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Updating AP Potential™ Expectancy Tables Involving PSAT/NMSQT® Writing

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Abstract

AP Potential™ is a data-driven tool offered by the College Board that uses scores from the PSAT/NMSQT® to identify students who have the potential to succeed in Advanced Placement Program® (AP®) courses (College Board, 2007). Research showing a moderate-to-strong correlation between PSAT/NMSQT scores and AP Exam scores serves as the basis for this tool (Camara and Millsap, 1998; Ewing, Camara, and Millsap, 2006). The PSAT/NMSQT is a shorter version of the SAT® designed to measure reasoning and thinking skills in the areas of critical reading, mathematics, and writing. In 2006, changes to the writing scale were made because it was the first year in which the PSAT/NMSQT writing scale was linked to the new SAT writing scale. This scale change had implications for AP Potential in that the AP Exams that used PSAT/NMSQT writing scores singly or in combination with critical reading and/or mathematics scores needed to be updated. Thus, the purpose of this study was to recompute the expectancy tables for those AP Exams that involved writing. Because this report focuses on the expectancy tables that involved writing, readers interested in the other AP Exams and in detailed information regarding the proper use of these tables should reference the full report (Ewing et al., 2006).

Background

More than 30 years ago, Novick and Jackson (1970) discussed the use of educational tests in guidance services and stated: "Indeed an important task of any guidance service will be to suggest to students that they may be qualified to enroll in programs" (p. 460). The rationale behind the development of AP Potential closely corresponds to this notion of educational guidance. AP Potential uses scores from the PSAT/NMSQT to identify students who should consider enrolling in AP courses because of their probability for success (College Board, 2007). Research originally conducted by Camara and Millsap (1998) and later updated by Ewing, Camara, and Millsap (2006) serves as the basis for this tool. Their research showed that PSAT/NMSQT scores were moderately to strongly correlated with grades on most AP Exams. The correlations between the PSAT/NMSQT scores and AP Exam grades that Ewing et al. reported are reproduced in Table 1. The table shows the correlations between grades on 33 AP Examinations and seven PSAT/NMSQT scores including (1) verbal (V), (2) mathematics (M), (3) writing (W), (4) V+M, (5) V+W, (6) M+W, and (7) V+M+W. The data used to compute these correlations included high school sophomores and juniors who completed the PSAT/NMSQT in October 2000 or October 2001 and one or more AP Examinations 19 months later (i.e., either in May 2002 or May 2003). As can be seen, the PSAT/NMSQT scores were moderately to strongly correlated with subsequent grades on all AP Examinations with the exception of the following four exams: (1) German Language, (2) Spanish Language, (3) Studio Art: Drawing, and (4) Studio Art: 2-D Design. Camara and Millsap (1998) found similar results and indicated that one reason for the low correlations between PSAT/NMSQT scores and the two language exams was because a significant number of the students taking these exams were native speakers acquiring language skills outside of the classroom. For the AP Studio Art Exams, the low correlations may have resulted because the AP Studio Art Exams consist entirely of portfolio reviews or because the constructs measured by the tests are unrelated. With the exception of these four AP Exams, all other AP Exams exhibited a correlation of .40 or higher with

