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Using Occupational Characteristics Information from O*NET to Identify Occupations for Compensation Comparisons with K-12 Teaching[1]

Anthony Milanowski

1. The Teacher Pay Comparison Problem

One common theme in policy discussions of teacher quality is that K–12 teacher salaries need to be increased (e.g., National Commission on Teaching and America's Future, 2003; Odden & Kelley, 2002). While raising pay would likely attract more people to the occupation—allowing for greater selectivity in hiring—and improve retention, it is not completely obvious how much pay levels should be increased. One way to determine the pay level needed has been to compare teacher pay to pay levels in other occupations. This approach avoids many complexities involved in trying to estimate a supply curve or in asking workers with the skills needed what pay levels would attract them to K–12 teaching. So it is attractive as the basis for a rough answer to the question of "how much more?" The approach does require, however, the identification of a set of credible comparison occupations. And it is not immediately apparent what those comparison occupations should be.

Some Bases for Pay Comparison

Discussions about teacher pay in comparison to pay in other occupations use a variety of methods to select comparisons. Some are based, at least indirectly, on comparisons of the human capital of occupation members. For example, the American Federation of Teachers' Survey and Analysis of Teacher Salary Trends (e.g., Nelson, Drown, & Gould, 2002) compares teachers' salaries with the average salaries of other degree-requiring white-collar occupations. The degree attained is in effect a measure of human capital. Bruschi and Coley (1999) compared teachers' level of literacy to that in other occupations and then compared median wage levels, concluding that teaching as an occupation was paid less than occupations with similar literacy levels. Here, literacy was the measure of human capital. A human capital approach is in harmony with the way most economists think about the determinants of earnings and is based on strong economic theory. It is, however, often hard to obtain complete measures of persons' human capital, so that simpler measures, or proxies such as degrees obtained, must be used to identify comparison occupations.

Another approach was taken by Goldhaber and Player (2003), who used information from the National Center for Education Statistics Schools and Staffing Survey and its Teacher Follow-up Survey to identify the occupations entered by teachers who leave teaching. This kind of analysis does not require a measure of human capital and avoids having to make qualitative judgments about which occupations are comparable, since tracing teachers' movements shows which occupations are labor market competitors.

[1] This paper was originally prepared for the 2003 annual meeting of the American Educational Finance Association, Orlando, Florida.

Yet another basis for pay comparison is often used in human resource management and organizational/industrial psychology. These fields have developed techniques that compare jobs based on the work tasks typically performed and the knowledge, skills, and abilities (KSAs) needed to perform them. The work tasks and KSAs are often called *job content*. Job content comparisons are often made to help set pay for jobs for which it is difficult to find the going rate in the labor market or for which labor markets are too imperfect to determine a usable going rate. The technique of job evaluation—an elaboration of job content comparison that uses a relatively small set of dimensions (usually related to skill, responsibility, effort, and working conditions)—has been used to compare jobs for pay-setting purposes for more than 75 years. Comparing tasks and KSAs can even be related to human capital theory, because the level and type of skill required to perform the work activities determine the training, experience, and attributes that workers need to have. Presumably, workers in jobs with similar work activities and skill requirements will have similar amounts and types of human capital. While job content has not been a common basis of comparison in the discussion of K–12 teacher salaries, it may be a useful supplement to the other approaches now used.

Comparing occupations is a bit more complex than comparing jobs because it is harder to identify common dimensions for comparison. Ideally, a set of dimensions would apply to most occupations and represent all or most of the important factors people see as differentiating among them, as well as important pay determinants. This would also require a database containing information on a large number of occupations. Fortunately, the U.S. Department of Labor has developed O*NET, a database of information on the characteristics of more than 1,100 occupations. O*NET was intended to be a data system that could describe a wide variety of occupations.

Since the O*NET database contains job content information on K–12 teachers and most of the other occupations in the U.S., I decided to see if it could be used to identify some occupations comparable to K–12 teaching based on job content. This paper reports on the initial analyses I conducted and on the comparison groups these analyses suggested. While it would be premature to conclude that a canonical set of comparison occupations has been identified, I hope the results show the feasibility of using job content as another basis of comparison and help broaden our thinking about which occupations are comparable to K–12 teaching.

*The O*NET Occupational Information System*

Replacing the Dictionary of Occupational Titles, O*NET includes 17 sets or domains of descriptors covering worker characteristics (such as abilities, and interests), worker requirements (such as basic and cross-functional skills, training, and licensing), occupational requirements (work activities and organizational context), and occupation-specific knowledge and skills (Dunnette, 1999). There are more than 300 descriptors for each occupation in the database. Each occupation is rated on the level, importance, and/or frequency of the job content represented by each descriptor. The choice of descriptors to include in O*NET was based on an extensive research project that integrated more than 30 years of job/occupational analysis research. The development of the O*NET taxonomy and the research investigating its reliability and validity were summarized in various chapters of a book edited by Peterson, Mumford, Borman, Jeanneret, and Fleischman (1999). The goal of the O*NET system was to base the description of each occupation on job content information obtained directly from surveys of people performing

jobs within the particular occupation, their supervisors, and other members of their organizations. The surveys were to be administered to a nationally representative sample of organizations (Peterson et al., 2001). At the time of writing, however, that data collection effort has not been completed, and the O*NET database used here—O*NET version 3.1[2]—was derived from ratings of job content information collected for the Dictionary of Occupational Titles by a large group of occupational analysts (Peterson, Mumford, Levin, Green, & Waksberg, 1999; Peterson et al., 2001). The O*NET research team did study the relationships between analyst and job incumbent ratings for occupations for which enough incumbent ratings were available. They found that median correlations between job incumbent and analyst ratings were relatively high.[3]

