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Refining Workforce Education Supply and Demand Analysis: Final Report

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FINAL REPORT

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I.   INTRODUCTION AND PURPOSE

The Washington legislature has requested the production of a forecast of net job openings for occupations that require higher education and training and the number of individuals who will have the education and training that is required to fill the openings. In other words, the legislature has requested an occupational supply and demand forecast by educational level for occupations that are moderately to highly skilled. The purpose of these occupational forecasts is to influence postsecondary institutions, to influence student choice, and to inform policy makers. Any given occupation may be characterized in one of three statuses: (1) a gap will exist because the forecasted demand for workers will far exceed the likely supply, (2) the forecasted demand for workers will be in rough balance with the potential supply, or (3) a surplus will exist because the forecasted demand for workers will be far less than the likely supply. Postsecondary institutions may need to expand the availability of education and training programs that lead to occupations with a gap. Policy makers may need to support such expansion and provide incentives to attract students to such programs. As interests and abilities warrant, students may want to pursue these education and training programs because of their favorable labor market opportunities.

Conversely, postsecondary institutions may wish to contract the availability of education and training programs that lead to occupations that are forecasted to have a substantial surplus. Policy makers may want to monitor the situation and make sure that scarce state resources are not invested in programs in which there is an oversupply of students. Students may want to avoid these education and training programs because of their limited economic opportunities.

State agencies have produced to date four studies to meet the legislative mandate. The publication dates on these reports were January 2006, March 2009, 2011 (no month published), and October 2013. All of the reports were authored jointly by staff members of the Workforce Training and Education Coordinating Board (WTECB), the State Board for Community and Technical Colleges (SBCTC), and the Higher Education Coordinating Board (now the Washington Student Achievement Council, (WSAC).

All four of the reports use labor market projections provided by the Employment Security Department (ESD) as their starting point for determining occupational demands (forecasted job openings by occupation). Three of the four reports (2006, 2009, and 2013) use two different methods to allocate those occupational demands by educational levels. The two methods are (1) educational requirements as determined by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor and (2) educational credentials held by employed individuals from Washington in national data sets (the 2000 Census of Population for the 2006 and 2009 reports

and the American Community Survey (ACS) for the 2013 report). The 2011 report used just the second method, and it, too, relied on the ACS.[1]

All four reports calculate potential gaps, i.e., occupational demand exceeding potential supply by a substantial margin, by comparing the projected openings by educational level to the number of individuals completing or exiting from postsecondary programs in the state. The supply estimates are not based on forecasts. The higher education completions are adjusted downward to reflect the fact that a percentage of completers will not enter Washington's labor market; in some cases, they have been adjusted upward to reflect the possibility that upskilling of occupations will occur over time.

The purpose of this report is to assess the methods used by the Washington agencies to estimate the balance between occupational demands by educational level and the potential supply of individuals who will be available to fill those demands. We offer several recommendations that we believe would improve upon the methods or data that have been used. To inform our recommendations, we have analyzed data from several sources. For the most part, these data sources have not been used by state analysts in prior studies. In some cases, however, the data sources have been used, but we employ different data restrictions.

In addition to the methodological suggestions based on empirical analyses of data sets, we offer some recommendations based on a critique of the prior studies.

The next section of the report focuses on the methods used to project job openings by education level. It provides a summary of our understanding of the methods employed in producing the 2013 report, and then presents our recommendation to forecast the demand side based on actual openings or based on new hires. The third section of the report turns to the supply side of the equation. In other words, it addresses the techniques for translating the numbers of individuals completing or exiting from their educational experiences, by instructional program, to the occupations that they may choose to enter. In shorthand, this section is about the crosswalk from the classification of instructional programs (CIP) to the standard occupational classification (SOC) system. The section summarizes our understanding of the methods used in the 2013 report, provides a description of analyses of alternative data sources, and presents potential alternative approaches. The final section of the report provides our recommendations that do not rely on data analyses.

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[1] We note there have also been some definitional changes in the occupational classification system and educational categories used by ESD over the different reports.

II. PROJECTION OF JOB OPENINGS BY EDUCATION LEVEL

A. Summary of 2013 Methods

As with all of the prior studies, the 2013 analysis begins with the forecasts of annual job openings by region and occupation supplied by ESD. According to documentation and our conversations with ESD, predictions from the Global Insight model are used as regressors in augmented autoregressive (AR) equations to forecast aggregated industry projections for the state, which are disaggregated to four-digit NAICS industry codes by county using Quarterly Census on Employment and Wages (QCEW) data and predictive models estimated in SAS. This disaggregation is done mostly by ratio adjustment using the latest available QCEW, subject to certain censoring rules and some regression adjustment. The county data are then aggregated to workforce development areas (WDAs).

The projections of openings by industry, which include both new and replacement openings, are converted to occupation projections by ratio adjustment using data from the Occupational Employment Statistics (OES) survey. The ESD document suggests that a few ad hoc adjustments are made at this step due to limited industry coverage of the OES. Furthermore, the ESD document alludes to the use of "change factors", created by BLS, to predict changes in occupational shares for each industry over time.[2] In our conversation with ESD, we learned that these change factors are used conservatively and play a minor role in adjusting the forecasts.

The 2013 study distributes the annual projections of openings by detailed occupation to openings by occupation and educational level using two different occupation/education mappings: (1) the BLS-derived education levels needed to enter an occupation and (2) actual education levels possess by incumbent employees in occupations as tabulated from the American Community Survey (ACS). The report refers to the former approach as the "entry-level" educational level needed to fill an opening and the latter as the "competitive" educational level. It is worth emphasizing that the BLS "entry-level" method assigns a single education level to each occupation; the ACS "competitive" method allows multiple education levels for each occupation. The educational distributions used in the 2013 study encompass five categories: high school or less; less than one year of postsecondary education; mid-level (apprenticeship, one or more years of postsecondary education, or associate's degree); bachelor's degree; and graduate degrees. The study focuses on occupations assigned to the latter three categories.

Each of the two methods used to distribute openings to educational levels has advantages and disadvantages. The main advantages for the BLS entry-level approach are its relative simplicity—a single educational level for an occupation—and its conceptually appropriate definition—it purports to be based on the entry requirements as observed in task analysis of

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[2] p.31 of ESD document.

actual jobs. The main disadvantages of this approach are that it doesn't reflect the range of educational levels at entry within an occupation, and it is abstract and static and not necessarily reflective of true requirements over time.

The main advantages of the competitive level based are that the large sample sizes in the ACS allow for the statistical identification of educational requirements for detailed occupations in subnational geographies, and the distributions are empirically derived and reflect changes over time. The main disadvantage of this approach may be referred to as incumbent worker bias. Since the distributions are derived from all workers, they include individuals who may have gained education on the job (e.g., teachers or firefighters) as well as older workers who may have entered the occupation when requirements were different than today (e.g., pharmacists or physical therapists). This bias may be positive or negative. It may be possible to reduce incumbent bias through restrictions on the data; however, this is cumbersome and ad hoc.

B.   Description of Other Sources Based on Actual Openings or New Hires

After reviewing the method used in the 2013 study and analyzing several other data sets, we recommend that the state consider using an approach based on the actual openings for jobs as derived from aggregating online postings, or using an approach based on the educational levels of individuals who have begun employment spells. Alternatively, the state could employ methods based on using another survey to supplement the ACS.

1.   Actual Openings from Job Postings

Job postings data consist of electronically posted vacancies that are collected, parsed, and systematized via computer algorithms. They can provide labor market information in real time and include changes driven by labor market conditions, unlike traditional survey data (such as the ACS) which often come with a significant time lag. Because detailed information including job title is collected, they can also provide a higher level of specificity than is typically found in survey data; for example, job postings data can distinguish demand for preschool administrators from college administrators. Importantly, they capture the conceptually appropriate definition of new jobs, avoiding incumbent worker bias. However, job postings data do not generally provide as complete job coverage as the survey data, as not all jobs are advertised electronically, and they have not been as thoroughly tested for reliability.

Two major sources of job postings data are Burning Glass Technologies and the Conference Board's Help Wanted Online Index (HWOL, which employs data from Wanted Technologies.) Both sources require a subscription and fees for access. In comparing these two sources with BLS Job Openings and Labor Turnover Survey (JOLTS) data, the government's official statistics on job openings, we found that overall trends in volume are similar, although

levels vary.[3] HWOL, to which ESD subscribes, provides more thorough coverage of occupations than does Burning Glass. In particular, Burning Glass appears to undercount jobs in agriculture and construction relative to HWOL.[4] A critical advantage of the Burning Glass data, on the other hand, is that they provide the educational requirements of the postings—if they are present—while HWOL data do not.

Of course, not all job postings specify education requirements. Across all postings in the 2010 to 2013 period, 53 percent listed such requirements, but some occupations are more likely to list them than others. In particular, occupations that cluster at both the extreme high and low ends of the education spectrum are less likely to specify necessary education in postings. For certain highly skilled occupations, such as medical doctors and lawyers, the lack of listed education requirements likely stems from an assumption that these professions almost universally require a terminal and specific degree. For many less skilled occupations, such as hairdressers and food servers, unspecified education requirements may mean that no formal education is needed (although specific training, skills, and experience might be.)[5] For the postings that do list education requirements, the algorithm used to classify them has been found fairly reliable. Carnevale, Jayasundera, and Repnikov (2014) determined that listed educational requirements were 85 percent accurate in quality control testing. This is comparable to typical national survey data (see Kane, Rouse, and Staiger 1999).

2.   New Hires from Current Population Survey

The Current Population Survey (CPS) is another source for education distributions across occupations. Rather than looking at incumbent workers, as in the ACS, the longitudinal nature of the CPS allows the identification of workers who have taken a new job between one month and the next. The education of these workers can then be tabulated by their new occupation.

This source also provides a conceptually appropriate definition of labor demand by capturing the education distribution of newly hired workers. Furthermore, the data are readily available without charge, and sample sizes become sufficient for detail at the national, 5-digit SOC level when data are aggregated over time. However, longitudinally linking the same individuals over time is somewhat complicated, and unlike postings data, sample sizes are too small for identifying state-level education distributions. Additionally, occupational coding

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[3] JOLTS data provide openings by industry but not by occupation.

[4] In turn, HWOL undercounts these jobs relative to Washington's (recently discontinued) ESD-administered occupational vacancy survey.

[5] For the 6-digit SOC occupations for which we have postings data, we have regressed the share of postings not specifying education requirements on the shares specifying different education levels, where these latter shares are *conditional* on postings that did specify education requirements. There is a strong positive association between the share requiring high school degree or less and the probability of not specifying education requirements. There was no association at the mid-level or graduate-degree level, and there was a strong negative relationship at the bachelor's-degree level.

error—which exists in any survey—is exacerbated when looking at job changes. Our review of these data suggest this issue is of greatest concern for the most-skilled occupations, such as lawyers and doctors, and is more modest for occupations with mid-level educational requirements.

3. Alternative Using Incumbent Workers from Other Sources and Data Restrictions

a. SIPP (Survey of Income and Program Participation)

The Survey of Income and Program Participation is a panel study of approximately 50,000 households that are followed for four or more years. Designed to capture detailed reporting of income from multiple sources, it also provides much greater detail on education than the CPS or ACS. It is the only representative data source that allows empirical separation, by occupation, of the "some college, no degree" category into those who have certificates and those who do not. Work by Carnevale et al. (2012) and Jacobson (2011) demonstrates how certain certificates can provide a substantial earnings return relative to those with college credits but no credential (especially true for certificates in skilled trades, such as welding and vehicle repair.) Moreover, it contains information on field of study for the highest credential earned, whether the credential is a certificate, associate's degree, bachelor's degree, or graduate degree. This may help refine the CIP-SOC crosswalks for additional occupations.

On the other hand, there are compelling reasons for the SIPP to serve as a supplemental rather than primary source for determining education distributions of occupations. Like the ACS, it captures incumbent workers rather than new hires, but it lacks the tremendous sample size and generally does not provide sufficient precision for detailed occupations. Furthermore, new waves of households are sampled infrequently relative to other sources, so rapidly occurring changes in education requirements will be missed.

b. ACS with restricted age ranges

As noted above, a drawback of using all workers in the ACS is incumbency bias, in which workers who have acquired additional education on the job or entered an occupation in the past under different educational pathways cannot be separated from workers taking jobs recently. A simple and straightforward (if ad hoc) modification is tabulating educational distributions for a subset of workers, such as those between the ages of 25 and 34. Workers in this age range are less likely to suffer from incumbency bias and more likely to capture relatively recent hires. While we readily acknowledge that not all new hires fall into this age range, including those completing new educational training as well as more experienced job changers, the age restriction may serve as a reasonable proxy for employment demand that balances simplicity with accuracy. This assumption may not hold as well for occupations that almost universally require extensive experience for entry, such as management occupations. In order to evaluate the validity of age-based proxies, we can use the CPS to identify the age distributions of newly hired

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workers by detailed occupations or broader occupational groups. Such a data-driven approach can serve to refine the appropriate age restriction to use in the ACS. This would trade simplicity for better accuracy.

c.   O*Net

O*Net is the successor to the Dictionary of Occupational Titles and provides hundreds of characteristics—including required education—for detailed occupations. These characteristics are drawn from surveys and interviews of either incumbent workers or human resource experts. While the O*Net database is the only non-empirical source we review (besides the BLS measure), it does allow for a range of educational requirements for each occupation based on what the interviewed individuals thought was the necessary preparation to be hired into that occupation.