Table 1

Correlations of PSAT/NMSQT Scores with AP Examination Grades

AP Examination	*V*	*M*	*W*	*V+M*	*V+W*	*M+W*	*V+M+W*	*Sample*
Art History	.566	.424	.521	.551	**.575**	.529	.571	16,055
Biology	.585	.591	.527	**.656**	.592	.625	.646	120,388
Calculus AB	.374	**.530**	.359	.507	.392	.498	.481	228,922
Calculus BC	.324	**.484**	.324	.454	.347	.452	.430	66,370
Chemistry	.472	**.599**	.453	**.599**	.492	.589	.579	76,704
Computer Science A	.423	.511	.401	**.527**	.440	.512	.510	16,020
Computer Science AB	.408	.454	.381	**.493**	.422	.471	.479	8,866
English Language and Composition	.712	.543	.659	.695	**.732**	.671	.725	188,200
English Literature and Composition	.704	.511	.657	.674	**.727**	.653	.710	324,151
Environmental Science	.591	.542	.515	**.632**	.590	.594	.628	35,679
European History	.577	.451	.503	.577	.577	.537	**.586**	47,027
French Language	.423	.342	.452	.426	**.465**	.445	.461	22,712
French Literature	.464	.382	.499	.468	**.509**	.486	.503	2,500
German Language*	.257	.195	.348	.251	.323	.306	.304	4,749
Government and Politics: Comparative	.520	.413	.458	.523	.522	.490	**.532**	14,759
Government and Politics: United States	.599	.515	.525	.620	.599	.582	**.622**	134,996
Human Geography	.597	.491	.540	.606	.605	.575	**.617**	4,600
Latin Literature	.443	.380	.479	.466	.496	.489	**.504**	4,161
Latin: Vergil	.432	.380	.471	.458	.485	.483	**.495**	5,437
Macroeconomics	.481	.533	.440	**.566**	.490	.543	.551	50,791
Microeconomics	.454	.525	.431	**.549**	.472	.535	.537	34,769
Music Theory	.375	.477	.422	.473	.424	**.498**	.480	8,382
Physics B	.419	.540	.396	**.541**	.435	.525	.517	51,915
Physics C: Electricity and Magnetism	.354	.455	.355	**.460**	.380	.455	.446	15,366
Physics C: Mechanics	.436	**.572**	.426	.567	.460	.556	.544	30,421
Psychology	.582	.523	.538	.614	.598	.593	**.624**	73,720
Spanish Language*	.005	.056	.030	.033	.013	.014	.012	74,433
Spanish Literature	.427	.379	.411	.424	**.433**	.415	.431	9,250
Statistics	.490	.604	.478	**.617**	.516	.612	.602	73,292
Studio Art: Drawing*	.157	.202	.160	.199	.168	.200	.195	10,970
Studio Art: 2-D Design*	.138	.160	.122	.167	.138	.157	.159	8,165
U.S. History	.584	.478	.513	.595	.587	.559	**.603**	231,889
World History	.573	.476	.488	.584	.565	.539	.583	7,990

*Correlations too low for reporting.
Note: Bold text indicates highest correlation among PSAT/NMSQT scores. Shaded box indicates the model used for estimating expected grades on AP Examinations from PSAT/NMSQT scores.
Source: From Ewing, Camara, and Millsap (2006). *The relationship between PSAT/NMSQT scores and AP Examination grades; A follow-up study.*

one or more PSAT/NMSQT scores, and in the majority of the cases the correlations were above .50.

The moderate-to-high correlations between PSAT/NMSQT scores and AP Exam grades provided validity evidence supporting the use of PSAT/NMSQT scores to predict performance on AP Exams. To assist educators in using the PSAT/NMSQT scores to identify potential AP students, Ewing et al. (2006) computed expectancy tables for the 29 AP Exams that showed a moderate-to-strong correlation with at least one PSAT/NMSQT score. The expectancy tables show the percent-

Table 2

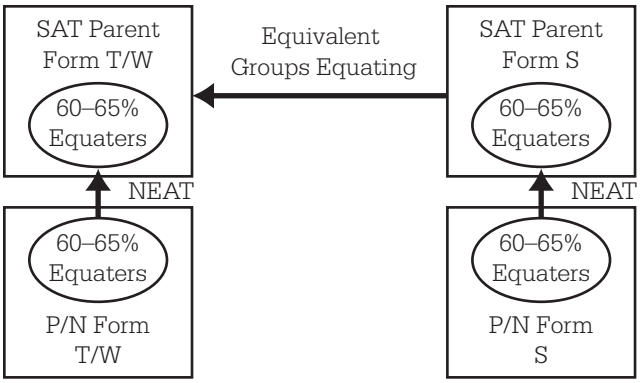
AP Expectancy Tables That Use PSAT/NMSQT Writing

PSAT/NMSQT Scale	*AP Exam*
Writing	French Literature Latin Literature Latin: Vergil Spanish Literature
Critical Reading + Writing	Art History English Language and Composition English Literature and Composition
Critical Reading + Mathematics + Writing	European History Government and Politics: U.S. Psychology U.S. History

age of test-takers earning a 3 or better and a 4 or better on AP Examinations across the range of PSAT/NMSQT scores, and educators can use these tables to identify students who are likely to succeed in an AP course. For 11 AP Exams, the writing score from the PSAT/NMSQT was used singly or in combination with mathematics and/or critical reading scores as the basis for building the expectancy table. These 11 tests are presented in Table 2. In 2006, changes to the writing scale were made because it was the first year in which the PSAT/NMSQT writing scale was linked to the new SAT writing scale. This scale change had implications for AP Potential in that the AP Exams that used writing scores singly or in combination with critical reading and/or mathematics scores needed to be updated. The details of the scaling change are described next.