Not all of the O*NET domains could be used as bases of comparison for this project. Some (e.g., *organizational context*) are more likely to distinguish between organizations than occupations. Others (e.g., *knowledge required*) tend to define occupations and so are not very useful for cross-occupational comparisons. It would also not be efficient to use them all, since they overlap. Research during the development of O*NET using samples of occupations showed substantial correlations between many of the descriptors across domains (Hanson, Borman, Kubsiak, & Sager, 1999). Based on occupational grouping research using O*NET dimensions done by Baughman, Norris, Cooke, Peterson, and Mumford (1999), I chose to concentrate on two domains: basic and cross-functional skills and generalized work activities. The *basic and cross-functional skills (BCFS) domain* attempts to represent a set of learned capacities applicable to almost all occupations. They are divided into basic skills—those that provide the foundation for acquiring new knowledge—and cross-functional skills—those thought to underlie broadly defined work processes or functions (e.g., solving problems, working with people). The *generalized work activities (GWA) domain* attempts to represent generic work behaviors that involve information input, mental or physical processes, and interaction with others. There are 46 BCFS and 42 GWA. Table 1 in the appendix lists the BCFS and GWA defined by O*NET.

Each occupation has two ratings for each BCFS (the skill's *level* and *importance on the job*) and three ratings for each GWA (*level*, *importance,* and *frequency of performance*). The ratings are based on 7-point scales with behavioral descriptions anchoring three or four scale points. Following Baughman et al. (1999), I used the level scales in the analyses reported here. As reported by Baughman et al. and confirmed by my preliminary analyses, the BCFS and GWA level scales are highly correlated for almost all dimensions in each domain. For the BCFS, the ratings can be taken to indicate a criterion-referenced skill level. GWA level ratings might be interpreted as the level of complexity or difficulty of the work performed.

[2] Shortly after this project began, this database was superseded by O*NET version 4.0. Luckily, there were few changes in the two domains of interest, so I proceeded with the analysis using the 3.1 database. The major change will come with the release of O*NET version 5, which will begin to incorporate information and ratings based on surveys of occupational incumbents.

[3] For the two O*NET domains used here—*basic and cross-functional skills* and *generalized work activities*—the medians were .75 and .70, respectively (Mumford, Peterson, & Childs, 1999; Jeanneret, Borman, Kubsiak, & Hanson, 1999).

2. Analysis Methods

Much of the work on job grouping based on job content information has used cluster analysis, typically hierarchical agglomerative methods. While substantial work has been done to try to identify which linkage technique is best (based mostly on simulation studies of the ability to recover predefined clusters), there is no consensus on the question. Ward's method and average linkage appear to be the most popular techniques. For the research reported in this paper, I used the average linkage method, based on the finding that Ward's method is biased toward producing same-sized spherical clusters (Everitt, Landau, & Leese, 2001). In this data, there was no reason to believe the clusters would have any particular shape or be the same size. In fact, given that O*NET divides some occupational groups into many titles and others into relatively few, similar-sized clusters were not expected. The average linkage method was also recommended for many job grouping situations by Garwood, Anderson, and Greengart (1991).

The hierarchical cluster analyses used the Euclidian distance between occupations as the distance measure. I standardized the ratings across occupations within each GWA or BCFS dimension, then performed six cluster analyses using different methods. *Method 1* used only the BCFS dimensions. This analysis thus resulted in groups of occupations with similar levels of the various skills. *Method 2* used both the BCFS and the GWA in order to represent similarities in both skills and work activities. *Method 3* used both the BCFS and the GWA, but before clustering, a principal components analysis was done of the 88 descriptor × 350 occupation matrix, and principal component scores obtained. I used principal components scores due to the substantial correlations (and conceptual overlap) between some descriptors across the GWA and BCFS domains. Using highly correlated dimensions in effect weights these dimensions more heavily. Using just the most important principal components (i.e., those that account for the largest percentage of the variance) removes this effect, and also removes components that explain little variance from the analysis. To see if different groupings might be found if highly correlated dimensions were combined and low-variance components removed, I decided to use component scores representing the components with eigenvalues of 1 or greater. There were 10 such components, and in combination they explained almost 84% of the variance.

