbent would have difficulty performing the job without using these skills. Skills are either mentioned directly or inferred from task descriptions. At a minimum, one core job task requires the skills. Supplemental tasks may also require the skills.

4	Very Important	*na [Somewhere between "Important and Extremely Important".]*
5	Extremely Important	These skills are crucial to the performance of the job. These skills are most likely needed in the majority of tasks an incumbent performs. An individual would not be able to perform the job without using these skills. Skills (or related KSAs) are either mentioned directly or inferred from task descriptions. The skills are needed for multiple core job tasks. Absence of skills would result in failure to perform the job.

A Frame of Reference approach (FOR; Chirico, Buckley, Wheeler, Facteau, Bernardin, & Beu, 2004) was employed to train the analysts who would be generating the Skill Importance Ratings. FOR training involves establishing a common frame of reference among raters by outlining the rating process and criteria, and reviewing examples together. In the present case, two raters received approximately one hour of FOR training that covered: (a) the project background; (b) overview of the methodology; (c) step-by-step methodological review; (d) review of rating scales, skill definitions, the use of O*NET™ KSA information; and (e) sample occupations to rate for practice.

After completing the training, the two raters independently rated the 17 occupations on each of the three composites. These ratings were correlated to determine their reliability, with correlations of .70 or better indicating adequate levels of reliability, and values of below .70 indicating an inadequate level of inter-rater reliability. Based on this criterion cutoff value, the inter-rater correlations for the Verbal and Science/Technical Skills dimensions were sufficient (.79 and .89 respectively) from a validity perspective. However, the correlation (.59) for the Math Skills dimension was judged inadequate. In discussion with the raters, it became clear that the Math composite was less reliable in part because there were too few relevant KSAs for adequate content mapping of the occupations. As such, two additional O*NET™ skills, critical thinking and complex problem solving, were added to the Math KSA Composite. This seemed appropriate because these two KSAs correlated strongly with the Math composite (.62 and .64 respectively in the O*NET™ 3.1 database) and would make for a more reliable set of ratings. The addition of these two KSAs to the composite was expected to increase the inter-rater correlation from .59 to at least .68.[2]

The final list of the KSAs that comprised the three Skill Composites was assessed for internal consistency of the skill composites in the 900 occupations for which there was complete KSA data in the O*NET™ 3.1 database. These reliability analyses (see Table 40) provided strong evidence of reliability and validity. In his thoughtful discussion of construct validity and construct validation, Messick (1989) argued that internal consistency reliability is also relevant construct-validity evidence: "let us begin by explicitly mentioning item homogeneity or *internal consistency reliability*. This is relevant validity information because the degree of homogeneity in the test, as we have seen, should be commensurate with the degree of homogeneity theoretically expected for the construct in question" (emphasis in the original; *p*. 51).

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2 This estimate borrows from Lord and Novick (2008, *pp*. 140-144, Theorem 6.8.3), using the variance of the Math composite calculated both with and without these two additional KSAs. These values were substituted for the estimated variances of the selected and unselected elements of the population. Substituting these values, along with the observed inter-rater correlation of .59, the estimated correlation between the raters after including these new KSAs would be .68. Since this is a lower-bound estimate, this value is close enough to the .70 criterion value to warrant the inclusion of the KSAs from a reliability perspective.

The Verbal Skills Composite (Table 39) demonstrated a high degree of internal consistency (α = .96). The corrected item-total correlations ranged from a minimum of .66 to a maximum of .89, with the squared multiple correlation of the item with all other items ranging from .50 to .90. Removing any of the KSAs from the composite would result in a minimal change in the internal consistency of the composite. From this perspective, the Verbal Skill Composite appears both robust and reasonable. Similarly, the Math Skills Composite also demonstrated a high degree of internal consistency (α = .92). The corrected item-total correlations ranged from a minimum of .30 to a maximum of .80, with the squared multiple correlation of the item with all other items ranging from .35 to .87. Removal of any of KSA from the composite would result in only a minimal change in the internal consistency of the composite. From this perspective, the Math Skill Composite also appears both robust and reasonable. Finally, the Science and Technical Skills Composite also demonstrated a high degree of internal consistency (α = .88). Two of the KSAs, Biology and Computers and Electronics, had near-zero (r = .01, .06 respectively) corrected item-total correlation. However, their multiple correlations with the rest of the KSAs were adequate (R = .75 and .62 respectively). Removing these KSAs would have marginally increased coefficient alpha from .88 to .91, but would serve to reduce the content coverage of the composite. Therefore, both were retained in the composite. The remaining KSAs manifested adequate corrected item-total correlations that ranged from a minimum of .31 to a maximum of .76, with the squared multiple correlation of the item with all other items ranging from .45 to .85. From this perspective, the Science and Technical Skill Composite appears both robust and reasonable.