New PSAT/NMSQT® Writing Scale

The 20-to-80 point scales of the critical reading, writing skills, and mathematics sections of the PSAT/NMSQT are established using the "parent" form equating model. Previously administered forms of the SAT serve as parent forms and provide 60–65 percent of the items for a given form of the PSAT/NMSQT (either Tuesday/Wednesday [T/W] or Saturday [S]). The parent SAT forms generally were administered on the same administration date, and the scores for the two SAT forms are equated using an equivalent groups equating design. See Figure 1 for a diagram of the equating process. These shared items serve as "equators," and test-taker performance on them provide the data for the statistical analyses that are undertaken when new PSAT/NMSQT forms are equated to the SAT. A nonequivalent groups external anchor test design (NEAT) is used to link



Source: From Oh, H-J. (2006, March 2). PSAT/NMSQT Equating. Reprinted with permission.

Figure 1. Equating design for the PSAT/NMSQT.

the PSAT/NMSQT to its SAT parent and various linear (i.e., Tucker, Levine, Chained-Linear), nonlinear (unsmoothed and smoothed chained equipercentile), and IRT (true score method) equating methods are attempted before choosing the best method for equating the PSAT/NMSQT. Equating methods link the raw scores on the PSAT/NMSQT to those for its SAT parent, and the raw scores are then placed on the 20-to-80 point scale using the raw-to-scale score conversion table for that form of the SAT. However, the ending zero for the 200-to-800 point SAT scale is omitted for the PSAT/NMSQT, creating a scale ranging from 20 to 80 points.

Because the SAT did not have a writing section until March 2005, it was not possible for the SAT to serve as the parent form for the PSAT/NMSQT writing skills section. Instead, the scale for the PSAT/NMSQT writing skills section was based on the SAT Subject Test in Writing. This changed in 2006 when the SAT writing section began serving as the parent form for the PSAT/NMSQT writing skills section. As a result of this change, a new scale was established for the PSAT/NMSQT writing skills section that made it an even stronger predictor of SAT writing scores. It is important to note that the change to the scale of the PSAT/NMSQT writing skills section is a permanent one: from 2006 on, PSAT/NMSQT writing skills sections will be created from the SAT and will share the same scale.

In 2003, a field trial was undertaken to evaluate the effects on test-takers of the changes to the SAT and PSAT/NMSQT (see Kobrin and Schmidt, 2005). One of the designs from this study provided a source of data that could be used to understand how the new parent form for the writing skills section of the PSAT/NMSQT affected its score scale. In this design, a group of students took both a new and old version of the PSAT/NMSQT writing skills section. The

scales for each test were set—using the SAT Subject Test in Writing as the parent form for the old PSAT/NMSQT and a prototype of the SAT writing section as the parent form for the new PSAT/NMSQT—and the scores on the new and old versions of the writing skills section were compared. The equipercentile method was used to create a conversion table relating scores from the new test to those for the old test and vice versa. The equipercentile method "sets equal the scores on each test having the same percentile ranks in each sample" (Schneider and Dorans, 1999). For example, the score at the 80th percentile on the old PSAT/NMSQT would correspond to the score at the 80th percentile on the new PSAT/NMSQT.

Table 3

Conversion Table for Comparing the Pre-2006 PSAT/NMSQT Writing Skills Score Scale to the Current PSAT/NMSQT Writing Skills Score Scale

Pre-2006 Scale	*Current Scale*	*Pre-2006 Scale*	*Current Scale*
80	77–80	49	47
79	76	48	46
78	74	47	45
77	73	46	44
76	72	45	43
75	71	44	42
74	70	43	41
73	69	42	40
72	68	41	39
71	67	40	38
70	66	39	37
69	65	38	36
68	64	37	34
67	63	36	33
66	63	35	31
65	62	34	29
64	61	33	26
63	60	32	24
62	59	31	20
61	58	30	20
60	57	29	20
59	56	28	20
58	55	27	20
57	54	26	20
56	54	25	20
55	53	24	20
54	52	23	20
53	51	22	20
52	50	21	20
51	49	20	20
50	48	—	—

The conversion table for comparing PSAT/NMSQT writing skills scores prior to 2006 to the PSAT/NMSQT writing skills test after 2006 is provided in Table 3. The conversion tables for the new writing skills section were used to adjust the data for the AP Potential tool (see next section).