It should be noted that the cluster analyses based on Euclidian distances using Methods 1, 2, and 3 do not separate profile similarity from level similarity. Because the similarity measure reflects both the pattern of high and low ratings and the level of the rating itself, it was possible for occupations with similar overall average skill levels to cluster together, even if the pattern of skills or activities was not that similar. To see how the clusters would differ if the effect of level was eliminated (basing the clusters only on the pattern of skills or activities emphasized in each occupation), I followed Baughman et al. (1999) by performing a second set analyses after standardizing each BCFS and GWA rating within the occupation. (For example, I calculated the average of the 42 GWA ratings within each occupation, and for each descriptor, its standardized value was the difference between the raw descriptor value and the mean for all descriptors, in standard deviation units.) Intuitively, this new set of scores reflects the emphasis in a given occupation on particular BCFS or GWA. I used three cluster analysis methods with this data: *Method 4* clustered occupations based on the transformed BCFS ratings. *Method 5* clustered occupations based on both the transformed BCFS and GWA ratings. *Method 6* again used principal components scores from both the BCFS and GWA, this time from the 16 principal

components with eigenvalues of 1 or more, which accounted for 77% of the variance in the combined GWA/BSCF ratings.

One issue in hierarchical agglomerative clustering is the choice of the number of clusters to take as representing the underlying structure of the object domain. Starting from *k* single-object clusters, the method continues to join objects and clusters until all the objects in the data set are members of one mega-cluster. A variety of criteria have been proposed to decide when to stop joining clusters so as to best represent the structure in the data. For the analyses reported here, I based stopping decisions on a combination of criteria, including the *R*-squared value representing the average cluster homogeneity, the change in that value between different cluster joins, and the cubic clustering criterion. In most of the analyses, the level of clustering chosen was such that the *R*-squared value was about .75, the value for the next level of agglomeration led to a substantial increase in *R*-squared, and the cubic clustering criterion declined substantially or turned negative. These decisions led to clusters of occupations related to teachers that included around 55 to 70 occupational titles.

Most of the methodological recommendations for hierarchical agglomerative clustering solutions appear to assume that there are "real" clusters to be found in the data. However, it is important to remember that occupations are not natural kinds, but artificial divisions of the world of work, much like national boundaries are artificial divisions of the globe. It is not necessary that clean, separable clusters exist. Occupations may shade into each other, and intuitively appealing groupings may have fuzzy borders. Being "like teachers" is probably a continuous multidimensional function, depending on what the philosopher Wittgenstein (1958) called *family resemblance*. Therefore, in addition to using hierarchical cluster analysis methods, I calculated distances between the core teacher titles and the other occupations, then sorted the occupations by distance. I used these lists to check the adequacy of some of the cluster solutions and to represent similarity in another way.

For this project, I restricted analyses to occupations in Job Zones 4 and 5.[4] These are occupations that according to O*NET require educational preparation equivalent to a bachelor's degree (Job Zone 4) or beyond (Job Zone 5). (There are some occupations in Job Zone 4 that are not traditionally thought of as requiring a bachelor's degree, but because of the extensive training and experience they require, they are assigned to that zone by O*NET.) I restricted my analyses to these two job zones because it is unlikely that states or districts will abandon the requirement that teachers possess a bachelor's degree, and therefore occupations in Job Zone 3 are effectively in a different labor market.

[4] A *job zone* is a group of occupations that are similar in these ways: (a) how most people get into the work, (b) how much overall experience people need to do the work, (c) how much education people need to do the work, and (d) how much on-the-job training people need to do the work. O*NET includes five job zones, describing the range of occupations from those that need little or no preparation (Job Zone 1) to those that need extensive preparation (Job Zone 5).

3. The O*NET View of Teachers

Teacher Titles

O*NET divides K–12 teaching into nine occupational titles: (a) kindergarten teacher, except special education; (b) elementary school teacher, except special education; (c) middle school teacher, except special and vocational education; (d) vocational education teacher, middle school; (e) secondary school teacher, except special and vocational education; (f) vocational education teacher, secondary school; (g) special education teacher, preschool, kindergarten, and elementary school; (h) special education teacher, middle school; and (i) special education teacher, secondary school. Taking into account the teacher titles that have identical ratings on the BCFS and GWA (the three special education titles; the middle and high school academic and vocational titles), there remain essentially four distinguishable types of K–12 teachers: kindergarten, elementary, middle and high (academic and vocational), and special education.

Comparisons of K–12 Teaching to Other Occupations in Job Zones 4 and 5

In comparing K–12 teaching to other occupations in Job Zones 4 and 5, one simple but interesting approach is to correlate the ratings of the four types of teachers— kindergarten, elementary, middle and high (academic and vocational), and special education—on the BCFS and GWA level scales with the average ratings of the 350 occupations O*NET assigns to those job zones. Table 2 shows the results.

These comparisons suggest that the core teacher titles, as described by O*NET, are not that different from the "average" occupation requiring a college degree. With the exception of kindergarten teachers, the average BCFS rating of the K–12 teacher titles does not differ greatly from the average across the 350 occupations in Job Zones 4 and 5. In fact, the average rating of elementary, middle/high school, and special education teachers is higher than the average for the 350 occupations. On the other hand, the BCFS ratings for kindergarten teachers are closer to the average, and the BCFS and GWA profiles for kindergarten teachers do not correlate as highly with those of the other teacher titles. These results led me to exclude kindergarten teachers from some of the analyses, where I combined the other K–12 teacher title categories by averaging their BCFS and/or GWA ratings. I refer to this average below as the *core teacher average*.