Table 40
Psychometric Analysis of the Final Skills Composite
Based on the 900 Occupations in the O*NET™ 3.1 Database

O*NET™ Composite	KSA	Mean	SD	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
Verbal Skills Composite (α = .96)						
English Language	K	2.62	0.88	.89	.81	.95
Communications and Media	K	1.86	0.73	.66	.52	.96
Reading Comprehension	S	3.24	0.91	.80	.80	.95
Writing	S	2.83	1.03	.85	.85	.95
Speaking	S	3.00	1.14	.85	.87	.95
Oral Comprehension	A	3.13	0.94	.85	.85	.95
Written Comprehension	A	3.21	0.91	.79	.78	.95
Oral Expression	A	3.15	1.14	.87	.90	.95
Written Expression	A	2.80	1.04	.89	.88	.95
Inductive Reasoning	A	2.51	0.80	.66	.50	.96
Math Skills Composite (α = .92)						
Mathematics	K	2.69	0.88	.69	.69	.91
Science	S	2.15	1.12	.55	.50	.92
Mathematics	S	2.92	0.90	.73	.74	.91
Critical Thinking	S	2.79	1.05	.72	.87	.91
Complex Problem Solving	S	2.70	0.76	.74	.86	.91
Written Comprehension	A	3.21	0.91	.71	.58	.91
Deductive Reasoning	A	2.81	0.72	.80	.74	.90
Inductive Reasoning	A	2.51	0.80	.76	.74	.90

Information Ordering	A	3.11	0.64	.30	.35	.92
Mathematical Reasoning	A	2.41	0.89	.80	.85	.90
Number Facility	A	2.72	0.80	.68	.83	.91
Science and Technical Skills Composite (α = .88)						
Biology	K	1.46	0.94	.01	.57	.90
Building and Construction	K	1.64	0.93	.31	.45	.88
Chemistry	K	1.70	0.88	.31	.51	.88
Computers and Electronics	K	2.04	0.95	.06	.38	.89
Engineering and Technology	K	2.03	0.95	.75	.76	.87
Mechanical	K	2.37	1.16	.65	.81	.87
Physics	K	1.82	0.77	.67	.66	.87
Equipment Selection	S	2.82	0.83	.76	.69	.87
Installation	S	1.89	1.02	.63	.67	.87
Operation and Control	S	2.74	1.06	.57	.82	.88
Science	S	2.15	1.12	.51	.75	.88
Technology Design	S	1.88	0.78	.64	.63	.87
Troubleshooting	S	2.02	0.93	.73	.74	.87
Operations Analysis	S	2.20	0.87	.31	.58	.88
Quality Control Analysis	S	2.57	0.83	.76	.71	.87
Operation Monitoring	S	2.28	1.08	.71	.85	.87
Control Precision	A	2.47	0.99	.63	.75	.87

Note. K = Knowledge KSA; S = Skills KSA; A = Ability.

Taken together, the results of the pilot study and the interrogation of the O*NET™ 3.1 database support the use of the new methodology. This method produced reliable ratings established in two ways. First, the KSAs that comprise the new skill composites demonstrated adequate internal consistency estimates across the entire O*NET™ 3.1 database. Second, the importance ratings provided by the analysts of the 17 pilot occupations proved to be reliable. Hence, the pilot study provided ample evidence both for inter-rater and internal consistency forms of reliability. From a validity perspective, the procedures employed to determine the appropriate KSAs and the training provided to the raters were designed to maximize evidence appropriate to support both content and construct forms of validity. Rater feedback and experience also proved valuable for improving and streamlining the rating process and to enhance the training provided to raters. Overall, this validation process easily met Messick's (1989) two-step rationale for test construction and validation: derive the appropriate domains from both empirical and theoretical sources, and utilize items that are construct-valid measures of the appropriate domains.

Providing Skill Importance Ratings for the O*NET™ Occupations

As a result of the positive outcomes from the pilot study, a process for rating the entire O*NET™ occupations database was created. Employing a five-step process in order to enhance the reliability and validity of the ratings in an efficient manner, the ratings would be made by two teams of two analysts. Each analyst independently rated the importance of Verbal Skills, Math Skills, and Science and Technical Skills. Rules for identifying rater consistency and reliability, the magnitude of acceptable differences between the raters, and deciding how these differences would be dealt with were established prior to the rating process. These rules helped ensure the ratings were of sufficient quality to support the OCCU-Find. The ratings by the analysts were compared and an initial estimate of reliability was derived based on the independent ratings. If the reliability estimates were of sufficient magnitude, the two analysts would then identify those occupations in which they disagreed and employ the specified procedure to reach consensus, with the team ratings being the final ratings. The analysts would use these skill definitions and rating scales as a basis for determining the importance of Verbal, Math, and Science and Technical Skills for the OCCU-Find occupations.