Methodology

Given the scaling changes, the purpose of this study was to recompute the expectancy tables for those AP Exams that involved writing. For this study, the data analyzed were the same data used by Ewing et al. (2006) and included sophomores and juniors who completed the PSAT/NMSQT in October 2000 or October 2001 and took one or more AP Examinations 19 months later (i.e., either in May 2002 or May 2003). To recompute the expectancy tables, the old PSAT/NMSQT scores from the 2000 and 2001 test administrations were placed on the new 2006 PSAT/NMSQT score scale using the conversion table displayed in Table 3. This conversion table was applied exactly as shown except for the conversion from 80 (on the old scale) to 77–80 (on the new scale), where the midpoint value of 78.5 was used for the new scale.

Once the conversion table was applied, the expectancy tables were recomputed following the same procedures that were outlined in previous research. That is, the data were pooled across schools, and expectancy tables were computed showing the percentage of test-takers earning a 3 or better and a 4 or better on AP Exams across the range of PSAT/NMSQT scores. In developing each expectancy table, the selected PSAT/NMSQT scale was divided into 5-point or 10-point score ranges. Five-point score ranges were used when one or two PSAT/NMSQT scales were used, and 10-point score ranges were used when all three PSAT/NMSQT scales were used. The percentages of test-takers earning a 3 or better and a 4 or better, were then calculated within each score range. Table 4 presents the expectancy results.

In reviewing the tables, it is important to keep in mind two points. First, if the number of AP students falling within the PSAT/NMSQT score interval was less than 20, or if only two or fewer students within a given interval earned a 3 or better or a 4 or better, percentages were not reported. Second, in some cases the computations yielded percentages that were unstable, particularly at the very low end of the PSAT/NMSQT scale, in that the percentages did not always increase as PSAT/NMSQT scores increased. This result is relatively common with the empirical approach used in this

Table 4

New Expectancy Tables Involving PSAT/NMSQT Writing Skills Scores for 11 AP Exams in Alphabetic Order: Probabilities of an AP Grade Greater Than or Equal to 3 and Greater Than or Equal to 4 by PSAT/NMSQT Score

Art History

PSAT/NMSQT	*AP Grade*		
V+W Score	*≥3*	*≥4*	**n**
160–156	100.0	92.6	95
155–151	98.8	92.1	165
150–146	97.8	85.5	275
145–141	98.2	83.9	397
140–136	96.5	79.6	608
135–131	94.7	71.8	895
130–126	92.8	65.2	1,157
125–121	91.0	59.2	1,370
120–116	86.7	54.8	1,473
115–111	81.3	42.7	1,687
110–106	77.4	38.0	1,701
105–101	69.1	29.8	1,529
100–96	63.3	23.4	1,311
95–91	53.3	17.4	1,102
90–86	42.0	10.3	826
85–81	34.7	7.9	585
80–76	28.8	4.1	386
75–71	21.4	3.1	229
70–66	19.0	5.6	126
65–61	9.4	–	64
60–56	9.3	–	43
55–51	13.0	–	23
50–46	–	–	5
45–40	–	–	3
Total	–	–	16,055

English Language and Composition

PSAT/NMSQT	*AP Grade*		
V+W Score	*≥3*	*≥4*	**n**
160–156	99.7	97.1	342
155–151	99.7	96.7	789
150–146	99.9	94.5	1,398
145–141	99.5	92.1	2,609
140–136	99.2	88.8	4,585
135–131	98.9	83.8	7,146
130–126	97.9	75.0	10,578
125–121	96.1	65.0	14,108
120–116	92.9	52.2	17,249
115–111	87.1	38.8	20,582
110–106	77.9	26.0	21,965
105–101	65.5	15.5	21,020
100–96	51.8	8.5	18,842
95–91	35.8	4.1	15,690
90–86	23.7	1.8	11,896
85–81	13.0	0.6	8,103
80–76	6.4	0.2	5,216
75–71	3.9	0.1	2,800
70–66	2.0	–	1,532
65–61	1.0	–	820
60–56	1.3	–	519
55–51	1.2	–	260
50–46	–	–	94
45–40	–	–	57
Total	–	–	188,200