C.   Analysis of Sources

For each of these sources, we have tabulated the education distribution of workers for each SOC occupation at the 4-, 5-, and 6-digit levels. The education distribution we use has eight categories: less than high school, high school diploma or equivalent, some college but no credential, certificate, associate's degree, bachelor's degree, master's degree, and professional or doctorate degree. (These easily can be collapsed to match the 2013 report's five categories.) These distributions are found in the supplementary spreadsheet OCC_edreq_master.xlsx.

Our initial goal is to determine empirically the similarity of the occupation-specific education distributions across the different sources. A simple and transparent approach is to examine modal education for each occupation. We illustrate this approach in Table 1 using the BLS distribution as a reference. The table shows how many detailed occupations, within broader occupation groups, have modal education across sources that match the BLS level. The four sources used in the comparison include O*Net, ACS (as used in the 2013 report), CPS new hires, and Burning Glass job postings.

Generally speaking, modal education across occupations and sources does not match the BLS distribution especially well. For the ACS, CPS, and Burning Glass, roughly 60 percent of occupations have the same modal education as BLS, whereas O*Net agrees slightly more at approximately 70 percent.[6] However, some occupational groups match better than others. Management, business, and production occupations consistently match at a 75 percent or higher rate across sources; scientist, sales, and transportation occupations consistently match at a roughly 50 percent or below rate; and healthcare support, protective service, food preparation, and office/administrative occupations match highly in some sources and poorly in others.

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[6] The match rates in the table are weighted by occupation and do not take into account different employment counts within occupation.

These differences may stem from incumbency bias (particularly in the ACS), but they may also reflect real (conceptually-consistent) differences in education requirements across sources. To examine this possibility, we develop a more systematic—if more complicated—method of comparing educational distributions across sources. Specifically, we construct an index of dissimilarity that can be used to compare any pair of sources (including additional restrictions on a given source) across all SOC occupations. The formula for this index is given in Appendix 1.

Table 1 Comparison of BLS Education Requirements by Occupations with Other Sources

2-digit Occupation Group	# of 6-digit occs in group	O*Net: Mode = BLS, %	ACS: Mode = BLS, %	CPS: Mode = BLS, %	BG: Mode = BLS, %
11 Management	34	78%	68%	74%	82%
13 Bus. and Finance	32	80	75	73	68
15 Computer/Math	19	63	68	63	65
17 Architecture/Engineering	35	74	74	60	69
19 Life, Physical, Social Sci	43	55	49	50	47
21 Community/Social Service	18	50	67	67	56
23 Legal	9	88	44	44	33
25 Education/Training	63	88	70	33	48
27 Arts, Design, Entertainment	41	72	54	53	77
29 Healthcare Practitioners	61	78	62	57	70
31 Healthcare Support	17	81	35	33	59
33 Protective Service	22	65	9	35	73
35 Food Preparation	18	69	17	41	7
37 Building/Grounds Maint.	10	75	50	60	56
39 Personal Care	33	73	15	29	53
41 Sales	22	55	27	32	43
43 Office/Administrative	56	81	21	53	80
45 Agriculture	15	62	80	85	21
47 Construction/Extraction	60	70	70	69	67
49 Installation/Maint./Repair	52	71	63	65	64
51 Production	108	80	78	81	79
53 Transportation	52	37	40	56	54
Total	820	69%	59%	57%	63%

NOTE: The table shows the percentage of the detailed 6-digit SOC occupations within 2-digit occupation groups with modal education, across different sources, that match the designated BLS education. If a data source lacks an education distribution for a specific 6-digit occupation, the denominator is adjusted accordingly in calculating the percentage. The ACS 2009–2012 sample is based on employed individuals ages 18+; the CPS 2005–2013 sample is based on individuals who are in a new job as of the reference month; the Burning Glass 2010–2013 sample is based on postings with listed educational requirements. All sources are national in scope.

Our index of dissimilarity has two important features. First, it captures ordinal differences in education distributions. For example, if sources disagree only over the relative shares of workers with high school diplomas and those with some college but no credential, their dissimilarity will be smaller than if they disagreed over the relative shares with high school diplomas and with bachelor's degrees. Second, as the magnitude of a disagreement increases, its effect on dissimilarity increases more than proportionately.

Table 2 below shows the matrix of the index values across sources.[7] The index effectively runs from 0 to 100, with larger values indicating greater dissimilarity between sources. We have weighted occupations by the May 2013 OES employment counts for Washington.

From a quick view of the table, it should be immediately apparent that the BLS source is an outlier, significantly disagreeing from every other source. This is a direct consequence of that source allowing only a single education level for each occupation. Sources that permit a broader distribution are more similar to one another. Unsurprisingly, versions of the same source (such as different restrictions of the ACS or Burning Glass postings) are also more similar to each other than to other sources. Finally, sources that are meant to capture the same concept of worker (incumbents: ACS and SIPP; new workers: BG and CPS) are more similar to each other, as well.

The Burning Glass index values are of roughly the same order as O*Net values. While these are higher than the incumbent workers in the ACS or SIPP, or even the more appropriate new worker concept in the CPS, the BG distributions generally exist for more detailed occupations than the other sources and can be calculated at the state level. In the next section, we illustrate how alternative sources can change the supply-demand gaps for select occupations and occupation groups.

Table 2 Source comparison educational dissimilarity, 6-digit: WA employment weights

	BLS	ONET	ACS	ACS25	ACS35	ACSW	SIPP	BG	BGWA	CPS
BLS		7.4	9.4	10.0	9.2	10.6	10.2	6.4	6.9	8.8
ONET	7.4		2.4	2.6	2.2	2.9	2.2	2.8	2.8	2.3
ACS	9.4	2.4		0.1	0.1	0.2	0.4	3.0	3.4	0.3
ACS2534	10.0	2.6	0.1		0.3	0.3	0.5	2.4	2.6	0.4
ACS3554	9.2	2.2	0.1	0.3		0.3	0.5	2.0	2.3	0.3
ACSWA	10.6	2.9	0.2	0.3	0.3		0.4	2.7	3.0	0.5
SIPP	10.2	2.2	0.4	0.5	0.5	0.4		2.3	2.6	0.5
BG	6.4	2.8	3.0	2.4	2.0	2.7	2.3		0.1	1.9
BGWA	6.9	2.8	3.4	2.6	2.3	3.0	2.6	0.1		2.1
CPS	8.8	2.3	0.3	0.4	0.3	0.5	0.5	1.9	2.1	

NOTE: ACS2534 refers to ACS with age restriction of 25 to 34, ACS3554 refers to ACS with age restriction of 35 to 54, ACSWA refers to ACS restricted to WA residents, and BGWA refers to Burning Glass job postings in WA.

Finally, we have also tabulated the 6-digit SOC occupations that exhibit the greatest dissimilarity in educational requirements across data sources. These occupations, along with their average dissimilarity across sources and the source pairs that have the largest index values, are shown in Appendix Table 1 near the end of the document. There is little consistent pattern among these occupations: they include managerial and professional positions (SOCs 11 and 13) as well as artistic and athletic occupations (SOC 27) and other service and manufacturing jobs.

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[7] Occupation-specific components to the dissimilarity indices can be found in the supplementary file, OCCsource_comparison_final.xlsx.

However, the BLS education requirements are almost always in a source pair with the greatest dissimilarity.

D.   Example Occupations

We first note that the 2013 report does not provide gaps by detailed occupations (demand is calculated at detailed occupations but not supply), but we provide some illustrative detailed cases for context as well as the broader occupation groups used in the joint reports.

1.   Aerospace Engineer (SOC 17-2011)

This occupation is a STEM occupation with a fairly tight link between the specificity of educational training and entry. It is also a historically important occupation in Washington because of the longtime presence of Boeing.

Supply: In 2012, there were 57 bachelor's degrees and 41 graduate degrees in aerospace engineering (CIP 14.02) granted by the state's postsecondary institutions (IPEDS).There were 0 mid-level (long certificates, associate's degrees) credentials awarded.[8]

Existing Demand Methodology: The state ESD forecasts 236 annual openings for aeronautical engineers over 2017–2022.[9] According to the BLS measure, filling these openings would require 236 bachelor's degrees per year, as the entry education requirement for aerospace engineers is exactly a bachelor's degree. According to the ACS for Washington, filling these openings would require a range of degrees: 173 bachelor's and 63 graduate degrees.[10]

Existing Gap Methodology: The joint report applies a supply correction factor, drawn from the ACS, to account for completers who do not enter the labor force or continue on with further study. This factor varies only with broad education level, not occupation, and in this case adjusts supply downward by about 25 percent, or to 45 bachelor's graduates and 31 advanced graduates. The effective gap is thus 160 at the bachelor's level (236 − 76) under the BLS standard, and 128 at the bachelor's level (173 – 45) and 32 at the graduate level (63 – 31) for the ACS standard.

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[8] We focus on IPEDS supply here for simplicity, ignoring other mid-level completion sources. We also do not apply occupation–field-of-study crosswalk ratio adjustment.

[9] https://fortress.wa.gov/esd/employmentdata/docs/occupational-reports/all-occupational-projections.xls. These openings are expected to come mostly from retirement of incumbents rather than net growth.

[10] Authors' calculations from the 2009–2012 ACS for Washington state. Following the joint report's existing approach, education levels in the ACS below the BLS minimum are attributed or "rolled up" to the BLS minimum category. For the case of aerospace engineers, 16 percent of workers who report an education level below bachelor's degree are effectively recoded as having a bachelor's degree.

Table 3 Demand and Gap Methodology Comparison: Aerospace Engineers

	Mid demand	BA demand	Grad demand	Mid gap	BA gap	Grad Gap
A. With rollup						
BLS	0	236	0	0	191	-31
ACS (WA)	0	173	63	0	128	32
ACS, 18–34	0	160	76	0	115	45
ACS, 35–54	0	153	83	0	108	52
O*Net	0	201	35	0	156	4
BG (US)	0	216	20	0	171	-11
BG (WA)	0	229	7	0	184	-24
CPS	0	157	79	0	112	48
B. Without rollup						
BLS	0	236	0	0	191	-31
ACS (WA)	32	136	63	32	91	31
ACS, 18–34	23	132	76	23	87	45
ACS, 35–54	33	115	83	33	70	52
O*Net	19	182	35	19	137	4
BG (US)	8	205	20	8	160	-11
BG (WA)	11	218	7	11	173	-24
CPS	35	107	79	35	62	48

Table 3 compares demand (and resulting gaps) across the different sources of the education distribution for aerospace engineers. For this occupation, the ACS and CPS measures agree fairly closely, despite the different definition of worker. This may be due to experienced workers changing jobs laterally rather than entering the profession and may not hold for other occupations. The Burning Glass numbers are more similar to the BLS measure except they allow separation of demand above the baccalaureate level.

The bottom panel provides no roll-up adjustment to a minimum bachelor's degree; that is, it takes the educational distribution as given. Here the ACS and CPS measures show a small but nontrivial share purporting a mid-level credential. This share may be due to occupational miscoding that classified engineering technicians as engineers or it may reflect true educational demand below the bachelor's level (as the Burning Glass source also shows a slight demand at this level).

To illustrate more broadly how different sources for the educational distribution affect supply-demand gaps, we also analyze all engineers.[11]

2.   Engineers and Architects (SOC 17)

These occupations are high-demand (and STEM) with a fairly tight link between the specificity of educational training and entry.

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[11] The final report will include additional detailed and aggregate occupations primarily at the mid- and graduate levels. It will also contain tabulations at the broad education levels across all occupations.

Supply: In 2012, there were 2,508 mid-level (1,492 if short certificates are excluded), 1,844 bachelor's, and 756 graduate credentials granted by the state's postsecondary institutions (IPEDS CIP 4, 14, and 15).

Existing Demand Methodology: The state ESD forecasts 3,118 annual openings for engineering occupations over 2017–2022.[12] According to the BLS measure, filling these openings would require 461 mid-level credentials (associate's degrees) and 2,600 bachelor's degrees (as well as 57 high school-level credentials). According to the ACS for Washington, filling these openings would require a broader range: 747 mid-level, 1,519 bachelor's and 671 graduate degrees.

Existing Gap Methodology: The supply correction factor adjusts supply downward to 1,705 (1,015) mid-level, 1,396 bachelor's, and 524 advanced graduates. The effective gap is thus −1,244 (−554) at the mid-level, 1,204 at the bachelor's level, and −524 at the graduate level under the BLS standard; and −958 (−268) at the mid-level, 123 at the bachelor's level, and 147 at the graduate level under the ACS standard.