The second step involved a thorough review and outline of the relevant occupational information upon which the ratings would be based. This information included O*NET™ and military job descriptions as appropriate, with a focus on both the tasks performed by job incumbents and the job qualifications needed for employment. Using the job information provided, each analyst highlighted the relevant tasks and duties of the job and identified qualifications and the various KSAs deemed important for successful job performance in the occupation. These were done independently, with each analyst blind to the KSAs and tasks identified as relevant by the other analysts. Once each analyst on the two-person team independently highlighted the relevant occupational information, the team members compared their work and determined if the correct tasks were highlighted from the job information. Any discrepancies were discussed and reconciled, creating a common list of KSAs ready for rating.

The third step in the rating process required each individual analyst to provide an Importance Rating for each of the identified KSAs and tasks that comprised the Verbal, Math, and Science and Technical Skills. Each rater reviewed the rating scale anchors and definitions, and then compared the job information against them to derive an importance rating. Raters relied on task information as well as KSA information in making their ratings. The rating scale and anchor definitions used by analysts ranged from 1 (Not Important) through 3 (Important) to 5 (Extremely Important) using the same anchor descriptions and definitions as were used in the pilot study. As in the pilot study, raters were instructed to give a rating of 2 or 4 as appropriate. Once each individual analyst had rated the occupation, the team members compared their ratings and established team ratings. When discrepancies between the raters were relatively small (one or fewer points on the five-point scale), the team ratings were calculated as the average of the two ratings. When the discrepancy was larger than one point, the raters discussed the occupation and their individual ratings. The discussion was intended to lead to a team-based consensus rating.

The absolute differences and measures of inter-rater reliability were calculated both for the pre- and post-consensus ratings. As can be seen (Table 41), the discrepancies for most of the pre-consensus ratings were small in magnitude, with only 4.7% (64/1356) of the rating discrepancies greater than one point in magnitude. The correlations between the raters were .87, .83, and .93 for the Verbal, Math and Science and Technical Skill Composites respectively. These high values led to reliability coefficients of the final ratings based on the average rating of .93, .91 and .96 respectively for the Verbal, Math and Science and Technical Skill Composites respectively.

Table 41
Absolute Value of Pre - Consensus Rater Differences

Rater	Skill Composite (Count)				Skill Composite (%)			
Differences	V	M	ST	Total	V	M	ST	Total
0.0	248	222	280	750	55	49	62	55
0.5	12	7	21	40	3	2	5	3
1.0	172	191	139	502	38	42	31	37
1.5	1	0	0	1	0	0	0	0
2.0	17	29	11	57	4	6	2	4
3.0	2	3	1	6	0	1	0	0
Totals	452	452	452	1356	100%	100%	100%	100%

Note. V = Verbal Skills rating; M = Math Skills rating; ST = Science and Technical Skills rating.

Post-rating discussion between the raters focused on the ratings for which the discrepancies were more than one point in magnitude. In these discussions, each rater explained the basis for the rating, the rationales employed, and the degree of confidence in the accuracy of the rating. Through this discussion, a team-based rating was created and in some cases, analysts changed their individual ratings to reflect the team consensus rating. Post-consensus differences and reliability estimates were calculated to determine the degree to which the consensus process led to better quality ratings. The reliability estimates were updated using the post-consensus ratings. As can be seen (Table 42), only a little more than one-third of one percent (0.37%; 5/1362) of the discrepancies was greater than one point in magnitude. This change, from 4.7% to .4% represents a statistically significant reduction in the number of ratings with discrepancies greater than one point $\chi^2(1; N = 2712) = 54.303$, $p < .0001$. The post-consensus correlations between the raters changed slightly to .88, .84, and .93 for the Verbal, Math and Science and Technical Skill Composites respectively. Because the consensus procedure marginally increased the inter-rater correlations, the procedure also marginally increased the reliability coefficients of the final ratings to .94, .91 and .96 for the Verbal, Math and Science and Technical Skill Composites respectively.

Table 42
Absolute Value of Post - Consensus Rater Differences

Rater	Skill Composite (Count)				Skill Composite (%)			
Differences	V	M	ST	Total	V	M	ST	Total
0.0	256	226	284	766	57	50	63	56
0.5	15	7	21	43	3	2	5	3
1.0	180	215	147	542	40	48	33	40
2.0	0	4	0	4	0	1	0	0
3.0	1	0	0	1	0	0	0	0
Totals	452	452	452	1356	100%	100%	100%	100%

Note. V = Verbal Skills rating; M = Math Skills rating; ST = Science and Technical Skills rating.

As a “spot check” of both the process and the results of the ratings process, an independent reviewer with expertise in occupational analysis and military careers was chosen to conduct ratings of a sample of OCCU-Find occupations. A random sample of approximately 5% of the occupations within each of the six RIASEC domains was chosen for review. In this quality review, a qualitative comparison was made between the independent reviewer’s ratings and the team consensus ratings. The reviewer concluded that the team rating process yielded accurate and consistent ratings.