Figures 1 and 2 compare the skill and activity profiles of the core teacher average to that obtained by averaging the ratings for the 350 Job Zone 4 and 5 occupations. The biggest differences between teachers, as represented by the core teacher average, and the "average" bachelor's degree–requiring occupations are found in skills and activities related to instruction and social interaction, on the one hand, and equipment and manufacturing, on the other. As might be expected, teaching is rated higher on the former and lower on the latter. (In general, most of the 350 Job Zone 4 and 5 occupations receive low ratings on the equipment and manufacturing scales, but teaching tends to be lower than average.) Table 3 lists the BCFS and GWA for which the average rating for the core teacher titles is more than one half of a standard deviation above or below that for all 350 Job Zone 4 and 5 occupations.

In general, the differences are consistent with our intuitions about teaching: We would expect teachers to be rated higher on skills and activities relating to instruction and interactions

with people. It is interesting, however, that teachers differ substantially from the "average" professional occupation on only a few of the BCFS and GWA descriptors. This result may reflect the relatively generic definitions of skills and activities in O*NET, an approach the designers took so that these definitions could be applied to a broad range of occupations. This can be seen as both a strength and a weakness of these O*NET domains as a basis for comparison between teaching and other occupations. The strength is that broad definitions allow a meaningful rating of many different occupations on most of the dimensions. If definitions of comparison dimensions were too narrow, many occupations would score very low because the dimensions would not apply to them at all. This result would lead to misleading measures of similarity because most of the similarity is due to the features occupations lack rather than the features they have. The weakness is that the generic definitions may result in grouping teaching with other occupations that do not seem intuitively similar. As will be seen in the next section, this does happen in some of the cluster analyses.

4. Comparison Groups Based on BCFS and GWA

Groups Identified by Hierarchical Agglomerative Clustering

The occupational titles that clustered with the core teacher titles in the hierarchical agglomerative cluster analyses using Methods 1–3 are shown in Table 4. The table lists the occupational titles added to the cluster containing the elementary, middle/high/vocational, and special education teacher titles at each level of agglomeration until the combination of change in *R*-squared and the cubic clustering criterion suggested that clusters were becoming substantially less homogeneous. As the table shows, K–12 teachers tend to cluster consistently with three types of professionals: (a) other teachers; (b) counselors, psychologists, and social workers; and (c) health care professionals. As might be expected, the other types of teacher titles that cluster with the K–12 teacher titles include adult literacy teacher, health educator, postsecondary vocational teacher, and training specialist. Less expected, perhaps, is the fact that this category includes college teachers as well. Interestingly, kindergarten teachers do not join a cluster with the other K–12 teachers until later in the agglomeration process. Kindergarten teachers join with preschool teachers, and then often with librarians, musicians, and athletic trainers. The inclusion of psychologists, social workers, and counselors—professionals not involved in formal instruction—makes some post hoc sense because of the similar emphasis on "helping" and the level of "people skills" required. Several health care occupational titles are grouped with the teacher titles, including audiologist, registered nurse, occupational therapist, dietician and nutritionist, recreation therapist, and optometrist. In some groupings, pharmacists and dentists and professionals in related occupations cluster with teachers. These health care occupations, along with the teaching and counseling occupations, might all be viewed as "helping professions."

The occupations that cluster with teaching include some that seem surprising at first glance, such as technical writing, anthropology, farm and home management (university extension agents), and public relations. Yet post hoc, it is relatively easy in most cases to see some similarities with teaching. Some of these occupations require the writing, speaking, and creative thinking skills O*NET attributes to K–12 teaching, while others involve teaching's "people skills" and high levels of interpersonal interaction.

Some of the unexpected occupations—such as optometry, dentistry, and fire investigation—may cluster with teaching as much because of the similar overall skill level as because of similarities in the specific skills required or activities performed. Because the multidimensional Euclidian distance is based on a sum of 46 or 88 descriptor-level differences, it is possible that an occupation could be quite different from teaching on one or two descriptors, like *instruction* or *teaching others*, but only slightly different on many others. It is not as intuitively satisfying to think of such occupations as like teaching, so I conducted additional cluster analyses after standardizing the descriptors within each occupation. As discussed above, this transformation removes the influence of the BCFS or GWA level, and so the similarity measures are based on the degree to which different occupations have similar profiles (i.e., the degree to which they specialize in or emphasize specific BCFS or GWA). I expected these analyses to group jobs with relative emphasis on similar skills or activities, irrespective of the level of the skill required or work activity performed.

Table 5 shows the clusters identified by Methods 4, 5, and 6 (using the within-occupation standardized BCFS, BCFS and GWA, and the principal components of the combined BCFS and GWA). The cluster results are quite similar to those shown in Table 4. Again, other types of teachers cluster with the core K–12 teachers, including postsecondary teachers. Here, however, kindergarten and preschool teachers also cluster with this group, illustrating the effect of the within-occupation standardization in keeping together occupations with the same profile but different absolute levels of GWA or BCFS. Again, the counselor, psychologist, and social worker titles cluster with the core teacher titles, as do many occupational titles from the health professions. Here, however, dentists are not clustered with teachers, and optometrists are found only in one set of clusters. Some not obviously similar occupational titles continue to be present, including anthropologist, public relations specialist, psychiatrist, and—using Method 6—medical scientist, management analyst, and lawyer.