Table 4 Demand and Gap Methodology Comparison: Engineering Occupations

	Mid demand	BA demand	Grad demand	Mid gap	BA gap	Grad Gap
A. With rollup						
BLS	461	2,600	0	-1,244	1,204	-524
ACS (WA)	399	2,033	671	-1,306	637	147
ACS, 18–34	385	2,071	642	-1,320	675	128
ACS, 35–54	412	1,900	789	-1,293	504	265
O*Net	332	2,087	645	-1,373	691	121
BG (US)	318	2,482	285	-1,387	1,086	-239
BG (WA)	358	2,490	250	-1,348	1,094	-274
CPS	392	2,011	689	-1,313	616	165
B. Without rollup						
BLS	461	2,600	0	-1,244	1,204	-524
ACS (WA)	747	1,519	671	-958	123	147
ACS, 18–34	606	1,682	642	-1,099	286	118
ACS, 35–54	719	1,388	789	-986	-8	265
O*Net	474	1,898	645	-1,231	502	121
BG (US)	225	2,367	285	-1,480	971	-239
BG (WA)	260	2,381	250	-1,445	985	-274
CPS	731	1,349	689	-974	-48	165

Table 4 shows demand and gaps estimates for alternative sources. Differences across sources are smaller in the top panel, which "rolls up" education distributions to the BLS minimum. The smaller differences occur mechanically, as the roll-up procedure reduces effective differences in educational distributions from one source to another. Nonetheless, even with the roll-up, differences across sources are sizable, especially for BA-level and graduate-level gaps.

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[12] https://fortress.wa.gov/esd/employmentdata/docs/occupational-reports/all-occupational-projections.xls. These openings are expected to come primarily from retirement of incumbents rather than net growth.

Although the Burning Glass numbers are again closer to those from BLS, the former's ability to parse out demand at other education levels is a strong plus. If the roll-up procedure is not applied, differences at the mid-level up to 500 workers are now apparent, although in every case there seems to be a surplus of mid-level engineering workers. The sources also disagree in the relative apportioning of demand at higher education levels, but the job postings numbers fall in between extremes.

3.   Installation, Maintenance, and Repair (SOC 49)

These occupations are typically high-school or mid-level (requiring some postsecondary education or training) and several are in high demand according to the 2013 report. The linkage between the specificity of educational training and entry is not as tight as it is for engineers, but there is still a high correlation.

Supply: In 2012, there were 5,668 mid-level (1,930 if short certificates are excluded), 59 bachelor's, and 0 graduate credentials granted by the state's postsecondary institutions (IPEDS CIPs 1.02, 15.04, 15.05, 15.08, 46.03, 46.04, 47, 49.0304, and 52.0205).[13]

Existing Demand Methodology: The state ESD forecasts 4,691 annual openings for installation, maintenance, and repair occupations over 2017–2022.[14] According to the BLS measure, filling these openings would require 3,879 high school-level credentials, 86 credentials between high school and a certificate, 608 certificates, and 118 associate's degrees, for a total of 812 mid-level credentials. According to the ACS for Washington, filling these openings would require a more-educated group of workers: 2,295 mid-level (1,597 with some college or a certificate and 698 associate's degrees); 313 bachelor's degrees; and 62 graduate degrees (the remainder requiring no more than a high school diploma).

Existing Gap Methodology: The supply correction factor adjusts supply downward to 3,854 (1,312) mid-level and 45 bachelor's graduates. The effective gap is thus −3,042 (−500) at the mid-level, −45 at the bachelor's level, and 0 at the graduate level under the BLS standard; and −1,559 (983) at the mid-level, 268 at the bachelor's level, and 62 at the graduate level under the ACS standard.

Table 5 shows demand and gaps estimates for alternative sources. In this occupational group, there are no differences between panels because the BLS minimum is never higher than mid-level. Still, differences across sources are sizable, especially for mid-level. Although the Burning Glass numbers are again closer to those from BLS (at least for mid-level demand), the former's ability to parse out demand at other education levels (and commensurately so with the

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[13] As we do not have data on the number of apprenticeships completed in this occupation group, we ignore them for this analysis, although we recognize they are a nontrivial source of supply in this case.

[14] https://fortress.wa.gov/esd/employmentdata/docs/occupational-reports/all-occupational-projections.xls. These openings are expected to come primarily from retirement of incumbents rather than net growth.

Table 5 Demand and Gap Methodology Comparison: Install, Maint., Repair Occupations

	Mid demand	BA demand	Grad demand	Mid gap	BA gap	Grad Gap
A. With rollup						
BLS	812	0	0	-3,042	-45	0
ACS (WA)	2,295	313	62	-1,559	268	62
ACS, 18–34	2,075	259	28	-1,779	214	28
ACS, 35–54	1,781	277	49	-2,073	232	49
O*Net	2,664	102	66	-1,190	57	66
BG (US)	577	323	38	-3,277	278	38
BG (WA)	449	289	43	-3,405	244	43
CPS	1,535	361	67	-2,319	316	67
B. Without rollup						
BLS	812	0	0	-3,042	-45	0
ACS (WA)	2,295	313	62	-1,559	268	62
ACS, 18–34	2,075	259	28	-1,779	214	28
ACS, 35–54	1,781	277	49	-2,073	232	49
O*Net	2,664	102	66	-1,190	57	66
BG (US)	577	323	38	-3,277	278	38
BG (WA)	449	289	43	-3,405	244	43
CPS	1,535	361	67	-2,319	316	67

other sources) is a strong plus. In general, there is a large surplus of mid-level workers, although this surplus either shrinks considerably or becomes a modest shortage if short-term certificate earners are excluded from supply. The sources also disagree in the relative apportionment of demand at higher education levels—BLS is a notable outlier, with no such demand—but the job postings numbers fall in between extremes.

E.   Recommended Approaches

We have also tabulated the age distribution of new hires using the CPS. Table 5 shows these distributions for 2-digit SOC groups. In general, more skilled occupations have an older distribution of workers entering them than less skilled occupations. If the joint agencies wish to continue using incumbent workers from the ACS in obtaining education distributions, a simple refinement to mitigate incumbency bias is to condition the ACS analysis sample on the interquartile range of the ages of new workers as shown below. This refinement is likely to matter most for management and food preparation occupations, whose age distributions are substantially older and younger, respectively, than other occupation groups.

We further caution against the use of the BLS typical education entry path to assign education to occupational openings. Although it is simple to use, the mapping does not appear to be especially reliable and does not reflect the multiplicity of educational demand for many occupations. In our comparison of sources, the BLS measure was consistently dissimilar to every other source. For some occupations, such as community health workers (SOC 21-1094), social and human service assistants (SOC 21-1093), and occupational safety technicians (SOC 29-9012), using the BLS measure instead of more reliable measures could lead to understated or missed supply gaps, as the BLS education level is substantially lower than other sources. For

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Table 6: Age distribution of new hires in CPS, by 2-digit SOC code

	25th percentile	Median	75th percentile
11 Management	35	46	56
13 Bus. and Finance	31	42	53
15 Computer/Math	30	38	49
17 Architecture/Engineering	31	42	53
19 Life, Physical, Social Sci	27	38	52
21 Community/Social Service	29	42	54
23 Legal	30	42	53
25 Education/Training	28	40	53
27 Arts, Design, Entertainment	25	37	51
29 Healthcare Practitioners	31	42	52
31 Healthcare Support	25	36	49
33 Protective Service	24	36	49
35 Food Preparation	19	24	38
37 Building/Grounds Maint.	25	38	50
39 Personal Care	22	33	49
41 Sales	22	33	49
43 Office/Administrative	25	37	51
45 Agriculture	21	33	47
47 Construction/Extraction	27	36	48
49 Installation/Maint./Repair	27	40	50
51 Production	28	39	50
53 Transportation	25	37	50

NOTE: CPS sample covers national data over the 2005–2013 period. New hires at month *t* are those who were not employed at month *t-1* and employed at month *t* or who specified they changed employers between *t-1* and *t*.

other occupations, such as heavy truck drivers (SOC 53-3032) and telecommunications equipment installers (SOC 49-2022), the BLS measure may overstate a shortage, as it posits a higher education level than other sources. (At broader levels, BLS tends to understate education in the 21, 27, 29 and 41 2-digit SOC groups, especially, and overstate it in the 49 and 53 2-digit SOC groups.)

Although the relatively small sample sizes of the SIPP preclude its use as the primary source for education distributions for occupations, it still may be highly relevant in identifying occupations that have a high concentration of certificates within the "some college, no degree" category. The SIPP-calculated certificate share for more populated occupations (or all occupational groups) could then be applied to the ACS by ratio adjustment. We acknowledge this level of detail may not be necessary for Skills Gap reports. However, we feel it is quite useful for educational needs projections, particularly with the question of how to assign mid-level workers who leave with a significant number of credits but no credential.

III. EDUCATIONAL COMPLETERS AVAILABLE TO FILL OPENINGS (CIP TO SOC)

A. Summary of 2013 Study Methods

The supply of new potential workers is based on educational program completion data, either from the National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System (IPEDS) for baccalaureate and graduate degrees or from the SBCTC and WTECB for mid-level data. The latter includes individuals completing certificate or associate degree programs as well as apprenticeships and some private career schools ineligible for federal financial aid, and therefore not in IPEDS.

There are a few exceptions to this completion-based approach, particularly for health-related occupations. For example, the current methodology categorizes registered nurses as a mid-level training occupation (as the typical pathway requires an associate's degree, although this has been changing to a bachelor's degree). Because this occupation requires state licensure, IPEDS completions for nursing (at either associate's or bachelor's level) are not used for supply. Rather state licensure examination counts from the state's Department of Health are used, with these counts excluding endorsements (reciprocity) earned in other states. (Out-of-state endorsements constituted 60 percent of new RN licenses in 2012.[15])

Supply is tabulated at the three educational levels and is distributed to specific occupations. While the tabulations at the broad educational levels are straightforward given the sources of data, the occupational assignments require a mapping between levels and fields of study to the occupations. At the baccalaureate level, this crosswalk relies on the ACS, which since 2009 contains the field of study for employed individuals. Washington-specific data are tabulated for 15 occupational groups and 13 aggregated fields of study. This matrix fractionally assigns the bachelor's degree completers from IPEDS to the occupational groups.

Unfortunately, field of study at the mid-level or graduate level is not available in the ACS, so alternative strategies are used that rely on the CIP to SOC field-of-study to occupational crosswalks produced by NCES. These crosswalks are based on national data. The request for proposals to which this report is responding expresses concern over this hybrid approach and asks for alternatives.

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[15] Electronic communication from Teresa Corrado of WA DOH to Carolyn McKinnon of WA WTB, 9/20/2013.

B. Alternative Data Sources

In general, we believe data-driven approaches are superior to theoretical linkages because they reflect actual practice.[16] Some occupations have less prescribed pathways of training or field of study than others, and empirical mappings can capture this dimension in a manner that stylized crosswalks cannot. For this reason, we cannot recommend exclusive use of CIP-SOC crosswalks to map completions into potential supply by occupation.

A full empirical crosswalk can allow the investigation of shortages for additional occupational groups beyond the selected high-demand occupations in existing reports. It also allows consistency with the gap analysis for bachelor's and graduate-level occupations. While it would be ideal to use one single data source to construct empirical cross-tabulations of occupation and field of study, this may not be feasible or practical due to issues of coverage and sample size. Nonetheless, using multiple data sources is still more straightforward and transparent than the aggregation and weighting steps inherent in a CIP-SOC crosswalk approach while maintaining the other advantages of a data-driven method.

1. SIPP

To our knowledge, the SIPP is the only publicly available data source that provides (nationally) representative distributions of fields of study for workers with certificates and associate's degrees. Using these data from the most recent (2008) wave, we have constructed an occupation–field-of-study crosswalk for the same 15 occupation groups and 13 fields of study as used in the 2013 joint report for the higher education levels.[17] This crosswalk appears toward the end of this document as Appendix Table 2A. The table summarizes the distribution both for a given field of study across occupational groups (top panel) and for a given occupational group across fields of study (bottom panel).

It is also possible to use the SIPP to construct similar crosswalks for the bachelor's and graduate degree levels. While we do not recommend this approach because the resulting sample sizes are smaller than those from other alternative sources, we provide such crosswalks for comparative purposes. Appendix Table 2B1, for example, provides the bachelor's-level crosswalk, and it can be compared to our construction of the ACS-based bachelor's-level crosswalk (Appendix Table 2B2) or the bachelor's level crosswalk used in the 2013 report as

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[16] Colorado, for example, uses SOC-CIP crosswalks for all occupations. However, because the crosswalks do not always provide specific matches, they cannot predict supply for several in-demand occupations, thus illustrating a key limitation of this approach (Colorado Department of Higher Education 2014).

[17] Statistical code to construct these crosswalks is available on request. The analysis sample includes currently employed individuals. Sample sizes are generally on the order of 5,000 individuals for each education level.

directly provided to us (Appendix Table 2B3).[18] Appendix Tables 2B1 and 2B2 accord reasonably closely, suggesting that the SIPP may be sufficiently reliable to be used for the mid-level crosswalk. (Some of the difference is likely due to comparing national patterns in the SIPP to Washington-specific patterns in the ACS.) Differences between Appendix Tables 2B2 and 2B3 are smaller still, as expected given their common source; these differences most likely reflect different processing of the data.