The means, standard deviations, intercorrelations and interrater reliability for the final ratings are reported in Table 43. Given the ratings range from 1 to 5, it seems reasonable to expect the means to be between 2.50 and 3.50 in order to minimize the probability of both floor and ceiling effects. These effects cause the empirical distribution of a variable to be truncated or skewed, reducing both the reliability and validity of the data. Further, these effects limit the usefulness of a set of scores in terms of their ability to lead to valid conclusions. While there are no exact tests to detect the presence of a floor/ceiling effect, one common rule of thumb is that a reasonable lower limit (M – 1.0SD) and upper limit (M + 1.0SD) both be possible values in the scale. Using this criterion, neither floor nor ceiling effects appear to be problematic for the skill importance ratings.

The mean of the Verbal Composite is significantly higher than both the Math ($t(451) = 4.85$, $p < .0001$) and Science/Technical Composites ($t(451) = 3.56$, $p < .001$). While this may be for a number of reasons, it is consistent with the view that across occupations, verbal competencies are more important than either mathematical or science/technical competencies (U.S. Department of Labor [SCANS], 1991). In 1991, the Department of Labor published the Secretary's Commission on Achieving Necessary Skills (SCANS) report, *What Work Requires of Schools: A SCANS Report for America 2000.* In this report, five basic skills considered to be foundational for successful employment were identified: (a) reading, (b) writing, (c) arithmetic/mathematics, (d) listening, and (e) speaking.[3] Of these, four are aspects of the Verbal Skills Composite.

All of the correlations among the skill importance rating composites are significant beyond the .001 level. As might be expected, the verbal and math skill composite ratings are positively correlated, suggesting that as the importance of verbal skills increases so does the importance of mathematical skills. The same relationship appears to be the case for the mathematics and science and technical skills ratings. However, the verbal and science and technical skill importance ratings are significantly negatively correlated (r = -.17). At first glance this seems counterintuitive. However, this finding is consistent with Holland's (1997) perspective on how Realistic occupations, which focus on tool use and physical "performance" tend to minimize human interaction and be populated by individuals with relatively poor social and verbal skills. Hence, a negative correlation between the two sets of skill importance ratings.

Table 43
Descriptive Statistics for the Final Composites

Composite	Mean	*SD*	*N*	α	V	M	ST
V	3.42	1.24	452	.94	1.00	.31	- .17
M	2.60	1.16	452	.91		1.00	.39
ST	2.68	1.50	452	.96			1.00

Note. V = Verbal Skills rating; M = Math Skills rating; ST = Science/Technical Skills rating; α = interrater reliability; all correlations are significant at the .001 level.

3 In SCANS, these Basic Skills are defined as: "Reading — locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules. Writing — communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts. Arithmetic/Mathematics — performs basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques. Listening — receives, attends to, interprets, and responds to verbal messages and other cues. Speaking — organizes ideas and communicates orally." (*p*. xi).

Ultimately, the skill importance ratings of each occupation will need to be placed into High, Medium or Low Importance groupings to ensure that all students will find occupations to explore. To help determine the degree to which the occupations can be so situated, the frequency distributions of the three skill importance ratings were examined (see Tables 44-46).

Table 44
Frequency Distribution of Verbal Skill Importance Ratings

Skill Importance Rating	Frequency	Percent	Cumulative Percent
1.00	34	7.5	7.5
1.25	4	0.9	8.4
1.50	14	3.1	11.5
1.75	4	0.9	12.4
2.00	40	8.8	21.2
2.25	3	0.7	21.9
2.50	30	6.6	28.5
3.00	57	12.6	41.2
3.25	1	0.2	41.4
3.50	56	12.4	53.8
4.00	55	12.2	65.9
4.25	2	0.4	66.4
4.50	79	17.5	83.8
5.00	73	16.2	100.0
Total	452	100.0	

Table 45
Frequency Distribution of Mathematics Skill Importance Ratings

Skill Importance Rating	Frequency	Percent	Cumulative Percent
1.00	67	14.8	14.8
1.25	1	0.2	15.0
1.50	53	11.7	26.8
1.75	1	0.2	27.0
2.00	76	16.8	43.8
2.25	1	0.2	44.0
2.50	72	15.9	60.0
3.00	36	8.0	67.9
3.25	2	0.4	68.4
3.50	63	13.9	82.3
3.75	1	0.2	82.5
4.00	27	6.0	88.5
4.50	31	6.9	95.4
4.75	1	0.2	95.6
5.00	20	4.4	100.0
Total	452	100.0	

Table 46
Frequency Distribution of Science/Technical Skill Importance Ratings

Skill Importance Rating	Frequency	Percent	Cumulative Percent
1.00	148	32.7	32.7
1.10	1	0.2	33.0
1.25	1	0.2	33.2
1.50	27	6.0	39.2
1.75	1	0.2	39.4
2.00	26	5.8	45.1
2.25	2	0.4	45.6
2.50	32	7.1	52.7
2.75	2	0.4	53.1
3.00	33	7.3	60.4
3.25	2	0.4	60.8
3.50	35	7.7	68.6
3.75	1	0.2	68.8
4.00	30	6.6	75.4
4.25	5	1.1	76.5
4.50	54	11.9	88.5
4.75	6	1.3	89.8
5.00	46	10.2	100.0
Total	452	100.0	