English Literature and Composition

PSAT/NMSQT	*AP Grade*		
V+W Score	*≥3*	*≥4*	**n**
160–156	99.9	98.0	1,475
155–151	99.5	95.9	3,026
150–146	99.5	93.6	5,063
145–141	99.4	90.4	8,968
140–136	98.7	83.9	14,019
135–131	97.6	75.2	19,790
130–126	95.6	63.2	26,180
125–121	91.8	50.3	32,400
120–116	86.4	37.3	35,969
115–111	77.3	25.0	37,874
110–106	65.8	14.8	36,125
105–101	51.5	8.0	30,623
100–96	37.1	4.0	24,134
95–91	24.3	1.8	18,083
90–86	14.0	0.7	12,392
85–81	7.1	0.3	7,963
80–76	3.7	0.2	4,602
75–71	1.8	–	2,545
70–66	1.0	–	1,464
65–61	0.6	–	689
60–56	–	–	430
55–51	–	–	215
50–46	–	–	82
45–40	–	–	40
Total	–	–	324,151

European History

PSAT/NMSQT	*AP Grade*		
V+M+W Score	*≥3*	*≥4*	**n**
240–231	98.6	95.9	221
230–221	99.6	91.5	779
220–211	99.0	85.8	1,816
210–201	97.5	77.2	3,243
200–191	95.3	67.3	5,109
190–181	91.1	54.1	6,776
180–171	84.9	40.4	7,667
170–161	75.9	29.0	7,332
160–151	66.0	19.3	5,848
150–141	54.0	12.7	4,042
140–131	39.8	7.2	2,338
130–121	28.3	2.7	1,113
120–111	17.1	2.7	438
110–101	12.8	–	203
100–91	6.2	–	65
90–81	–	–	27
80–71	–	–	6
70–60	–	–	4
Total	–	–	47,027

French Literature

PSAT/NMSQT	*AP Grade*		
W Score	*≥3*	*≥4*	**n**
80–76	95.5	82.2	202
75–71	94.1	78.0	337
70–66	84.8	61.4	402
65–61	75.7	47.9	514
60–56	63.8	36.4	431
55–51	53.1	23.8	324
50–46	31.2	16.9	154
45–41	33.3	17.3	75
40–36	19.4	8.3	36
35–31	–	–	19
30–26	–	–	4
25–20	–	–	2
Total	–	–	2,500

Government and Politics: U.S.

PSAT/NMSQT	*AP Grade*		
V+M+W Score	*≥3*	*≥4*	**n**
240–231	98.6	87.9	487
230–221	98.1	84.3	1,729
220–211	95.3	74.4	4,288

Table 4 (Continued)

New Expectancy Tables Involving PSAT/NMSQT Writing Skills Scores for 11 AP Exams in Alphabetic Order: Probabilities of an AP Grade Greater Than or Equal to 3 and Greater Than or Equal to 4 by PSAT/NMSQT Score

210–201	91.9	64.6	8,189
200–191	86.3	52.8	13,014
190–181	79.0	40.3	18,265
180–171	67.9	29.0	21,059
170–161	54.6	17.9	21,236
160–151	40.0	10.2	17,747
150–141	27.1	5.5	12,811
140–131	15.0	2.2	7,890
130–121	7.7	0.8	4,508
120–111	3.6	0.1	2,238
110–101	1.6	–	945
100–91	1.2	–	407
90–81	–	–	135
80–71	–	–	39
70–60	–	–	9
Total	–	–	134,996

Latin Literature

PSAT/NMSQT W Score	*AP Grade*		
	≥3	*≥4*	**n**
80–76	90.2	67.4	193
75–71	87.3	63.4	314
70–66	78.2	53.0	496
65–61	72.4	42.2	880
60–56	58.9	30.4	836
55–51	43.2	19.8	834
50–46	28.6	8.7	367
45–41	19.6	8.8	148
40–36	12.1	4.5	66
35–31	8.7	–	23
30–26	–	–	2
25–20	–	–	2
Total	–	–	4,161

Latin: Vergil

PSAT/NMSQT W Score	*AP Grade*		
	≥3	*≥4*	**n**
80–76	91.9	76.7	210
75–71	90.8	68.8	478
70–66	83.5	55.5	620
65–61	75.4	44.3	1,162
60–56	65.2	31.1	1,109
55–51	50.3	22.0	1,010
50–46	36.4	15.5	511
45–41	30.3	10.4	241
40–36	20.0	5.7	70
35–31	–	–	18
30–26	–	–	7
25–20	–	–	1
Total	–	–	5,437