Finally, Appendix Table 2C1 contains the SIPP-based crosswalk for graduate degrees, and Appendix Table 2C3 contains the CIP-SOC matching method crosswalk used in the 2013 report. These differ more noticeably than do the empirical crosswalks for bachelor's degrees. We anticipate that our recommended data source for graduate degrees, discussed next, will also vary notably from the CIP-SOC matching counts.

2. NSCG

The National Survey of College Graduates represents the best source for tabulating empirical distributions of occupation by field of study at the graduate degree level. Consisting exclusively of bachelor's+ graduates drawn from the ACS sampling distribution, the NSCG has a sample size of approximately 75,000, about seven times that of the original 1993 Baccalaureate and Beyond (B&B) cohort. Further, the most recent NSCG survey was in 2010, providing more recent data than the B&B.[19]

We present an empirical graduate crosswalk in Appendix Table 2C2.[20] Compared with the CIP-SOC matching method crosswalk (Appendix Table 2C3), the NSCG crosswalk attributes substantially less occupational density in business, management, and sales occupations among science, math, and engineering graduates; this density is generally shifted toward the respective science occupations. On the other hand, the empirical crosswalk attributes more density to business, management, and sales occupations among professional (health, legal) graduates; this density generally comes from administrative, education, and human service occupations, leaving relatively similar the density in the respective professional occupation. Also of note is that the NSCG has far fewer math and computer science graduates going into computer science occupations than does the CIP-SOC matching method. The math graduates are more likely to be in education occupations, the computer science graduates are more likely to be in business occupations, and both are more likely to be in engineering occupations. Together, these differences imply that using the empirical crosswalk will likely reduce employment gaps at the

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[18] The SIPP does not provide sufficient detail for three major fields of study in the bachelor's crosswalk: family and consumer sciences, law, and vocational technology. All of these contain only a trivial fraction of bachelor's graduates according to the ACS.

[19] The most recent B&B survey was the 2008 cohort, which had an original sample size of about 19,000. While there is a 2012 follow-up, this is unlikely to be a sufficiently long time-horizon for these students to have earned graduate degrees and entered the workforce.

[20] The sample size in the NSCG is sufficient to create a more detailed crosswalk at the 2-digit CIP by 2-digit SOC level. This finer-grained crosswalk is in the last tab of OCC_edreq_master.xlsx.

graduate level in research, science, and technical occupations and, to a lesser extent, in engineering occupations. However, the gap in computer science occupations will increase further.

The NSCG can also be used to construct a bachelor's-level crosswalk, but we do not recommend this approach because the ACS has even larger sample sizes, permitting Washington-specific tabulations, and is updated annually. For the mid-level crosswalk, we recommend that empirical tabulations from the SIPP be used to assign fields of study to occupational groups. For the bachelor's-level crosswalk, we recommend that the ACS continue to be used to construct such mappings. For the graduate-level crosswalk, we recommend that the CIP-SOC match method be replaced with empirical tabulations from the NSCG.

IV.   OTHER RECOMMENDATIONS

A.   Statistical Uncertainty and Forecast Error

The current report methodology does not provide the reader with any indication that demand projections and supply-demand gaps are calculated with statistical error. In our estimation, the largest source of statistical error stems from the employment demand projections, with a smaller role on the supply side from incomplete correction for growth in supply and labor force entry adjustments. While it is beyond the scope of this report to propose a system for implementation of confidence intervals or other measures of statistical uncertainty, we do recommend a few simple steps that suggest to the reader that supply-demand gaps are estimates and have bounded precision.

(1) Round supply and demand figures in each relevant cell to the nearest hundred for aggregate categories. Providing unit-level numbers provides a false sense of precision.

(2) Take a three-year average of completion data. While this will mask rapidly changing trends it will guard against errant fluctuations in a single year in smaller fields.

B.   In-migrants (and Out-migrants)

Projections in the current (and past) reports mention but explicitly do not account for both international and interstate domestic migration. The State of Washington has lately exhibited net in-migration, both domestically from other states and internationally. It is likely that many of these moves are job-driven or at least job-related. Standard economic theory posits that in-migration will respond (through wages) to excess demand for certain occupations. While we recognize that the state is concerned with whether it can self-supply the skills and education to meet employer demand, we note that the labor market for certain occupations (and among certain employers), especially higher-skilled ones, is national and even international. Even if

Washington were to increase the supply of graduates with training for these occupations, it is not clear that this supply would fully displace workers hired from outside the state. Similarly, if Washington were to decrease the supply of graduates for which there is a perceived surplus, it is not clear these workers would find other employment within the state, as it might manifest through reduced out-migration. While more fully addressing the question of how to treat migrants in calculations of supply-demand gaps is beyond the scope of this report, we believe that the agencies should consider briefly mentioning in future reports that migration often serves to partially mitigate supply-demand imbalances, either for a shortage (in-migration) or a surplus (out-migration).

C.   Licenses and Other Supply Adjustments

State licensure restrictions affect potential supply for many occupations besides nursing (see http://www.dol.wa.gov/listoflicenses.html.) While nursing is an in-demand occupation receiving particular focus, other licensed occupations may meet this criterion as well without receiving licensure-based supply adjustments. Colorado, for example, applies licensure-based supply estimates for K-12 teachers, as bachelor's degrees earned in education are even less likely to lead to teaching jobs than nursing baccalaureates are to nursing jobs. (See Colorado Department of Education [2014] and http://benschmidt.org/jobs/.) Besides health occupations, almost all of which require licensure regardless of education level, other in-demand jobs where licensure may affect supply include (at the mid-level): electricians, plumbers, and certain mechanics; (at the bachelor's degree level): accountants, teachers, and most engineers; and (at the graduate level): lawyers and social workers. In each of these cases, the joint agencies may wish in the future to request licensure data to adjust supply in a manner similar to that used for registered nurses.

Furthermore, a substantial share of students earning mid-level credentials has already entered the labor force. As documented in previous reports, the median age of students completing mid-level credentials is approximately 30. While some of these students may be using their new credentials to take new jobs, many of them may instead use them to advance in their current position. If this latter phenomenon is widespread, the effective supply of new mid-level completers may be overestimated.

An analysis of anonymized Washington unemployment insurance files merged with 2011−2012 completion records from the SBCTC and PVS (which constitute the majority of granters of mid-level credentials) show that only 52 percent of completers are employed in new industries in the four quarters after completing their credential, relative to when they began their program (or in the quarter before they finished for longer programs). This share also varies somewhat by field of study, ranging from 29 percent in education programs to 63 percent for mechanical repair programs. Changing industry of employment is only a crude proxy for taking a

new job, but these results indicate a substantial share of mid-level completers may be upgrading their skills with their current employer and not filling new openings.

We recommend that the joint agencies consider adjusting supply of mid-level completers—especially for in-demand occupations—to account for the share that continues on with their current employer. Program files that provide the algorithm for calculating these shares by educational program are available on request.

D.   Annual forecasts from ESD

The joint report on "A Skilled and Educated Workforce" compares the current supply of potential workers, which is based on credentials produced in state, with long-term projected openings on an annualized basis. The original RFP asked for the most efficient way to convert the measure of mean annual job openings over a 5-year or 10-year span into the projected job openings in a calendar year. In our conversations with ESD analysts, we learned that job projections are produced using a monthly time-series for specified time horizons at 2, 5 and 10 years out. The projections at each horizon require significant balancing and validation checks that preclude the simple provision of the estimates from intermediate horizons. Nonetheless, the 2-year-out projection that ESD currently produces could be incorporated into a procedure for the joint report to annualize projected job openings. Specifically, an exponential growth model could be fit for each occupation based on these three data points (2, 5, and 10 years out); the additional data point beyond that needed to define the growth parameter allows for a goodness-of-fit criterion for the growth model, and occupations meeting a certain threshold could be amenable for annualized estimates. While it may not be (budgetarily) feasible, we believe it would also be helpful for ESD to construct forecasts at the 1-year horizon in addition to the other horizons in order to improve the validation of the growth models. Such validation could also be used to generate predication-based confidence intervals, should the joint agencies believe these would add value.

E.   Vacancy Surveys

Currently, WTECB conducts a biennial employer needs and practices survey (subject to budgetary approval). In addition, ESD until recently conducted a semiannual job vacancy and hiring survey. The latter was intended to collect information on job vacancies, recent hires, and expected future vacancies by occupation and industry, firm size, educational demand, experience required, and geography. It, however, has been discontinued for budgetary reasons. The former survey is intended to provide context to how employers go through the hiring process and the difficulties they perceive. Because these surveys are closely thematically related and even overlap directly on a few questions, we believe there may be scope to combine them to reduce costs and respondent burdens. We recommend ESD and WTECB communicate with each other in an attempt to optimize a single survey design for the interests of both agencies. For example, while the ESD vacancy survey directly asked education requirements for current openings by

occupation, it did not ask the education of newly hired workers. Adding this element (or a similar one asking whether the new hire met the educational requirements advertised) could be useful in determining employer difficulty in hiring and how they respond. The two agencies, perhaps in cooperation with WSAC and SBCTC, could then propose a unified survey for legislative and budgetary approval that describes how the survey would benefit the several agencies. As such, a survey has the potential to meet the legislatively mandated requirements of multiple state agencies, there may be greater political will to allow its implementation.

V.   CONCLUSIONS

This section enumerates our recommendations. They are presented here in the same order as we have presented them in the document, and so should not be interpreted as being in any order of priority.

Recommendation 1: The joint agencies producing the report should use an empirical approach based on the actual openings for jobs as derived from aggregating online postings or an approach based on the educational levels of individuals who have begun employment spells.

Recommendation 2: If the joint agencies continue to use the ACS incumbent worker approach for determining the educational levels needed for occupations, staff members should use empirically-based age restrictions in sampling the ACS.

Recommendation 3: The joint agencies should discontinue the BLS "entry-level" approach of assigning the single educational level necessary for an occupation.

Recommendation 4: The joint agencies should use the SIPP as a basis for identifying and ratio adjusting occupations that have a high concentration of certificates within the "some college, no degree" category.

Recommendation 5: On the supply side, the joint agencies should use the occupation-by-field of study from the SIPP for workers with certificates and associate's degrees. They should use the ACS for graduates (adjusted for labor market entry and upskilling) with a baccalaureate degree, and the NSCG for individuals with graduate degrees.

Recommendation 6: In consideration of the statistical error inherent in projections and data, the published report should have rounded supply and demand figures in each relevant cell to the nearest hundred and the agencies should base supply on a three-year average of completion data.

Recommendation 7: The joint agencies should request licensure data that can be used to adjust supply in a manner similar to what is done for registered nurses for occupations that require licenses in occupations outside of health. Other in-demand jobs where licensure may affect supply include (at the mid-level): electricians, plumbers, and certain mechanics; (at the bachelor's degree level): accountants, teachers, and most engineers; and (at the graduate level): lawyers and social workers.

Recommendation 8: The joint agencies should adjust downward the supply of mid-level completers—especially for in-demand occupations—to account for the share that continues on with their education with their current employer.

Recommendation 9: Because the agencies had an interest in how to annualize projections to the calendar year, we recommend fitting occupation-specific exponential growth models based on ESD's projections at the 2-year, 5-year, and 10-year level. Alternatively, ESD could produce occupation projections at another time horizon to improve these growth models.

Recommendation 10: WTECB and ESD have conducted surveys that are closely thematically related and that even overlapped directly on a few questions. These two agencies, in cooperation with WSAC and SBCTC, may be able to create an optimized survey design that meets the needs of the several agencies and could be cost-shared among them. Ideally such a joint survey could capture the educational requirements of openings.

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Appendix 1: Dissimilarity Index

Let $i = 1, 2, ..., I$ index occupations; $k = 1, 2, ..., K$ index ordered education categories; and $s = 1, 2$ index sources. For each s, let p_{ik}^s p_{ik}^s be the fraction of workers in occupation i that have education level k such that $\sum_k p_{ik}^s = 1$. Now define P_{ik}^s as the cumulant, the fraction of workers in occupation i that have education level k *or less*: $P_{ik}^s = \sum_{j=1}^k p_{ij}^s$.

The index of dissimilarity D is equal to:

$$D = \frac{1}{IK} \sum_{i=1}^I \sum_{k=1}^{K-1} (P_{ik}^2 - P_{ik}^1)^2$$

Note that the inner summation goes only to $K-1$; this is because $P_{iK}^s = 1$ by construction, and so including this term would not contribute to D. The outer division by IK serves to normalize the index, important particularly if all values of i and k are not present in every source.