To facilitate the use of these composite ratings, the occupations needed to be classified into a small number of clusters that would reflect the relative importance of Verbal, Math and Science and Technical KSAs. It was decided that a three-cluster solution would be appropriate for exploration purposes. This would essentially place each occupation into a High, Medium or Low cluster on each of the three KSA importance composites. In doing so, it was important to ensure that within-cluster occupations were maximally similar in their importance ratings, and the between-cluster similarity was minimized. One way to accomplish this task is through cluster analysis employing Ward's (1963) method to simultaneously minimize within-cluster variance and maximize between-cluster variance. Ward's method was set to determine three levels of importance (high, medium, and low) for each of the three importance composites. In these types of situations, Ward's method generally tends to produce clusters with approximately equal number of elements. This will be essential if these composites are to be useful for career exploration, as it will provide a large number of potential occupations in each of the high, medium and low importance clusters. While Ward's method does not create specific cut-points that differentiate among the high, medium and low importance clusters, it can be used to determine those cut-points. This was accomplished by finding the midpoint between the element with the smallest score in the high importance cluster and the element with the highest score in the medium importance cluster, repeating the procedure with the medium and low importance clusters. The cut-points and number of occupations in each of the importance clusters, as defined by the results of the cluster analysis employing Ward's method, are reported in Tables 47 - 49.

Table 47
Verbal Skill Importance Composite Cut Points

	Verbal Skill Composite Score				
Skill Importance Level	Mean	SD	N	Lower Limit	Upper Limit
Low	1.77	0.57	129	1.00	2.79
Medium	3.25	0.25	114	2.80	3.75
High	4.54	0.39	209	3.76	5.00
Total	3.42	1.24	452	1.00	5.00

Note. Based on a five-point scale where higher scores indicate greater importance.

Table 48
Mathematics Skill Importance Composite Cut Points

	Mathematics Skill Composite Score				
Skill Importance Level	Mean	SD	N	Lower Limit	Upper Limit
Low	1.23	0.25	122	1.00	1.69
Medium	2.39	0.37	185	1.70	3.04
High	4.02	0.56	145	3.05	5.00
Total	2.60	1.16	452	1.00	5.00

Note. Based on a five-point scale where higher scores indicate greater importance.

Table 49
Science and Technical Skill Importance Composite Cut Points

	Science and Technical Skill Composite Score				
Skill Importance Level	Mean	SD	N	Lower Limit	Upper Limit
Low	1.20	0.35	204	1.00	2.02
Medium	3.01	0.42	107	2.03	3.83
High	4.56	0.37	141	3.84	5.00
Total	2.68	1.50	452	1.00	5.00

Note. Based on a five-point scale where higher scores indicate greater importance.

One of the strong motivations for revising the ASVAB CEP was to provide expanded career exploration opportunities for all students who participate in the new program regardless of the academic capability of the participant. It was hoped that linking together three ASVAB composites to their corresponding occupational KSA-based ‘footprints’ would broaden participants’ horizons. This could only be the case if the placement of occupations in one composite (*e.g.*, high) is not matched by its placement in other composites (*e.g.*, also high). To assess this possibility, a series of cross tabulations were conducted to see how many occupations were designated in the same importance level across the three composites. Tables 49 through 51 report these two-way cross-tabulations, and demonstrate a substantial degree of success in this endeavor, no doubt related to the relatively small intercorrelations among the skill composites themselves.

Table 49

OCCU-Find Occupations Verbal Skill Importance by
Mathematics Skill Importance Composite Overlap

Verbal Skill	Mathematics Skill Importance Composite			
Importance Composite	Low	Medium	High	Total
Low	62	53	14	129
Medium	24	41	49	114
High	36	91	82	209
Total	122	185	145	452

Table 50

OCCU-Find Occupations Science and Technical Skill Importance by
Verbal Skill Importance Composite Overlap

Verbal Skill	Science and Technical Skill Importance Composite			
Importance Composite	Low	Medium	High	Total
Low	49	42	38	129
Medium	35	31	48	114
High	120	34	55	209
Total	204	107	141	452

Table 51

OCCU-Find Occupations Mathematics Skill Importance by
Science and Technical Skill Importance Composite Overlap

Mathematical Skill	Science and Technical Skill Importance Composite			
Importance Composite	Low	Medium	High	Total
Low	76	34	12	122
Medium	92	50	43	185
High	36	23	86	145
Total	204	107	141	452

Because students will be exploring potential occupations based on the three skill importance dimensions, it is important to assess the distribution of occupations based on the three-way classification table. As shown in Table 52, almost all of the various combinations of skill importance have at least three associated occupations. Only one combination (High Verbal Skills Importance; Low Mathematics Skills Importance; High Science and Technical Skills Importance) fails to have at least one associated occupation for exploration.