I tried several more variations of hierarchical agglomerative clustering using different linkage methods, but the results were generally similar to those discussed above. Overall, these results suggest that, based on these two O*NET dimensions (BCFS and GWA), the occupational groups that are most similar to K–12 teachers include other types of teachers, including college teachers; social workers; counselors and psychologists; and health care providers except doctors. It is also interesting to note some of the occupations that do not cluster with K–12 teaching based on the two O*NET dimensions. Though salary comparisons have been made with engineers, information technology specialists, and accountants, these analyses suggest these occupational groups have little relative content similarity with K–12 teachers.

Similarities as Defined by Euclidian Distances Without Clustering

One problem with using hierarchical clustering for assessing similarities among occupations is that methods like average linkage can fail to group objects as expected. While the initial clustering combines single occupations, subsequent clustering is essentially based on the distance between clusters. Intercluster distances are calculated using all of the occupations in the cluster. If similar occupations are initially assigned to different clusters and the other members are more distant, these occupations may not be joined in a common cluster until quite late in the process. Conversely, occupations at “opposite edges” of two clusters may be joined into one cluster based on the average distance between all the other members, even though the distance

between them may be greater. And since hierarchical clustering methods do not reassess each set of similarities between individual occupations after each joining, clustering at a prior stage cannot be subsequently undone. These effects are illustrated in some of the results reported in Table 4. In that table, kindergarten and preschool teachers do not cluster with K–12 teachers until quite late in the process, because they are initially more similar to a few nonteacher occupational groups and initial clustering with these prevents their joining the core teacher groups. Another apparent oddity is the inclusion of psychiatry with teaching in the results shown in Table 5. It may be that this occupation is on the "outer edge" of the cluster including psychology and counseling, but because of the similarity of those occupations to teaching, it is brought along into the same cluster. The inclusion of anesthesiologists in Table 4, Method 2, is another potential example.

There are nonhierarchical clustering methods that can avoid these effects, such as those based on the *k*-means approach or kernel density estimation (Everitt et al., 2001). However, these methods require either an a priori decision on how many clusters are to be found (*k*-means) or the choice of the kernel radius or number of nearest neighbors in the kernel (kernel density). These decisions can be somewhat arbitrary, and analysis appears to proceed on a cut-and-try basis until a subjectively satisfactory solution is reached (Khattree & Naik, 2000, chap. 6). A simpler approach to assessing the relative similarity of other occupations to K–12 teaching is to use the Euclidian distances between these occupations as a multidimensional index of similarity, without partitioning the occupations into a set of mutually exclusive groups. Occupations can then be ordered by their Euclidian distance from teaching, and the ordered list can represent the continuum of similarity from most to least similar.

To check on whether the hierarchical clustering process was including some dissimilar occupations and excluding some similar ones, I calculated the Euclidian distances between the 350 Job Zone 4 and 5 occupational titles and the core teacher titles in such a way as to allow comparison with the groups identified by Clustering Methods 3 and 6. First, the BCFS and GWA ratings were averaged across the core teacher titles. These averages were added to the data matrix, and the ratings of the separate titles deleted. A principal components analysis was performed, and principal component scores were calculated using (a) the first 10 principal components, as in Method 3, and (b) the first 16 principal components for the within-occupation standardized data, as in Method 6. Euclidian distances were calculated based on these component scores, and the occupations were ordered by their distance from the core teacher title average. The closest 20% of the occupations are listed in Table 6. The occupations shown in the first column can be compared with those shown for Method 3 in Table 4, while those shown in the second column can be compared with the occupations shown for Method 6 in Table 5. (The 20% cutoff was used to make sure that the list would include about as many occupations as cluster with teaching in the final clusters represented in Tables 4 and 5.)

Comparison of the relevant columns suggests that the cluster analysis groupings represent the similarities as measured by the Euclidian distances fairly well. Almost all of the occupations in the final clusters are found in the comparable ordered distance lists of Table 6. The psychologist, social worker, and counselor titles are represented as fairly close to the core teacher titles, as are the postsecondary teacher titles and many health care titles. Some of the less expected occupational titles from the cluster analysis groups are also found in Table 6, such as psychiatrist, optometrist, anthropologist, and lawyer. The similarities between the core teacher

average and kindergarten and preschool teachers are better represented by the simple ordering of distances in Table 6 than by the cluster analysis results in Table 4. However, there are some occupational groups within the closest 20% that were not found in the cluster analysis groups and that are not intuitively that similar to teachers, such as dancers, audio and video equipment technicians, and coroners. This suggests that further refinement of the input data (the domains and dimensions used to describe the occupations) might be more useful in defining plausible comparison groups than refinements of the clustering technique.