This index weights each occupation equally. However, weighting occupations with relatively few workers the same as those with a large number of workers may not be ideal. Weighting each occupation by its share of the total workforce, m_i, prioritizes similarity among larger occupations.[21] This version of the index is:

$$D = \frac{1}{K} \sum_{i=1}^I m_i \sum_{k=1}^{K-1} (P_{ik}^2 - P_{ik}^1)^2$$

Our index of dissimilarity has two important features. First, it captures ordinal differences in education distributions. For example, if sources disagree only over the relative shares of workers with high school diplomas and those with some college but no credential, their dissimilarity will be smaller than if they disagreed over the relative shares with high school diplomas and with bachelor's degrees. Second, as the magnitude of a disagreement increases, its effect on dissimilarity increases more than proportionately.

If sources match exactly for all occupations, $D = 0$. The maximum possible value for D is 1, which occurs if all occupations have polar opposite education distributions. For ease in interpretation, we multiply D by 100 in this report.

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[21] The parameter m_i is constructed empirically using data from OES. Either U.S. or Washington employment counts can be used, but functionally it makes little difference.

Appendix Table 1 Occupations With Large Education Requirement Differences Across Sources

Occupation name	SOC	Average Dissimilarity	Largest Index	2nd largest index	3rd largest index
Managers, all other	11-9199	3.04	BLS-ONET	BLS-BG_WA	BLS-BG
Farm labor contractors	13-1074	3.01	BLS-ACS0912_1834	BLS-SIPP	BLS-ACS0912
Substance abuse and behavioral disorder counselors	21-1011	3.00	BLS-ACS0912_3554	BLS-ACS0912_WA	BLS-ACS0912
Commercial pilots	53-2012	2.92	BLS-ACS0912_WA	BLS-ACS0912_3554	BLS-ACS0912
Ushers, lobby attendants, and ticket takers	39-3031	2.64	ONET-ACS0912_WA	BLS-ACS0912	BLS-ACS0912_1834
Purchasing agents, except wholesale/retail/farm products	13-1023	2.57	BLS-ONET	BLS-BG	BLS-BG_WA
Recreation and fitness studies teachers, postsecondary	25-1193	2.54	BLS-BG_WA	ACS0912_3554-BG_WA	ACS0912-BG_WA
Occupational therapy aides	31-2012	2.48	BLS-ACS0912_1834	BLS-ACS0912_3554	BLS-ACS0912
Occupational health and safety technicians	29-9012	2.36	BLS-ONET	BLS-ACS0912_1834	BLS-ACS0912_WA
Semiconductor processors	51-9141	2.35	BLS-ONET	BLS-ACS0912_3554	BLS-ACS0912
Athletes and sports competitors	27-2021	2.29	ONET-ACS0912_3554	ONET-ACS0912	BLS-ACS0912_3554
Ship engineers	53-5031	2.29	BLS-ACS0912_1834	BLS-ACS0912	BLS-ACS0912_3554
Artists and related workers, all other	27-1019	2.27	BLS-SIPP	BLS-BG	BLS-ACS0912_1834
Detectives and criminal investigators	33-3021	2.27	BLS-BG	BLS-ACS0912_1834	BLS-ACS0912_WA
Business operations specialists, all other	13-1199	2.27	BLS-BG_WA	BLS-BG	BLS-ACS0912_1834
Fine artists, including painters, sculptors, and illustrators	27-1013	2.24	BLS-SIPP	BLS-BG_WA	BLS-ACS0912_1834
Transportation, storage, and distribution managers	11-3071	2.22	BLS-ONET	BLS-BG_WA	BLS-BG
Community health workers	21-1094	2.20	BLS-ONET	BLS-ACS0912_1834	BLS-ACS0912
Craft artists	27-1012	2.15	BLS-SIPP	BLS-ACS0912_1834	BLS-ACS0912
Floral designers	27-1023	2.15	BLS-ACS0912_1834	BLS-ACS0912_WA	BLS-ACS0912
Merchandise displayers and window trimmers	27-1026	2.15	BLS-ACS0912_1834	BLS-ACS0912_WA	BLS-ACS0912
Orthotists and prosthetists	29-2091	2.14	BLS-ACS0912_1834	BLS-CPS0513	BLS-ACS0912_WA
Wholesale and retail buyers, except farm products	13-1022	2.13	BLS-BG_WA	BLS-BG	BLS-ACS0912_1834
Brokerage clerks	43-4011	2.10	ONET-ACS0912_WA	BLS-ACS0912_1834	BLS-ACS0912
Judicial law clerks	23-1012	2.06	BLS-BG_WA	ACS0912_1834-BG_WA	ONET-BG_WA
Claims adjusters, examiners, and investigators	13-1031	2.06	BLS-ONET	BLS-ACS0912_1834	BLS-ACS0912_WA

NOTE: Average Dissimilarity is the average of the three largest dissimilarity index values among the 45 comparisons shown in the matrix of Table 2. ACS0912_2534 refers to ACS with age restriction of 25 to 34, ACS0912_3554 refers to ACS with age restriction of 35 to 54, ACS_WA refers to ACS restricted to WA residents, and BG_WA refers to Burning Glass job postings in WA.

Appendix Table 2A: Midlevel Occupation-Field of Study Crosswalk from 2008 SIPP (National data)

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	26.2%	0.8%	0.0%	10.7%	0.9%	0.0%	0.0%	1.1%	0.0%	6.4%	3.7%	1.8%	10.8%	12.0%	25.6%	**100.0%**
Business/Mgment	31.8%	1.8%	0.9%	0.2%	0.0%	0.0%	0.1%	2.7%	1.1%	32.4%	2.5%	1.7%	2.7%	10.2%	12.0%	**100.0%**
Computer Science	20.7%	17.6%	3.1%	0.1%	0.0%	0.0%	0.2%	1.3%	0.5%	17.7%	2.5%	2.2%	1.3%	8.8%	24.0%	**100.0%**
Education	20.0%	1.3%	0.9%	1.2%	0.0%	0.0%	0.0%	5.5%	0.3%	14.8%	30.1%	5.0%	4.4%	11.4%	5.2%	**100.0%**
Engineering	18.8%	3.3%	25.0%	0.9%	1.0%	0.0%	0.0%	1.4%	0.0%	8.7%	1.4%	2.6%	0.8%	6.6%	29.4%	**100.0%**
Fam./Cons. Science	19.3%	0.4%	0.4%	0.1%	0.2%	0.0%	0.2%	0.9%	0.4%	14.5%	2.9%	0.7%	5.8%	45.8%	8.4%	**100.0%**
Health	11.0%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	2.0%	0.4%	14.1%	2.0%	0.5%	54.1%	10.6%	5.0%	**100.0%**
Humanities & Comm. Legal	29.0%	1.9%	1.3%	0.5%	0.0%	0.0%	0.2%	3.2%	0.7%	22.2%	5.8%	5.1%	4.4%	12.2%	13.5%	**100.0%**
Math	18.0%	1.5%	0.0%	3.2%	0.0%	0.0%	0.6%	2.8%	0.0%	16.5%	2.6%	6.0%	2.8%	19.0%	27.0%	**100.0%**
Physical Science	19.1%	1.3%	0.0%	2.5%	0.0%	1.5%	3.9%	0.0%	5.4%	19.4%	4.7%	3.2%	21.0%	12.7%	5.2%	**100.0%**
Social Science	20.7%	0.9%	0.5%	1.0%	0.0%	0.0%	0.0%	32.9%	0.9%	10.5%	2.2%	0.8%	2.7%	11.0%	16.0%	**100.0%**
Voc Tech	14.0%	0.7%	1.5%	1.5%	0.0%	0.0%	0.2%	1.3%	0.1%	5.7%	0.5%	0.6%	1.4%	6.7%	65.7%	**100.0%**
Total	**19.9%**	**2.4%**	**1.9%**	**0.8%**	**0.1%**	**0.0%**	**0.1%**	**3.0%**	**0.5%**	**16.5%**	**2.9%**	**1.5%**	**13.7%**	**12.0%**	**24.8%**	**100.0%**
Life Science/Agrc	2.6%	0.6%	0.0%	25.4%	26.4%	0.0%	0.0%	0.7%	0.0%	0.8%	2.5%	2.4%	1.6%	2.0%	2.0%	**2.0%**
Business/Mgment	33.6%	15.3%	10.1%	4.7%	0.0%	0.0%	12.5%	19.2%	43.2%	41.3%	18.6%	23.2%	4.1%	17.8%	10.2%	**21.0%**
Computer Science	8.9%	62.0%	14.1%	1.3%	0.0%	0.0%	15.4%	3.6%	8.2%	9.1%	7.4%	12.6%	0.8%	6.2%	8.3%	**8.5%**
Education	2.5%	1.3%	1.2%	3.4%	0.0%	0.0%	0.0%	4.6%	1.6%	2.2%	26.0%	8.2%	0.8%	2.3%	0.5%	**2.5%**
Engineering	3.3%	4.8%	47.3%	3.8%	50.1%	0.0%	0.0%	1.7%	0.0%	1.9%	1.8%	6.0%	0.2%	1.9%	4.2%	**3.5%**
Fam./Cons. Science	6.7%	1.1%	1.4%	0.9%	23.5%	0.0%	11.2%	2.1%	5.6%	6.1%	6.9%	3.1%	2.9%	26.2%	2.3%	**6.9%**
Health	11.7%	1.0%	1.3%	5.0%	0.0%	34.2%	0.0%	13.9%	15.1%	17.9%	14.6%	6.4%	83.2%	18.6%	4.2%	**21.0%**
Humanities & Comm. Legal	9.7%	5.2%	4.8%	3.7%	0.0%	0.0%	8.4%	7.0%	8.8%	8.9%	13.5%	22.7%	2.2%	6.7%	3.6%	**6.6%**
Math	0.8%	0.6%	0.0%	3.5%	0.0%	0.0%	4.2%	0.9%	0.0%	0.9%	0.8%	3.6%	0.2%	1.4%	1.0%	**0.9%**
Physical Science	0.6%	0.4%	0.0%	2.0%	0.0%	65.8%	18.7%	0.0%	6.6%	0.8%	1.1%	1.4%	1.0%	0.7%	0.1%	**0.7%**
Social Science	3.4%	1.2%	0.8%	3.8%	0.0%	0.0%	0.0%	35.8%	5.3%	2.1%	2.5%	1.7%	0.6%	3.0%	2.1%	**3.2%**
Voc Tech	16.3%	6.6%	19.0%	42.5%	0.0%	0.0%	29.5%	10.4%	5.5%	8.1%	4.3%	8.7%	2.4%	13.0%	61.4%	**23.2%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Appendix Table 2B1: Bachelor Occupation-Field of Study Crosswalk from 2008 SIPP (National data)

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	33.4%	3.3%	2.8%	6.4%	2.8%	0.7%	1.7%	4.3%	0.3%	8.2%	6.8%	2.0%	11.3%	6.1%	10.0%	**100.0%**
Business/Mgment	60.8%	3.4%	1.4%	0.3%	0.1%	0.1%	0.0%	1.4%	0.5%	15.5%	3.1%	1.6%	2.1%	3.5%	6.2%	**100.0%**
Computer Science	27.4%	47.0%	4.0%	0.0%	0.0%	0.0%	0.5%	1.5%	0.0%	5.7%	3.0%	0.9%	1.7%	1.6%	6.8%	**100.0%**
Education	15.5%	1.1%	0.6%	0.1%	0.0%	0.1%	0.1%	3.9%	1.3%	10.3%	52.1%	1.8%	2.2%	6.0%	4.8%	**100.0%**
Engineering Fam./Cons. Science	29.5%	10.8%	36.1%	0.1%	0.4%	0.4%	0.3%	0.8%	0.0%	4.1%	2.0%	1.5%	1.0%	1.3%	11.4%	**100.0%**
Health	15.5%	1.2%	0.4%	0.6%	0.0%	0.1%	0.5%	2.6%	0.2%	5.6%	3.9%	0.5%	63.4%	3.3%	2.3%	**100.0%**
Humanities & Comm. Legal	35.0%	3.3%	3.7%	0.3%	0.2%	0.2%	0.3%	3.5%	1.5%	15.0%	12.7%	11.4%	2.4%	5.0%	5.4%	**100.0%**
Math	38.9%	14.6%	4.2%	0.5%	0.7%	0.0%	0.0%	3.5%	0.6%	9.2%	12.7%	1.7%	3.0%	5.6%	4.9%	**100.0%**
Physical Science	23.3%	3.1%	1.2%	2.7%	4.1%	0.0%	1.6%	1.2%	0.0%	7.7%	11.1%	1.5%	17.2%	8.6%	16.8%	**100.0%**
Social Science Voc Tech	35.5%	2.6%	0.4%	0.5%	0.2%	1.0%	0.2%	14.7%	1.3%	12.6%	11.6%	2.9%	6.8%	5.1%	4.6%	**100.0%**
Total	**37.3%**	**6.0%**	**5.0%**	**0.7%**	**0.3%**	**0.3%**	**0.3%**	**3.8%**	**0.8%**	**11.5%**	**12.4%**	**3.5%**	**7.7%**	**4.2%**	**6.3%**	**100.0%**
Life Science/Agrc	5.6%	3.4%	3.5%	57.0%	50.0%	16.7%	33.7%	7.0%	2.2%	4.4%	3.4%	3.5%	9.1%	9.0%	9.8%	**6.2%**
Business/Mgment	45.0%	15.8%	7.4%	11.1%	4.1%	6.3%	3.8%	10.3%	19.3%	37.1%	6.8%	12.9%	7.6%	23.1%	27.3%	**27.6%**
Computer Science	3.7%	40.0%	4.1%	0.0%	0.0%	0.0%	7.6%	2.0%	0.0%	2.5%	1.2%	1.2%	1.1%	1.9%	5.5%	**5.1%**
Education	5.3%	2.4%	1.5%	2.1%	0.0%	3.7%	5.7%	13.2%	20.8%	11.3%	53.1%	6.6%	3.7%	18.0%	9.6%	**12.6%**
Engineering Fam./Cons. Science	7.3%	16.8%	66.5%	1.9%	11.3%	15.3%	9.3%	2.0%	0.0%	3.3%	1.5%	4.1%	1.2%	2.9%	16.7%	**9.2%**
Health	2.9%	1.4%	0.5%	6.3%	0.0%	3.2%	10.3%	5.0%	1.4%	3.4%	2.2%	1.0%	58.4%	5.5%	2.5%	**7.1%**
Humanities & Comm. Legal	17.4%	10.4%	13.6%	7.5%	10.8%	15.0%	16.5%	17.5%	36.5%	24.1%	18.9%	60.5%	5.9%	21.9%	16.1%	**18.6%**
Math	1.9%	4.5%	1.5%	1.3%	3.5%	0.0%	0.0%	1.7%	1.4%	1.4%	1.9%	0.9%	0.7%	2.4%	1.4%	**1.8%**
Physical Science	0.8%	0.7%	0.3%	5.0%	15.5%	0.0%	6.5%	0.4%	0.0%	0.9%	1.2%	0.6%	2.9%	2.7%	3.5%	**1.3%**
Social Science Voc Tech	10.0%	4.6%	0.9%	7.8%	4.9%	39.7%	6.5%	41.0%	18.5%	11.5%	9.8%	8.7%	9.3%	12.6%	7.7%	**10.5%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Appendix Table 2B2: Bachelor Occupation-Field of Study Crosswalk from 2009–2012 ACS (WA data)