Psychology

PSAT/NMSQT V+M+W Score	*AP Grade*		
	≥3	*≥4*	**n**
240–231	100.0	99.3	136
230–221	100.0	98.4	569
220–211	99.2	94.6	1,416
210–201	99.1	91.9	3,025
200–191	97.1	86.6	5,254
190–181	94.8	78.0	8,090
180–171	90.0	66.7	10,545
170–161	82.8	54.0	11,883
160–151	72.4	40.5	11,087
150–141	58.2	27.7	8,953
140–131	43.4	16.4	6,320
130–121	28.6	8.7	3,503
120–111	17.7	4.5	1,719
110–101	9.5	2.1	802
100–91	4.4	–	274
90–81	–	–	111
80–71	–	–	30
70–60	–	–	3
Total	–	–	73,720

Spanish Literature

PSAT/NMSQT W Score	*AP Grade*		
	≥3	*≥4*	**n**
80–76	94.9	80.0	215
75–71	94.6	77.8	410
70–66	91.8	66.0	582
65–61	85.4	56.3	1,051
60–56	82.8	49.6	1,039
55–51	79.0	45.2	1,253
50–46	72.8	38.2	1,082
45–41	68.0	28.4	1,255
40–36	57.2	20.7	1,199
35–31	55.1	18.2	643
30–26	47.8	14.7	232
25–20	44.6	10.0	289
Total	–	–	9,250

U.S. History

PSAT/NMSQT V+M+W Score	*AP Grade*		
	≥3	*≥4*	**n**
240–231	98.8	95.8	260
230–221	97.9	93.0	1,030
220–211	97.4	86.9	3,069
210–201	95.0	80.4	7,001
200–191	90.8	71.7	13,855
190–181	85.3	60.5	23,296
180–171	76.6	47.1	32,340
170–161	64.2	34.2	38,550
160–151	50.4	22.5	37,920
150–141	37.1	13.7	30,786
140–131	25.2	8.0	20,879
130–121	14.9	4.0	12,216
120–111	8.2	1.9	6,268
110–101	4.1	1.0	2,748
100–91	2.3	0.4	1,127
90–81	2.4	–	424
80–71	–	–	100
70–60	–	–	20
Total	–	–	231,889

study, especially when the number of students per interval is small. To help address this issue, 10-point PSAT/NMSQT score intervals were used when all three PSAT/NMSQT scales were used to compute the expectancy table in order to increase the number of students per interval. In addition, *AP Potential* (College Board, 2007) reports percentages only once an increasing trend has stabilized. Similarly, at the high end of the scale, some percentages were nearly identical and, when rounded, equaled the same whole number. *AP Potential* handled this by collapsing categories with nearly identical percentages and reporting the average of the percentages for the collapsed categories.

Using the Expectancy Tables

The expectancy tables are designed to assist educators in identifying potential students who may be successful in AP courses. Educators may also use AP Potential, which is based on this research, available online, and provided free to schools that administer the PSAT/NMSQT (see appotential.collegeboard.com for demonstration). To use these tables or AP Potential to identify possible AP students, the first step would be for the educator to select the AP Examination of interest and then determine the probability of success (or success rate) that the educator feels is appropriate for the school in question. As discussed in previous research (Camara and Millsap, 1998; Ewing et al., 2006), the appropriate success rate is a decision that should be made by school administrators, school counselors, or educators. There are no absolute rules for selecting the rate. A reasonable starting point may be to select the probability level that is closest to 50 percent for earning an AP Examination grade of 3 or better; however, it may be advisable to adjust that level up or down depending on each school's unique characteristics (e.g., teacher resources, class sizes, etc.). Once the success rate is selected, the educator can then determine the minimum PSAT/NMSQT score that is associated with that success rate. For example, consider AP French Literature, which uses writing scores as the basis for building the expectancy table. The minimum writing score associated with a probability of success closest to 50 percent is a score of 51. Therefore, a counselor might begin by identifying all students who have a writing score of 51 or higher as a starting point when considering placement decisions in this course. Similarly, if a student or parent expresses interest in AP French Literature, the table can also be used to look up the student's expected success rate to help make a more informed decision.

It is important to emphasize that AP Potential is not intended to replace other methods for identifying students for AP course work. Other methods may include teacher recommendations, grades in relevant courses, and student interest. Scores on the PSAT/NMSQT can serve as one piece of information in making placement decisions, but the scores should never be used as the only piece of information, nor should test scores be weighted more heavily than other indicators. For more information about the development of the expectancy tables, and for additional cautions about the proper use of the expectancy tables, please see Ewing et al. (2006).

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