5. Some Illustrative Pay Comparisons

I used the final clusters from each method represented in Tables 4 and 5 to make some pay comparisons between K–12 teaching and other occupations, simply to illustrate the use of these comparison groups and to see how sensitive pay comparisons would be to differences in occupations included by the different clustering methods. Pay data was taken from the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) survey, which reports average and median annual wages for 700 occupations using the same standard occupational codes used in O*NET. Data was downloaded from the BLS Web site for three years (1999, 2000, and 2001). The OES program estimates wages based on surveys of a representative national sample of establishments, and combines 3 years of data to produce an estimate for each year. Wage data from 1999 and 2000 were updated to 2001 levels by multiplying them by the Employment Cost Index. To further smooth out annual fluctuations, the weighted average of the 1999, 2000, and 2001 annual mean wage estimates was calculated for each occupation in the final clusters, using the BLS estimate of the number of employees in that occupation for each year. To produce a cluster average (not including K–12 teacher titles), these weighted averages were further combined by weighting each occupation's average by the estimated number of employees in that occupation. Wage information was available for almost all of the O*NET occupations in the various comparison groups. For a few occupations, the OES data did not break out titles as finely as O*NET, so the wage data for the OES code one level up had to be used. For two others, no wage data for the O*NET occupation was available, and these had to be left out of the comparison.

Table 7 shows (a) the 3-year weighted average OES annual wage for selected comparison groups from Tables 4 and 5 and (b) the weighted average of the K–12 teacher titles. The substantial differences in comparison group averages in Table 7 suggest that which occupations are included in the groups makes a substantial difference, even though most of the occupations are included in all six comparison groups. The groups based on Methods 2 and 6 have higher averages, in part because they include some high-paid professionals perhaps not often compared with K–12 teachers: anesthesiologists in the Method 2 group and lawyers in the Method 6 group.

These comparisons suggest that the average K–12 teacher pay level is not too far from the average of the occupations in the comparison groups. However, the comparisons are meant to be illustrative, not definitive. Since there is no completely objective way to determine the true number of clusters (or the level of agglomeration at which to stop clustering), some may prefer clusters that include more or fewer occupations. Stopping the clustering process earlier than was done here would have eliminated some questionable comparisons, especially in the groups identified by Methods 2 and 6. There is also room for argument as to whether multiplying the OES average for the K–12 teacher occupations by 12/10 as I have done results in the best

representation of the annual value of teacher salaries. While it seems appropriate to account for the value of time not worked over the summer, it may not be realistic to use the monthly wage from the school year to value that time for all teachers; some may not value the non-work time at that rate, preferring to work during the summer months to obtain higher annual earnings, while others may be doing some preparation for the next school year during the period.

6. Implications, Limitations, and Directions for Further Research

Though it has not been possible to produce definitive comparison groups, the analyses presented here do suggest some interesting implications for teacher pay comparison. First, elementary, middle, and high school teaching appears to require about as high a BCFS level, and to require performance of many GWA at about the same level of complexity, as the average bachelor's degree–requiring occupation. This result supports the practice of comparing teaching to other occupations requiring at least a bachelor's degree, and especially to the average for such occupations.

Second, the results suggest that three occupational groups in particular may be good comparisons for K–12 teachers: (a) counselors, psychologists, and social workers; (b) postsecondary teachers; and (c) health care professionals. While it may seem obvious that counselors and social workers are reasonable comparisons, it may be somewhat surprising that health care professionals such as registered nurses, physical therapists, occupational therapists, and audiologists appeared consistently in the comparison groups. Taking postsecondary teachers as a comparison group may also seem unusual, because the discussion about K–12 teacher pay tends not to mention this group. While it is clear that the educational requirements are generally higher for postsecondary teaching, it may still be useful to track the relationship between K–12 teaching salaries and the salaries of postsecondary teachers. Goldhaber and Player (2003) showed that a considerable proportion of those leaving high school teaching moved into postsecondary teaching. The results reported here also suggest that it may not be useful to compare salaries for K–12 teaching as a whole with those for occupations such as engineering, accounting, and information technology, which are not found in the comparison groups. (Of course, these comparisons may still be relevant for specific teaching specialties.)

Third, these results remind us that teachers' jobs are multidimensional. They have similarities with a number of occupations outside the "helping professions." O*NET ratings bring out some aspects of the occupations not ordinarily emphasized. That teacher occupations are rated higher than average on skills like *learning strategies*, *monitoring*, and *operations analysis*, and activities like *judging qualities of things, services, and people*, *thinking creatively*, and *developing objectives and strategies* suggests an analytic dimension to the profession that may often be overlooked by analysts and pundits within and outside the education policy community.

Limitations

Hopefully, it is clear that the results presented above are a first attempt to develop comparison groups based on job content. These analyses have only scratched the surface of what could and should be done. Several limitations need to be kept in mind. As mentioned above,

because of the somewhat subjective nature of the decision as to the number of clusters at which to stop agglomerating, the exact content of any comparison group is open to revision, though the appearance of some occupations in many variations of the analysis does support their inclusion in any comparison group based on the O*NET domains used. A second limitation is the use of only two O*NET domains. Though these may be the most economical representations of job content, they may not represent all the attributes that we intuitively believe characterize teaching and that we know help determine pay levels. O*NET is not as useful as it might be in representing all pay determinants. We know that lengthy academic training, such as in law or medicine, leads to higher earnings. Ideally, we would like to have a measure of years of training required, but this is not available in O*NET 3.1. The job zone rating is too crude to be of much use. The O*NET knowledge domain is not helpful because it focuses on the subject of knowledge (e.g., chemistry versus accounting) rather than the depth of knowledge; including it might be misleading because most dimensions would not apply to most jobs, and the consequent low ratings could produce similarity estimates based mostly on what occupations *do not* require.