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	32.4%	3.2%	1.8%	7.2%	3.2%	0.6%	2.8%	3.5%	0.4%	7.9%	5.4%	1.7%	14.2%	7.7%	8.0%	**100.0%**
Business/Mgment	63.6%	4.8%	1.3%	0.2%	0.0%	0.1%	0.1%	2.4%	0.4%	11.2%	2.3%	1.2%	1.9%	4.2%	6.2%	**100.0%**
Computer Science	21.7%	61.7%	2.7%	0.3%	0.2%	0.0%	0.0%	0.8%	0.1%	4.4%	0.9%	1.2%	0.6%	1.4%	4.2%	**100.0%**
Education	19.9%	1.3%	1.2%	0.4%	0.1%	0.0%	0.0%	3.2%	0.6%	9.1%	44.8%	2.2%	3.6%	8.1%	5.4%	**100.0%**
Engineering	25.2%	16.2%	36.6%	0.2%	0.4%	0.3%	0.4%	0.8%	0.2%	3.1%	1.6%	2.7%	1.1%	2.3%	8.9%	**100.0%**
Fam./Cons. Science	31.6%	1.9%	0.4%	0.9%	0.1%	0.0%	0.0%	5.5%	0.6%	17.0%	17.8%	2.2%	5.8%	11.9%	4.2%	**100.0%**
Health	13.5%	1.0%	0.4%	0.4%	0.3%	0.0%	0.1%	3.0%	0.0%	6.1%	2.7%	1.2%	63.3%	5.6%	2.1%	**100.0%**
Humanities & Comm.	35.9%	4.5%	0.7%	0.3%	0.2%	0.1%	0.2%	5.1%	1.2%	13.9%	7.3%	11.4%	3.8%	8.2%	7.4%	**100.0%**
Legal	22.3%	8.2%	0.0%	0.0%	0.0%	0.0%	0.0%	9.6%	24.1%	4.8%	0.0%	4.2%	0.0%	9.8%	16.9%	**100.0%**
Math	29.6%	32.4%	5.4%	0.0%	0.5%	0.2%	0.0%	2.1%	0.1%	7.5%	8.7%	0.8%	1.8%	3.7%	7.3%	**100.0%**
Physical Science	31.9%	10.7%	7.9%	1.4%	8.3%	0.0%	0.4%	3.0%	0.7%	7.4%	4.0%	2.0%	7.4%	5.5%	9.7%	**100.0%**
Social Science	39.6%	3.6%	1.4%	0.2%	0.3%	0.2%	0.2%	13.7%	2.2%	14.1%	5.0%	1.8%	4.4%	6.9%	6.4%	**100.0%**
Voc Tech	41.8%	1.6%	8.1%	0.1%	0.0%	0.0%	0.0%	1.2%	0.4%	5.9%	2.1%	0.4%	1.9%	1.6%	35.0%	**100.0%**
Total	**37.2%**	**8.0%**	**5.6%**	**0.7%**	**0.6%**	**0.1%**	**0.3%**	**4.7%**	**0.8%**	**10.1%**	**7.2%**	**3.9%**	**8.2%**	**5.8%**	**6.8%**	**100.0%**
Life Science/Agrc	5.1%	2.3%	1.9%	62.0%	33.6%	22.6%	50.7%	4.4%	2.5%	4.6%	4.4%	2.6%	10.2%	7.7%	6.8%	**5.8%**
Business/Mgment	35.5%	12.4%	4.9%	5.5%	1.4%	12.8%	8.5%	10.5%	9.9%	22.9%	6.6%	6.6%	4.9%	15.0%	18.7%	**20.7%**
Computer Science	2.4%	31.8%	2.0%	2.0%	1.6%	0.0%	0.0%	0.7%	0.3%	1.8%	0.5%	1.3%	0.3%	1.0%	2.5%	**4.1%**
Education	3.9%	1.2%	1.5%	4.1%	1.0%	0.0%	0.8%	5.0%	5.4%	6.5%	45.1%	4.2%	3.2%	10.1%	5.8%	**7.3%**
Engineering	7.9%	23.4%	76.6%	4.1%	7.4%	23.6%	15.4%	1.9%	2.3%	3.6%	2.6%	8.2%	1.6%	4.5%	15.2%	**11.7%**
Fam./Cons. Science	0.7%	0.2%	0.1%	1.1%	0.1%	0.0%	0.0%	1.0%	0.6%	1.4%	2.0%	0.5%	0.6%	1.7%	0.5%	**0.8%**
Health	2.7%	0.9%	0.5%	4.4%	4.3%	1.7%	2.0%	4.8%	0.4%	4.5%	2.8%	2.4%	57.9%	7.2%	2.3%	**7.5%**
Humanities & Comm.	21.4%	12.3%	2.6%	8.2%	6.2%	15.8%	11.8%	24.2%	32.2%	30.3%	22.3%	65.3%	10.4%	31.2%	24.0%	**22.1%**
Legal	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	3.4%	0.1%	0.0%	0.1%	0.0%	0.2%	0.3%	**0.1%**
Math	1.0%	5.1%	1.2%	0.0%	1.0%	1.7%	0.0%	0.6%	0.1%	0.9%	1.5%	0.3%	0.3%	0.8%	1.3%	**1.3%**
Physical Science	2.0%	3.2%	3.4%	4.7%	35.8%	0.0%	2.7%	1.5%	2.0%	1.7%	1.3%	1.2%	2.1%	2.2%	3.4%	**2.4%**
Social Science	16.2%	6.9%	3.8%	3.8%	7.6%	21.8%	8.1%	44.9%	40.5%	21.2%	10.5%	7.3%	8.2%	18.1%	14.2%	**15.2%**
Voc Tech	1.1%	0.2%	1.4%	0.2%	0.0%	0.0%	0.0%	0.2%	0.4%	0.6%	0.3%	0.1%	0.2%	0.3%	4.9%	**1.0%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Appendix Table 2B3: Bachelor Occupation-Field of Study Crosswalk from 2013 Joint Report

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	25.4%	2.1%	1.7%	8.6%	4.5%	0.4%	1.7%	2.5%	1.5%	2.8%	9.5%	1.7%	27.8%	4.9%	4.9%	**100.0%**
Business/Mgment	65.9%	3.4%	1.3%	0.3%	0.1%	0.3%	0.1%	2.6%	1.5%	6.0%	3.8%	1.6%	2.3%	4.5%	6.3%	**100.0%**
Computer Science	27.1%	53.8%	3.3%	0.5%	0.5%	0.0%	0.1%	0.9%	0.5%	2.5%	2.1%	1.0%	1.2%	2.3%	4.1%	**100.0%**
Education	19.3%	0.6%	0.8%	0.6%	0.1%	0.4%	0.1%	4.8%	0.6%	3.3%	54.2%	2.4%	3.3%	5.4%	4.2%	**100.0%**
Engineering	27.4%	11.5%	36.8%	0.4%	0.7%	0.4%	0.2%	0.9%	1.1%	1.5%	3.5%	3.0%	2.1%	2.2%	8.4%	**100.0%**
Fam./Cons. Science	25.9%	0.3%	0.4%	1.2%	0.1%	0.1%	0.0%	9.3%	0.9%	10.0%	23.3%	3.2%	8.5%	11.6%	5.2%	**100.0%**
Health	14.0%	0.4%	0.4%	0.5%	0.4%	0.1%	0.2%	3.2%	0.6%	2.8%	4.9%	0.8%	66.9%	3.5%	1.5%	**100.0%**
Humanities & Comm.	32.8%	3.4%	0.7%	0.4%	0.1%	0.9%	0.1%	6.5%	4.2%	5.6%	15.3%	10.9%	5.4%	7.4%	6.3%	**100.0%**
Legal	18.8%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	9.5%	34.2%	1.1%	10.9%	0.0%	0.0%	8.3%	11.8%	**100.0%**
Math	27.6%	21.0%	5.5%	0.4%	2.0%	0.4%	0.0%	2.2%	1.6%	2.4%	21.7%	2.1%	3.7%	2.4%	7.0%	**100.0%**
Physical Science	28.5%	6.8%	6.9%	1.1%	9.1%	0.5%	0.8%	2.9%	1.6%	2.9%	9.4%	1.7%	16.8%	3.3%	7.7%	**100.0%**
Social Science	37.5%	2.5%	1.2%	0.5%	0.3%	2.3%	0.1%	14.5%	6.6%	5.8%	9.7%	2.1%	6.2%	5.7%	4.9%	**100.0%**
Voc Tech	42.4%	1.4%	9.5%	0.0%	0.0%	0.0%	0.0%	1.5%	0.6%	2.2%	2.6%	0.4%	2.1%	2.1%	35.2%	**100.0%**
Total	**34.9%**	**5.6%**	**5.5%**	**1.1%**	**1.0%**	**0.8%**	**0.3%**	**5.4%**	**2.6%**	**4.3%**	**13.4%**	**3.6%**	**10.7%**	**4.9%**	**5.8%**	**100.0%**
Life Science/Agrc	6.0%	3.1%	2.6%	62.5%	38.3%	3.9%	54.3%	3.8%	4.8%	5.3%	5.8%	4.0%	21.3%	8.2%	6.9%	**8.2%**
Business/Mgment	32.4%	10.4%	4.1%	5.2%	0.9%	6.5%	7.1%	8.2%	9.5%	23.9%	4.8%	7.6%	3.7%	15.8%	18.6%	**17.2%**
Computer Science	2.6%	31.7%	2.0%	1.6%	1.7%	0.0%	0.8%	0.6%	0.6%	1.9%	0.5%	0.9%	0.4%	1.5%	2.3%	**3.3%**
Education	5.9%	1.2%	1.6%	5.2%	1.3%	6.0%	3.0%	9.4%	2.3%	8.1%	43.3%	7.1%	3.3%	11.7%	7.6%	**10.7%**
Engineering	8.9%	23.4%	75.7%	4.0%	8.6%	5.9%	8.7%	1.9%	4.7%	3.9%	3.0%	9.4%	2.2%	5.0%	16.3%	**11.4%**
Fam./Cons. Science	0.6%	0.0%	0.1%	0.9%	0.1%	0.1%	0.0%	1.4%	0.3%	1.9%	1.4%	0.7%	0.7%	2.0%	0.7%	**0.8%**
Health	2.7%	0.5%	0.5%	3.1%	2.6%	1.0%	4.0%	4.0%	1.4%	4.3%	2.5%	1.4%	42.6%	4.8%	1.8%	**6.8%**
Humanities & Comm.	17.3%	11.4%	2.2%	5.7%	1.9%	21.6%	5.3%	22.1%	29.1%	24.0%	21.0%	55.9%	9.4%	27.7%	19.9%	**18.4%**
Legal	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	1.3%	0.0%	0.1%	0.0%	0.0%	0.2%	0.2%	**0.1%**
Math	1.2%	5.7%	1.5%	0.5%	3.1%	0.8%	0.0%	0.6%	0.9%	0.8%	2.4%	0.9%	0.5%	0.7%	1.8%	**1.5%**
Physical Science	3.1%	4.5%	4.7%	3.8%	35.5%	2.4%	10.8%	2.0%	2.3%	2.5%	2.6%	1.8%	5.9%	2.5%	4.9%	**3.7%**
Social Science	18.3%	7.7%	3.7%	7.5%	6.1%	51.8%	5.9%	45.5%	42.6%	22.9%	12.4%	10.1%	9.9%	19.7%	14.4%	**17.1%**
Voc Tech	0.9%	0.2%	1.3%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.4%	0.1%	0.1%	0.1%	0.3%	4.5%	**0.7%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Appendix Table 2C1: Graduate Occupation-Field of Study Crosswalk from 2008 SIPP (National data)