Table 52

Distribution of OCCU-Find Occupations Across the Three Skill Importance Composite Clusters

Skills Importance Composite Cluster			Occupations	
Verbal	Math	Science/Technical	Number	Percent
H	H	H	44	10
H	H	M	13	3
H	H	L	25	6
H	M	H	11	2
H	M	M	18	4
H	M	L	62	14
H	L	H	0	0
H	L	M	3	1
H	L	L	33	7
M	H	H	35	8
M	H	M	7	2
M	H	L	7	2
M	M	H	10	2
M	M	M	15	3
M	M	L	16	4
M	L	H	3	1
M	L	M	9	2
M	L	L	12	3
L	H	H	7	2
L	H	M	3	1
L	H	L	4	1
L	M	H	22	5
L	M	M	17	4
L	M	L	14	3
L	L	H	9	2
L	L	M	22	5
L	L	L	31	7
Total			452	100

Clearly, in an aggregate sense, the importance ratings and subsequent importance groupings demonstrated satisfactory psychometric and distributional properties. However, because the importance of verbal, mathematical and scientific and technical tasks may differ by RIASEC domain (Holland, 1997), it was important to examine how the importance ratings and subsequent importance groupings differ among the RIASEC domains. This is essential because the OCCU-Find occupations also need to be well distributed across the RIASEC domains with regard to the three skills importance factors. A number of interesting findings emerge from the data reported in Table 53. First, the inter-rater reliability correlations generally were adequate in magnitude, ranging from a low .71 to a high of .96. Second, the reliability estimates for the Investigative domain (Verbal and Math) were considerably lower than for the other RIASEC domains. While such findings can be interpreted in a number of ways, it probably reflects that both verbal and mathematical skills are more uniformly important for Investigative occupations than for the occupations selected for inclusion from the other RIASEC domains. This seems reasonable given the smaller standard deviations for the verbal and math composites in the Investigative domain than for most of the other domains. This may have adverse consequences in terms of making it more difficult to find Investigative occupations that place relatively low importance on verbal and mathematical skills. Third, as would be expected, MANOVA confirms that there are considerable differences in the importance of verbal, math and science/technical skills among the six RIASEC domains $\lambda = .284$, $F(15, 1226) = 47.174$, $p < .00001$. The verbal composite scores differed significantly among the six RIASEC types, $F(5, 239.46) = 42.054$, $p < .0001$ (based on the Brown-Forsythe test which corrects for heterogeneity of variance). The ordering of the means mirrors those found in the previous OCCU-Find, which used the entire O*NET™ 3.1 database ($r = .98$, $p < .001$). Similar findings emerged with the mathematics composite $F(5, 373.60) = 50.910$, $p < .0001$ (based on the Brown-Forsythe test which corrects for heterogeneity of variance). Again, the ordering of the means mirrors those found in the previous OCCU-Find, which used the entire O*NET™ 3.1 database ($r = .85$, $p < .03$). The univariate findings with the science and technical importance composite echo those reported for the verbal and mathematics composites: large univariate differences $F(5, 446) = 46.727$, $p < .0001$ with a pattern of means similar to the previous OCCU-Find ($r = .99$, $p < .001$). Equally important, the pattern of the means appear consistent with what one would expect based on Holland's (1997) descriptions of the personality and environment characteristics associated with the RIASEC types.

Table 53
Skill Importance Dimension Descriptive Statistics Across Occupations Within Each RIASEC Domain

RIASEC	Verbal Composite			Mathematics Composite			Science/Technical Composite		
Domain	α	*M*	*SD*	α	*M*	*SD*	α	*M*	*SD*
R	.95	2.39	1.18	.92	2.44	1.10	.92	3.60	1.14
I	.72	3.99	0.70	.71	3.84	0.71	.94	4.05	1.16
A	.96	3.30	1.50	.86	1.41	0.69	.95	1.78	1.09
S	.88	4.17	0.81	.88	2.20	0.80	.96	1.90	1.18
E	.92	4.01	0.94	.88	2.34	0.89	.94	1.87	1.15
C	.85	3.54	0.86	.94	3.05	1.18	.96	1.59	1.02
Total	.94	3.42	1.24	.91	2.60	1.16	.96	2.68	1.50

Note. α = interrater reliability; R = Realistic (*N* = 130 occupations); I = Investigative (*N* = 73 occupations); A = Artistic (*N* = 46 occupations); S = Social (*N* = 71 occupations); E = Enterprising (*N* = 66 occupations); C = Conventional (*N* = 66 occupations). The actual occupations for each RIASEC domain are listed in Tables 32-37.

Based on these findings, it was hoped that for each of the RIASEC dimensions, there would be a corresponding set of occupations in the high, medium, and low skill importance dimensions. These cross-tabulations are reported in Tables 54 – 56, and shows only one instance where there are no occupations – low mathematics skills importance for Investigative occupations, a result anticipated earlier.