A third limitation is that the O*NET ratings used here were not derived from data obtained from current job incumbents. The analyses relied on the accuracy of the older job content information used by O*NET occupational analysts to prepare the 3.1 database and the accuracy of their judgments as they translated that information into O*NET ratings. Though developmental research reported in various chapters of the book edited by Peterson, Mumford, Borman, et al. (1999) shows between-analyst reliabilities typically in the low .90s, it also shows that analysts tended to rate lower than incumbents. This concern will be addressed when the O*NET 5 database is released, because it will have incorporated incumbent ratings into the dimension scales.

Future Research

Three major directions for future research seem attractive. First, an alternative grouping strategy needs to be tried. Perhaps the grouping should be based more heavily on the dimensions on which teachers differ most from the average occupation. That is, a comparison group could be constructed that includes those occupations that involve a similar level of those skills and work activities that are especially important to teaching. This would be truer to the way human resources professionals look at knowledge, skills, and abilities (KSAs) in setting hiring standards. Generally, they determine the key or most important KSAs needed, assess job applicants' KSA levels, and hire those with acceptable levels. This could be done based on the 8 BCFS and 11 GWA for which teachers are rated substantially above the average of the other Job Zone 4 and 5 occupations. These could be taken as the critical skills of teachers, and occupations in which incumbents have the same level of these critical skills could be used as the comparison group for K–12 teachers.

Second, it would be interesting to add an additional O*NET domain to the group of dimensions used to form comparison groups. For example, adding dimensions from the *work context* domain, which covers interpersonal relationships and physical and mental working conditions, might provide better coverage of the important job characteristics that we intuitively think of as differentiating teaching from other occupations. It may be possible to eliminate some of the rather unlikely occupational titles identified as comparisons above, such as epidemiologist and management analyst.

Third, it would be interesting to see if some of the implications of the above groupings could be supported by empirical studies of the teacher labor market. For example, following Goldhaber and Player's (2003) lead, it may be possible to see if teachers who leave teaching tend to move into the occupations identified as comparable. Though few teachers are likely to become anesthesiologists, finding that a significant number move into social work, counseling, or health care would support the appropriateness of these occupations. So would evidence that people leaving these occupations move into teaching more than into some other occupations. Another empirical test might be to see whether college students who abandon majors in teaching tend to move to majors related to the occupations identified as comparable more often than they move to other majors.

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Appendix

Figure 1
Teacher BCFS Ratings Compared to Mean for Occupations in Job Zones 4 and 5

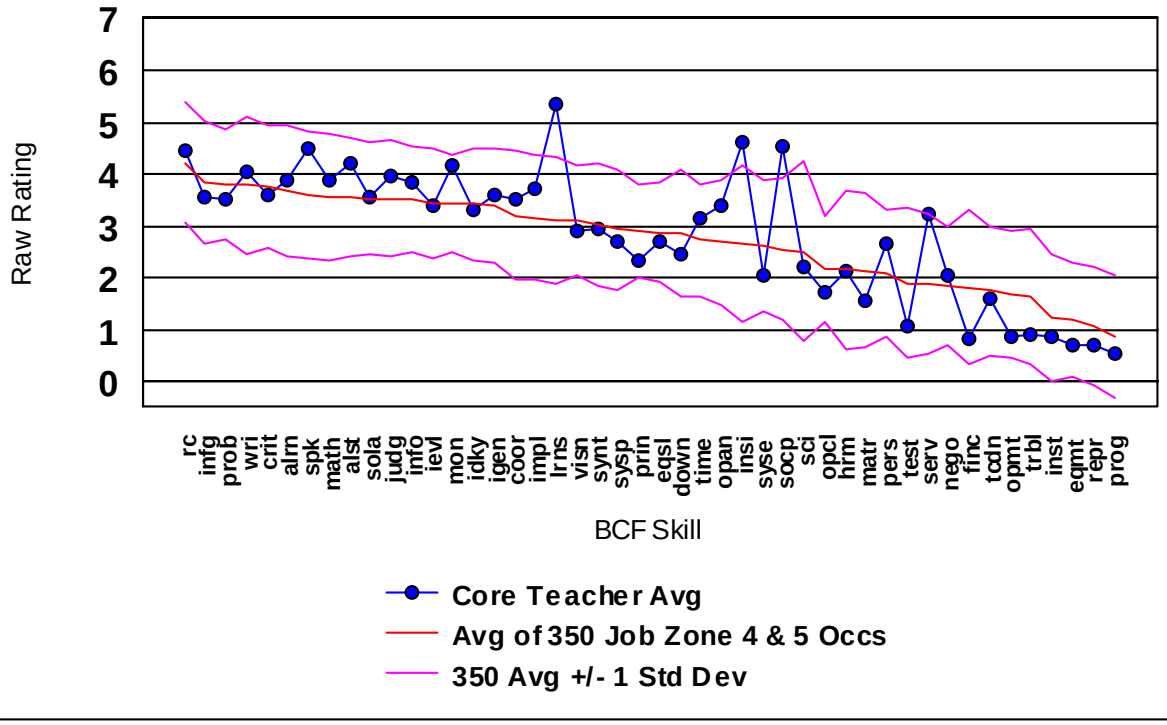

Figure 2
Teacher GWA Profile Compared to Mean of Occupations in Job Zones 4 and 5