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	24.3%	1.5%	4.1%	8.6%	11.2%	0.0%	1.4%	3.8%	0.0%	4.3%	24.6%	2.7%	10.4%	2.5%	0.8%	**100.0%**
Business/Mgment	67.9%	5.3%	3.2%	0.3%	0.3%	0.3%	0.2%	1.1%	0.7%	5.7%	6.6%	1.9%	1.5%	0.9%	4.3%	**100.0%**
Computer Science	27.3%	47.4%	3.2%	0.0%	1.5%	0.0%	0.0%	1.3%	0.9%	1.7%	10.3%	0.9%	3.7%	0.9%	1.0%	**100.0%**
Education	16.9%	0.3%	0.1%	0.3%	0.0%	0.8%	0.0%	5.2%	0.6%	4.1%	65.3%	2.2%	1.8%	1.3%	1.2%	**100.0%**
Engineering	27.3%	9.3%	37.6%	0.0%	1.0%	0.5%	0.0%	1.2%	0.5%	4.1%	5.7%	3.5%	2.5%	1.3%	5.3%	**100.0%**
Fam./Cons. Science																
Health	9.7%	0.6%	0.4%	1.2%	0.6%	0.0%	0.3%	2.2%	0.0%	1.6%	4.4%	0.8%	75.9%	1.4%	0.7%	**100.0%**
Humanities & Comm.	18.9%	2.0%	5.1%	0.2%	0.0%	0.0%	0.6%	13.5%	2.5%	4.6%	33.5%	11.3%	2.3%	2.3%	3.2%	**100.0%**
Legal	16.0%	0.6%	0.2%	0.2%	0.0%	0.9%	0.3%	1.7%	69.6%	1.4%	4.8%	1.1%	0.7%	1.3%	1.1%	**100.0%**
Math	22.0%	13.4%	2.9%	0.5%	0.7%	0.0%	0.0%	0.9%	0.0%	1.5%	51.6%	3.5%	0.7%	0.0%	2.2%	**100.0%**
Physical Science	26.2%	3.7%	4.8%	5.9%	17.9%	0.0%	2.0%	2.9%	0.0%	4.8%	16.2%	1.3%	11.6%	0.0%	2.9%	**100.0%**
Social Science	25.5%	1.3%	0.9%	0.9%	0.0%	10.8%	0.9%	21.8%	0.6%	4.3%	19.3%	1.7%	9.0%	1.6%	1.3%	**100.0%**
Voc Tech																
Total	**27.4%**	**4.3%**	**4.4%**	**0.8%**	**0.9%**	**1.4%**	**0.3%**	**5.5%**	**7.3%**	**3.7%**	**25.2%**	**2.7%**	**12.5%**	**1.3%**	**2.2%**	**100.0%**
Life Science/Agrc	2.8%	1.1%	2.9%	35.0%	38.5%	0.0%	14.2%	2.2%	0.0%	3.6%	3.0%	3.1%	2.6%	5.9%	1.1%	**3.1%**
Business/Mgment	43.3%	21.5%	12.6%	5.7%	4.8%	3.6%	9.2%	3.6%	1.7%	26.6%	4.5%	12.1%	2.1%	12.2%	34.3%	**17.5%**
Computer Science	3.9%	43.3%	2.9%	0.0%	6.7%	0.0%	0.0%	0.9%	0.5%	1.8%	1.6%	1.3%	1.2%	2.6%	1.8%	**3.9%**
Education	14.6%	1.4%	0.3%	8.7%	0.0%	13.5%	0.0%	22.4%	1.9%	25.9%	61.2%	19.0%	3.4%	22.2%	13.2%	**23.6%**
Engineering	7.4%	16.0%	64.0%	0.0%	8.3%	2.9%	0.0%	1.6%	0.5%	8.2%	1.7%	9.6%	1.5%	7.0%	18.0%	**7.4%**
Fam./Cons. Science	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Health	4.6%	1.9%	1.3%	20.8%	8.7%	0.0%	13.4%	5.4%	0.0%	5.4%	2.3%	4.0%	78.9%	13.6%	4.3%	**13.0%**
Humanities & Comm.	6.4%	4.2%	10.7%	2.8%	0.0%	0.0%	18.3%	22.9%	3.2%	11.5%	12.3%	38.2%	1.7%	15.8%	13.5%	**9.3%**
Legal	5.6%	1.4%	0.4%	2.9%	0.0%	6.7%	9.7%	3.0%	91.4%	3.7%	1.8%	3.8%	0.5%	9.4%	4.8%	**9.6%**
Math	1.3%	5.1%	1.1%	1.1%	1.2%	0.0%	0.0%	0.3%	0.0%	0.7%	3.4%	2.1%	0.1%	0.0%	1.7%	**1.6%**
Physical Science	1.5%	1.4%	1.8%	12.3%	31.7%	0.0%	10.0%	0.8%	0.0%	2.0%	1.0%	0.8%	1.5%	0.0%	2.1%	**1.6%**
Social Science	8.6%	2.8%	2.0%	10.8%	0.0%	73.4%	25.2%	36.9%	0.8%	10.6%	7.1%	5.9%	6.7%	11.2%	5.3%	**9.2%**
Voc Tech	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Appendix Table 2C2: Graduate Occupation-Field of Study Crosswalk from 2013 NSCG (National Data)

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	17.7%	2.6%	1.2%	37.6%	2.8%	0.9%	4.9%	1.4%	0.0%	1.2%	18.8%	0.9%	9.1%	0.4%	0.7%	**100.0%**
Business/Mgment	73.8%	4.7%	4.3%	0.3%	0.2%	0.2%	1.8%	1.8%	0.1%	3.0%	4.6%	1.2%	1.8%	0.7%	1.5%	**100.0%**
Computer Science	24.6%	39.1%	17.5%	0.1%	0.0%	0.0%	4.6%	0.7%	0.0%	0.8%	6.9%	1.9%	0.8%	1.9%	0.9%	**100.0%**
Education	15.1%	0.8%	0.0%	0.0%	0.0%	0.2%	0.1%	6.8%	0.1%	1.7%	71.2%	1.3%	1.3%	0.7%	0.7%	**100.0%**
Engineering	22.1%	8.4%	44.3%	1.2%	1.4%	0.5%	10.5%	0.6%	0.1%	1.9%	6.4%	0.5%	0.3%	0.2%	1.6%	**100.0%**
Fam./Cons. Science	18.0%	6.8%	0.0%	0.0%	0.4%	4.0%	0.0%	28.1%	2.6%	0.0%	14.5%	0.0%	25.7%	0.0%	0.0%	**100.0%**
Health	13.4%	0.5%	0.1%	1.9%	0.2%	0.3%	0.3%	2.6%	0.0%	1.0%	7.4%	0.5%	71.4%	0.2%	0.1%	**100.0%**
Humanities & Comm.	17.2%	3.4%	1.3%	0.2%	0.1%	0.5%	0.4%	6.9%	0.9%	5.2%	47.9%	8.9%	1.9%	2.9%	2.4%	**100.0%**
Legal	16.9%	0.4%	0.1%	0.0%	0.0%	0.9%	0.1%	0.9%	71.8%	1.2%	3.4%	0.4%	1.1%	2.5%	0.2%	**100.0%**
Math	20.2%	22.7%	9.2%	1.0%	0.1%	0.3%	5.0%	0.3%	0.0%	1.3%	36.5%	0.0%	2.3%	0.4%	0.5%	**100.0%**
Physical Science	18.8%	3.1%	10.2%	4.7%	32.2%	0.3%	3.7%	0.6%	0.1%	0.5%	23.5%	0.4%	1.6%	0.3%	0.1%	**100.0%**
Social Science	30.0%	2.1%	0.4%	0.3%	0.3%	14.4%	0.6%	27.6%	0.3%	2.9%	13.6%	2.3%	3.1%	1.3%	0.8%	**100.0%**
Voc Tech																
Total	**28.3%**	**3.9%**	**4.7%**	**2.0%**	**1.0%**	**1.9%**	**1.6%**	**6.0%**	**6.9%**	**2.1%**	**25.4%**	**1.6%**	**12.6%**	**1.0%**	**0.9%**	**100.0%**
Life Science/Agrc	2.4%	2.5%	1.0%	70.9%	11.1%	1.8%	11.3%	0.9%	0.0%	2.1%	2.8%	2.0%	2.7%	1.6%	2.9%	**3.8%**
Business/Mgment	46.8%	21.9%	16.5%	2.5%	4.0%	2.3%	19.3%	5.4%	0.2%	25.6%	3.2%	13.3%	2.6%	13.2%	30.5%	**18.0%**
Computer Science	2.9%	33.5%	12.2%	0.2%	0.1%	0.1%	9.3%	0.4%	0.0%	1.3%	0.9%	3.8%	0.2%	6.5%	3.4%	**3.3%**
Education	11.9%	4.6%	0.2%	0.5%	0.6%	2.7%	2.0%	25.2%	0.2%	18.0%	62.9%	17.5%	2.3%	14.9%	17.8%	**22.4%**
Engineering	5.0%	13.9%	59.9%	3.8%	9.1%	1.6%	40.9%	0.7%	0.1%	5.7%	1.6%	1.9%	0.2%	1.5%	11.5%	**6.4%**
Fam./Cons. Science	0.0%	0.1%	0.0%	0.0%	0.0%	0.2%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	**0.1%**
Health	7.3%	1.9%	0.4%	14.7%	2.4%	2.7%	2.8%	6.7%	0.1%	7.6%	4.5%	4.8%	86.8%	2.3%	2.4%	**15.3%**
Humanities & Comm.	4.3%	6.2%	1.9%	0.6%	1.0%	1.7%	1.6%	8.1%	0.9%	17.6%	13.4%	38.4%	1.1%	20.6%	19.2%	**7.1%**
Legal	5.7%	1.0%	0.2%	0.1%	0.2%	4.4%	0.5%	1.4%	98.1%	5.5%	1.3%	2.6%	0.8%	24.1%	1.6%	**9.5%**
Math	0.8%	6.7%	2.2%	0.6%	0.2%	0.2%	3.5%	0.1%	0.0%	0.7%	1.6%	0.0%	0.2%	0.5%	0.6%	**1.1%**
Physical Science	1.3%	1.6%	4.4%	4.7%	68.0%	0.3%	4.6%	0.2%	0.0%	0.5%	1.9%	0.5%	0.3%	0.5%	0.2%	**2.0%**
Social Science	11.7%	6.1%	1.0%	1.4%	3.3%	82.3%	4.2%	50.6%	0.4%	15.3%	5.9%	15.3%	2.8%	14.3%	9.9%	**11.0%**
Voc Tech																
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Appendix Table 2C3: Graduate Occupation-Field of Study Crosswalk from 2013 Joint Report