Table 54

OCCU-Find Occupations Verbal Skill Importance Grouping by RIASEC Domain Matrix

	Verbal Skill Importance Grouping			
RIASEC Domain	Low	Medium	High	Total
Realistic	81	30	19	130
Investigative	4	21	48	73
Artistic	20	7	19	46
Social	4	16	51	71
Enterprising	7	17	42	66
Conventional	13	23	30	66
Total	129	114	209	452

Table 55

OCCU-Find Occupations Mathematics Skill Importance Grouping by RIASEC Domain Matrix

	Mathematics Skill Importance Grouping			
RIASEC Domain	Low	Medium	High	Total
Realistic	39	55	36	130
Investigative	0	11	62	73
Artistic	38	7	1	46
Social	17	48	6	71
Enterprising	22	28	16	66
Conventional	6	36	24	66
Total	122	185	145	452

Table 56

OCCU-Find Occupations Science and Technical Skill Importance Grouping by RIASEC Domain Matrix

	Science and Technical Skill Composite			
RIASEC Domain	Low	Medium	High	Total
Realistic	68	19	43	130
Investigative	51	6	16	73
Artistic	3	32	11	46
Social	8	51	12	71
Enterprising	7	44	15	66
Conventional	4	52	10	66
Total	141	204	107	452

APPENDIX A:

Skills Dimension Definitions and Task Statements

Verbal Skills

Understand the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.

- Proofread and correct a memo or report.
- Write a memo or report using proper grammar and syntax.
- Transcribe dictation from a medical report.
- Identify mistakes in technical reports and check with specialists to obtain correct information.
- Type reports and other written material from rough drafts.

Communicate information and ideas effectively using written, oral, and visual media as appropriate for the needs of the audience. Organize ideas in a logical sequence (*e.g.* using correct grammar, syntax, punctuation, and spelling.

Writing

- Write a report to staff outlining new directives.
- Create a presentation.
- Write a newspaper article or book.
- Convince a superior in writing to buy a new copy machine.
- Write a detailed report following an investigation of a fire.
- Compose a letter in response to a customer complaint.
- Write technical documentation for software.
- Write a report outlining the results of a medical test.

Visualizing

- Design a marketing brochure.
- Develop imagery for an advertising campaign, including graphics, photographs, animation, and video.
- Create graphics to best convey a message.
- Design a website.
- Develop multimedia presentation for a new product.
- Create training video.

Speaking

- Conduct workshops.
- Deliver a presentation.
- Instruct a patient about using a medical device.
- Preside as judge or facilitate a dispute.
- Greet or guide tourists.
- Interview patients to obtain medical history.
- Argue a case in a courtroom.
- Present a strategic plan to upper management.
- Solicit donations for a charity.
- Counsel a student and/or athlete about college.
- Advise a patient about treatment options.
- Explain scientific principles to students.
- Interview applicants to obtain personal and work history.
- Answer customer questions and/or complaints about products and/or services.

Understand information and ideas presented through spoken words (listening) and written sentences (reading).

- Listen to a patient and prepare a treatment plan.
- Conduct a job interview.
- Read trade journals and convey information to coworkers.
- Take a customer's order.
- Follow verbal instructions.
- Read and follow step-by-step instructions.
- Read a memo from management.
- Understand an instruction book on repair and maintenance.

Use logic and reasoning to identify: (a) main ideas; (b) patterns; (c) the strengths and weaknesses of alternative solutions; and/or, (d) approaches to problems.

- Analyze a new product/service through comparison and contrast.
- Determine whether a subordinate has a good excuse for being late.
- Evaluate customer complaints and determine appropriate responses.
- Write a legal brief challenging a federal law.
- Identify an alternative approach to help trainees who are having difficulties.
- Write a soil comparison study for a state agency.
- Determine leads in a case based on evidence; solve crimes.
- Diagnose a disease using results of many different tests.

Math Skills

Compute and calculate: Add, subtract, multiply, or divide quickly and correctly.

- Count the amount of change to give a customer.
- Calculate the square footage of a room.
- Take money from petty cash to purchase supplies and record the amount taken.
- Measure the correct dose of medication for a patient.

Choose the right mathematical methods or formulas to solve a problem involving number theory, numeration, algebraic operations and equations, geometry and measurement, and probability.

- Develop a mathematical model to resolve an engineering problem.
- Calculate the interest payments on a mortgage.
- Write a statistical analysis formula to analyze demographic data.
- Follow a recipe and understand measurements.
- Modify a recipe to increase/decrease quantity.
- Develop/use a statistical model to predict trends in health and/or a disease outbreak in different populations.

Compile, interpret, evaluate, categorize, tabulate, audit, or verify information or data.

- Compare actual inventory to inventory listed on paper.
- Determine the impact of new menu changes on a restaurant's purchasing requirements.
- Identify how changes in tax laws will impact your company's year-end profits.
- Evaluate a loan application for degree of risk.
- Develop a yearly budget for a company.
- Prepare and manage a budget for a short-term project.
- Analyze statistical data from research studies.
- Verify accuracy of billing data and revise any errors.
- Perform bookkeeping work, including posting data and keeping other records concerning costs of goods and services and the shipment of goods.
- Develop, maintain, and analyze budgets, preparing periodic reports that compare budgeted costs to actual costs.
- Balance currency, coin, and checks in cash drawers at ends of shifts.
- Calculate daily transactions using computers, calculators, or adding machines.

Arrange things in a certain order or pattern according to a specific rule or set of rules (*e.g.,* patterns of numbers, mathematical operations). Identify, interpret, and use patterns, diagrams, or relationships among objects or items.

- Plot and record data from radars.
- Compose music.
- Develop computational methods for solving problems that occur in areas of science and engineering, or that come from applications in business or industry.
- Assemble weapons.
- Recognize a pattern among points plotted in a graph.
- Compare weather patterns and predict future outcomes.
- Make a quilt; sew a dress.
- Interpret a medical test such as an EKG.
- Lay out a newspaper or magazine for publication.
- Create a tile pattern on a floor.
- Survey land and plot elevation, contour, etc.

ASVAB
CAREER EXPLORATION PROGRAM

Science and Technical Skills

Apply principles, techniques, procedures, and equipment to the design and production of equipment and technology to serve user needs.

- Create a computer program.
- Draw plans for remodeling a kitchen.
- Identify implications of a new scientific theory for product design.
- Redesign the handle on a hand tool for easier gripping.
- Create new technology for producing food packaging.
- Develop detailed plans for a high-rise office building.
- Suggest changes in software to make a system more user friendly.
- Program a website for a retail store.
- Develop a database to link records in a hospital system.
- Conduct analyses of aerodynamic systems to determine practicality of aircraft design.
- Design a bridge using principles of engineering.
- Use the proper concentration of chlorine to purify a water source.
- Identify the control system needed for a production plant.
- Determine computer system needs for a large corporation.
- Read and interpret blueprints, technical drawings, schematics, and computer-generated reports.

Install, perform maintenance, and repair equipment, machines, wiring, or programs to meet specifications.

- Install a computer network in an office.
- Rewire a house or building.
- Take apart and repair a watch.
- Clean/maintain moving parts in production machinery.
- Fix a plumbing leak in the ceiling.
- Overhaul an engine.
- Conduct maintenance checks on an aircraft.
- Prepare, maintain, and repair medical equipment.
- Install air conditioning and heating systems.
- Remove and replace a fuel filter.
- Replace a faulty hydraulic valve.
- Disassemble car parts and inspect for wear, using micrometers, calipers, and gauges.
- Use/select the appropriate type of constructions materials to build a deck.

Conduct tests and inspections of people, products, machines, services, or processes to evaluate health/quality, diagnose diseases, or determine causes of operating errors.

- Examine a patient.
- Conduct standard tests to determine car failure.
- Perform an X-ray, EKG, EEG, etc.
- Conduct product tests to ensure that safety standards are met.
- Monitor machine functions on automated production line.
- Identify the circuit causing an electrical system to fail.
- Interpret a medical and/or diagnostic test.
- Evaluate the long-term performance problem of a new computer system.
- Develop procedures to test a prototype of new computer system.
- Calibrate and maintain medical and/or laboratory equipment.
- Monitor and integrate control feedback in a processing facility to maintain production flow.
- Conduct analysis of body fluids to determine presence of normal and abnormal components.

Perform experiments, develop theories, and predict outcomes using knowledge of one of the following: (a) physical principles and laws; (b) life science principles and laws; (c) electrical principles and laws; (d) earth science principles and laws; or, (e) social science principles.

- Analyze ground radar geological data for mineral deposits.
- Perform tests on water, food and the environment to detect harmful microorganisms.
- Study the structure and function of human, animal and plant tissues, and cells.
- Prepare meteorological forecasts.
- Test electrical systems and continuity of circuits in electrical wiring.
- Isolate and identify a new virus.
- Observe the structure and properties of matter, and the transformation and propagation of energy, using equipment such as masers, lasers, and telescopes.
- Conduct research to determine the impact of psychological treatments.
- Study the impact of alcohol on human responses.
- Investigate the relationship between organisms and disease including the control of epidemics.

Select and operate machines, vehicles, and equipment adjusting controls to exact positions when necessary.

- Drill a tooth.
- Operate a bulldozer.
- Perform surgery.
- Fit patients for orthopedic braces, prostheses, and supportive devices.
- Adjust elevator safety controls, counterweights, door mechanisms, and components.
- Select a screwdriver to use in adjusting a vehicle's carburetor.
- Identify the equipment needed to produce a new product line.
- Adjust the speed of assembly line equipment based on the type of product being assembled.
- Control airplane approach and landing at a large airport during a busy period.

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