	Business/ Sales	Computer Science	Engineering /Arch.	Life Science \Agrc	Physical Sciences	Social Sciences	Technicians	Human Protective Service	Legal	Admin./ Clerical	Educators	Editors, Writers, Performers	Health Professions	Service occupations	Production and Trades	Total
Life Science/Agrc	40.3%	2.5%	0.0%	13.5%	0.8%	0.2%	0.1%	6.2%	0.0%	1.0%	30.6%	0.3%	0.9%	3.1%	0.6%	**99.9%**
Business/Mgment	68.8%	1.2%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	21.6%	6.7%	0.3%	0.0%	0.6%	0.2%	**99.9%**
Computer Science	11.4%	74.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.6%	3.8%	1.3%	0.0%	0.0%	0.0%	**99.6%**
Education	13.4%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	2.2%	0.0%	0.0%	83.7%	0.3%	0.0%	0.3%	0.0%	**100.1%**
Engineering	32.4%	3.3%	45.6%	0.0%	0.4%	0.5%	0.1%	0.0%	0.0%	0.0%	14.8%	0.3%	1.6%	0.0%	1.0%	**99.9%**
Fam./Cons. Science	21.9%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.4%	0.0%	0.0%	16.1%	2.6%	13.3%	40.8%	1.2%	**99.5%**
Health	4.1%	0.8%	0.2%	0.2%	0.3%	0.1%	0.0%	7.4%	0.0%	2.0%	8.4%	0.2%	75.4%	0.7%	0.2%	**100.0%**
Humanities & Comm.	11.4%	1.5%	0.0%	0.4%	1.1%	2.9%	0.0%	8.3%	0.1%	1.3%	50.3%	20.6%	1.2%	0.0%	0.9%	**100.0%**
Legal	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	65.7%	19.6%	15.5%	0.0%	0.0%	0.0%	0.0%	**100.8%**
Math	32.3%	49.5%	0.0%	0.3%	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%	16.1%	0.0%	0.0%	0.0%	0.0%	**99.5%**
Physical Science	39.6%	0.0%	0.7%	0.0%	34.8%	0.0%	0.7%	0.0%	0.0%	0.0%	23.3%	0.0%	0.0%	0.0%	0.9%	**100.0%**
Social Science	35.9%	0.9%	0.3%	0.0%	0.0%	10.8%	0.0%	34.2%	0.0%	0.8%	17.0%	0.0%	0.0%	0.0%	0.0%	**100.1%**
Voc Tech	6.4%	0.0%	1.7%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.5%	0.0%	1.1%	88.6%	99.7%
Total																
Life Science/Agrc	2.8%	1.1%	2.9%	35.0%	38.5%	0.0%	14.2%	2.2%	0.0%	3.6%	3.0%	3.1%	2.6%	5.9%	1.1%	**3.1%**
Business/Mgment	43.3%	21.5%	12.6%	5.7%	4.8%	3.6%	9.2%	3.6%	1.7%	26.6%	4.5%	12.1%	2.1%	12.2%	34.3%	**17.5%**
Computer Science	3.9%	43.3%	2.9%	0.0%	6.7%	0.0%	0.0%	0.9%	0.5%	1.8%	1.6%	1.3%	1.2%	2.6%	1.8%	**3.9%**
Education	14.6%	1.4%	0.3%	8.7%	0.0%	13.5%	0.0%	22.4%	1.9%	25.9%	61.2%	19.0%	3.4%	22.2%	13.2%	**23.6%**
Engineering	7.4%	16.0%	64.0%	0.0%	8.3%	2.9%	0.0%	1.6%	0.5%	8.2%	1.7%	9.6%	1.5%	7.0%	18.0%	**7.4%**
Fam./Cons. Science	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Health	4.6%	1.9%	1.3%	20.8%	8.7%	0.0%	13.4%	5.4%	0.0%	5.4%	2.3%	4.0%	78.9%	13.6%	4.3%	**13.0%**
Humanities & Comm.	6.4%	4.2%	10.7%	2.8%	0.0%	0.0%	18.3%	22.9%	3.2%	11.5%	12.3%	38.2%	1.7%	15.8%	13.5%	**9.3%**
Legal	5.6%	1.4%	0.4%	2.9%	0.0%	6.7%	9.7%	3.0%	91.4%	3.7%	1.8%	3.8%	0.5%	9.4%	4.8%	**9.6%**
Math	1.3%	5.1%	1.1%	1.1%	1.2%	0.0%	0.0%	0.3%	0.0%	0.7%	3.4%	2.1%	0.1%	0.0%	1.7%	**1.6%**
Physical Science	1.5%	1.4%	1.8%	12.3%	31.7%	0.0%	10.0%	0.8%	0.0%	2.0%	1.0%	0.8%	1.5%	0.0%	2.1%	**1.6%**
Social Science	8.6%	2.8%	2.0%	10.8%	0.0%	73.4%	25.2%	36.9%	0.8%	10.6%	7.1%	5.9%	6.7%	11.2%	5.3%	**9.2%**
Voc Tech	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Refining Workforce Education Supply and Demand Analysis

FINAL REPORT ADDENDUM

Upjohn Institute Technical Report 15-031

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I. PURPOSE

At the presentation and discussion of the final report on November 21, 2014, representatives of the joint agencies requested that the recommendations of the report be operationalized. That is, rather than simply providing a list of specific recommendations, Upjohn was asked to illustrate how the recommendations could be implemented, step by step. This operationalization was to account for the informal decision made by the joint agencies at the meeting to continue to use the ACS for determining educational levels for occupations.

The guide in the following section is meant to comply with the joint agencies' request. In conjunction with the guide, Upjohn will be delivering under separate cover any processed data files and program files, in SAS format, that are necessary for implementation of the recommendations.

II. GUIDE TO IMPLEMENTATION OF RECOMMENDATIONS

A. DEMAND: Educational Distribution Across Occupations

The first three recommendations all pertain to the determination of education levels across occupations. The original recommendations are below:

> **Recommendation 1:** The joint agencies producing the report should use an empirical approach based on the actual openings for jobs as derived from aggregating online postings or an approach based on the educational levels of individuals who have begun employment spells.
>
> **Recommendation 2:** If the joint agencies continue to use the ACS incumbent worker approach for determining the educational levels needed for occupations, staff members should use empirically-based age restrictions in sampling the ACS.
>
> **Recommendation 3:** The joint agencies should discontinue the BLS "entry-level" approach of assigning the single educational level necessary for an occupation.

It was decided to use the ACS approach with age-based restrictions on a sample of Washington state residents to both reduce incumbency bias and better represent Washington's labor market. Recommendations 2 and 3 were thus accepted, while recommendation 1 was thought to be complicated to be feasible given resource constraints.

To implement recommendation 2, the joint agencies may choose from two options:

1. Use fixed age cutoffs of 25 to 34 for all occupations except management occupations (SOC 11), which will use a 35 to 54 age cutoff, or;

2. Use empirically derived age cutoffs, from the CPS, by 2-digit occupation group as shown in Table 6 of the final report.

Both options are readily implemented using ACS microdata, although the first is simpler. The step-by-step rules at the bottom of the document provide more detail.

B.   DEMAND: Using the SIPP to Refine Education Levels

To refine the broad education category of "some college, no degree" in the ACS, the fourth recommendation stated:

> **Recommendation 4:** The joint agencies should use the SIPP as a basis for identifying and ratio adjusting occupations that have a high concentration of certificates within the "some college, no degree" category.

To implement this recommendation, the share of workers with "some college, no degree" from the ACS tabulations in *A.* can be multiplied by the SIPP certificate tabulations from the OCC_edreq_master.[22]

Specifically, the ratios in column D of the tab 'SUPP_6-digit SOC CERTS' from OCC_edreq_master.xlsx would be multiplied by the share of workers with "some college, no degree" from the 6-digit ACS tabulations in *A*. (Occupations at the 5-digit or 4-digit SOC level would work analogously). The results would yield the share of workers in each occupation within Washington state, for the appropriate age range, whose highest level of education was a certificate.

Steps *A.* and *B.* together yield the refined educational distributions (across eight categories) for new workers in Washington, at the 4-, 5-, and 6-digit SOC level. The mid-level for education used in prior reports comprises the certificate and associate's degree categories; the bachelor-level comprises the bachelor's degree category; and the graduate-level comprises the master's and doctoral/professional categories.

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[22] The SIPP tabulations are based on national, and not Washington-specific, data.

C.   **SUPPLY: Occupation-by-field mappings by education level**

To better align and empirically derive fields of study by education level and occupation, the fifth and seventh recommendations stated:

> **Recommendation 5:** On the supply side, the joint agencies should use the occupation-by-field of study from the SIPP for workers with certificates and associate's degrees. They should use the ACS for graduates (adjusted for labor market entry and upskilling) with a baccalaureate degree, and the NSCG for individuals with graduate degrees.

> **Recommendation 7:** The joint agencies should request licensure data that can be used to adjust supply in a manner similar to what is done for registered nurses for occupations that require licenses in occupations outside of health. Other in-demand jobs where licensure may affect supply include (at the mid-level): electricians, plumbers, and certain mechanics; (at the bachelor's degree level): accountants, teachers, and most engineers; and (at the graduate level): lawyers and social workers.

The process in recommendation 5 would supersede the ad hoc crosswalk for mid-level completers and the CIP-SOC crosswalk for graduate degree completers. These crosswalks were provided in the final report: Appendix Table 2A for mid-level; Appendix Table 2B2 for baccalaureate degree; and Appendix Table 2C2 for graduate degree completers.

As in the current methodology, completers from IPEDS would be supplemented with completers from technical and community colleges; private and vocational schools; and apprenticeships, and these completion counts would be crosswalked by coarse field of study to coarse occupation group. If full licensure data is obtained, the supply counts for specific occupations from the above crosswalk procedure would be replaced by the counts of new licenses for licensed occupations.

D.   **SUPPLY: Adjustments for incumbent workers**

To more accurately measure supply of newly available workers, the eighth recommendation stated:

> **Recommendation 8:** The joint agencies should adjust downward the supply of mid-level completers—especially for in-demand occupations—to account for the share that continues on with their education with their current employer.

To implement this recommendation, some programming and manipulation of the databases from private vocational schools (PVS), the State Board of Community and Technical Colleges (SBCTC), and possibly Washington Student Achievement Council (WSAC) are required. The provided code files output the share of completers for each credential level by 2-digit CIP program that were employed in a different industry in the four quarters after completion relative to the industry in the quarter before the program began (including none).

E.   OTHER: Miscellaneous refinements

The report made three additional recommendations:

Recommendation 6: In consideration of the statistical error inherent in projections and data, the published report should have rounded supply and demand figures in each relevant cell to the nearest hundred and the agencies should base supply on a three-year average of completion data.

Recommendation 9: Because the agencies had an interest in how to annualize projections to the calendar year, we recommend fitting occupation-specific exponential growth models based on ESD's projections at the 2-year, 5-year, and 10-year level. Alternatively, ESD could produce occupation projections at another time horizon to improve these growth models.

Recommendation 10: WTECB and ESD have conducted surveys that are closely thematically related and that even overlapped directly on a few questions. These two agencies, in cooperation with WSAC and SBCTC, may be able to create an optimized survey design that meets the needs of the several agencies and could be cost-shared among them. Ideally such a joint survey could capture the educational requirements of openings.

These recommendations are generally straightforward (recommendation 6) or are more conceptual/ideational (recommendation 10). Recommendation 9 assumes that (in the short run) occupational-specific projections can be approximated by an exponential growth function, notably $O_{i,t+x} = O_{i,t} \times e^{bx}$, where the term of the left hand side refers to an occupational-specific projection at an intermediate time, the first term on the left is an initial occupation count, and the second term is the growth factor. By solving for *b,* one can create projections for other time periods. This is detailed in the step-by-step guide below.

STEP-BY-STEP INSTRUCTIONS FOR DEMAND AND SUPPLY

Demand

1. Pick which of two age cutoffs to use for the ACS

2. Run tabulation SAS code on ACS extract to get 7-category education distribution for each occupation at the 6-digit, 5-digit, and 4-digit SOC levels

3. Multiply the vector/column of the "some college, no degree" education category for 6-digit SOCs by the ratios in column D of the tab 'SUPP_6-digit SOC CERTS' from OCC_edreq_master.xlsx. Repeat for 5-digit and 4-digit SOCS, using the appropriate tab from OCC_edreq_master.xlsx.

4. Create an eighth education category, certificates, from these multiplication products, between "some college, no degree" and "associates degree."

5. Subtract the values in the new "certificate" category from the "some college, no degree" category to replace the latter category with "some college, no credential" (netting out certificates).

6. Impute missing 6-digit SOC education distributions (from insufficient data; fewer than 30 observations) with 5-digit SOC education distributions. For example, impute education for SOC 49-2092, "Electric motor, power tool, and related repairers," with SOC 49-209, "Electrical and electronic system installers." Repeat imputations of missing 5-digit SOC education distributions with 4-digit SOC education distributions.

7. Collapse education distributions to desired aggregation: less than postsecondary credential, mid-level, bachelor's, and graduate.

Supply

1. Create occupational supply by mapping completers from IPEDS (bachelor's and graduate degrees) and state administrative data (mid-level) using provided crosswalks: Appendix Table 2A for mid-level; Appendix Table 2B2 for baccalaureate degree; and Appendix Table 2C2 for graduate degree completers.

   Use state licensing board data on new licenses granted by occupation to replace occupational supply from the crosswalked completers for licensed occupations.

Occupational Projection Interpolation

1. In an Excel worsheet, take the natural logarithm of the current occupation count, and the 2-year, 5-year, and 10-year ESD projection for each occupation.
2. For each occupation, subtract the current count from the 2-year projection, the 2-year projection from the 5-year projection, and the 5-year projection from the 10-year projection.
3. For each occupation, divide the first difference by 2, the second difference by 3, and the third difference by 5.
4. Occupation projections at 1-year are given by exponentiating (e^x) the first set of quotients and multiplying by current occupation counts.

5. Occupation projections at a 3-year horizon are given by exponentiating (e^x) the second set of quotients and multiplying by the 2-year projection; for 4-year horizon, exponentiate two times the second set of quotients (e^{2x}) and then multiply by the 2-year projection.
6. Occupation projections at 6- through 9-year horizons are given by (a) subtracting 5 from the horizon length, (b) exponentiating the product of this difference and the third set of quotients (e^{tx}, where $1 \leq t \leq 4$), and then multiplying by the 5-year projection.