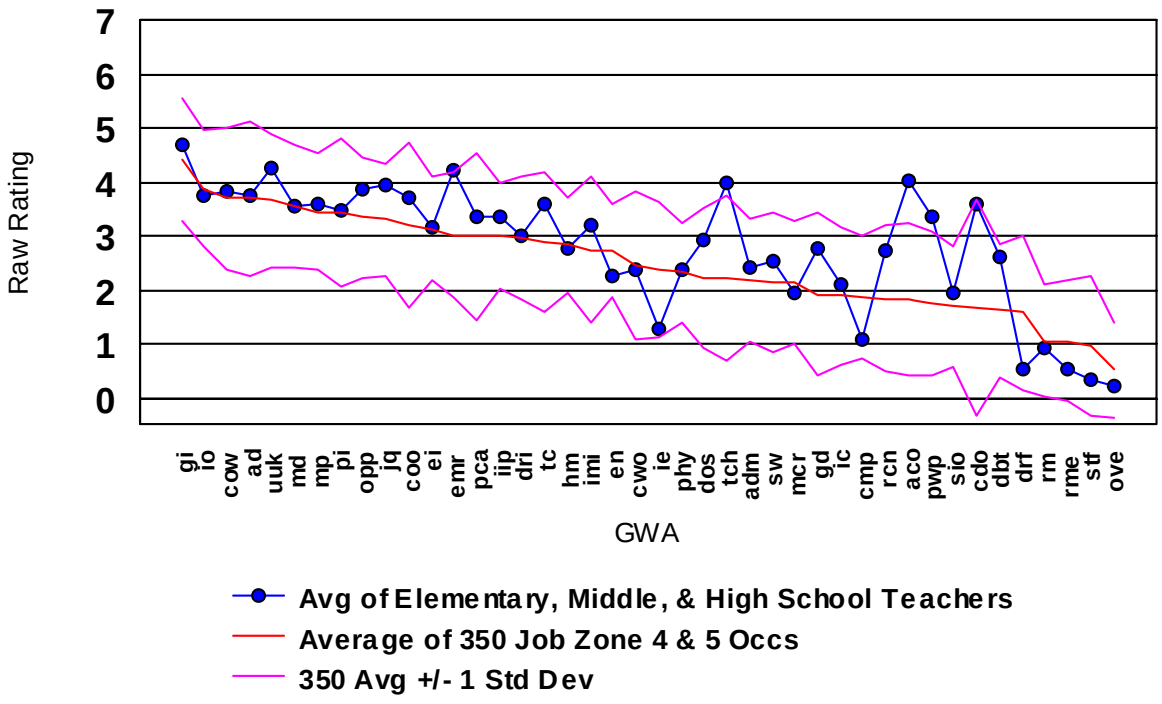

Table 1
O*NET Basic and Cross-Functional Skills (BCFS) and Generalized Work Activities (GWA)

BCFS	GWA
Reading comprehension	Getting information needed to do the job
Active listening	Identifying objects, actions, and events
Writing	Monitoring processes, material, surroundings
Speaking	Inspecting equipment, structures, material
Mathematics	Estimating needed characteristics
Science	Judging qualities of things, services, people
Critical thinking	Evaluating information against standards
Active learning	Processing information
Learning strategies	Analyzing data or information
Monitoring	Making decisions and solving problems
Social perceptiveness	Thinking creatively
Coordination	Updating and using job-relevant knowledge
Persuasion	Developing objectives and strategies
Negotiation	Scheduling work and activities
Instructing	Organizing, planning, and prioritizing
Service orientation	Performing general physical activities
Problem identification	Handling and moving objects
Information gathering	Controlling machines and processes
Synthesis/reorganization	Interacting with computers
Idea generation	Operating vehicles or equipment
Idea evaluation	Drafting and specifying technical devices, etc.
Implementation planning	Implementing ideas, programs, etc.
Solution appraisal	Repairing and maintaining electrical equipment
Operations analysis	Documenting/recording information
Technology design	Interpreting meaning of information to others
Equipment selection	Communicating with other workers
Installation	Communicating with persons outside organization
Programming	Establishing and maintaining relationships
Testing	Assisting and caring for others
Operation monitoring	Selling or influencing others
Operation and control	Resolving conflict, negotiating with others
Product inspection	Performing for/working with public
Equipment maintenance	Coordinating work and activities of others
Troubleshooting	Developing and building teams
Repairing	Teaching others
Visioning	Guiding, directing, and motivating subordinates
Systems perception	Coaching and developing others
Identifying downstream consequences	Providing consultation and advice to others
Identification of key causes	Performing administrative activities
Judgment and decision making	Staffing organizational units
Systems evaluation	Monitoring and controlling resources
Time management	
Management of financial resources	
Management of material resources	
Management of personnel resources	

Table 2
Correlations Between Teacher BCFS and GWA Ratings and the Average Rating for All Occupations in Job Zones 4 and 5

Teacher title	Correlation of BCFS ratings	Correlation of GWA ratings
Elementary teacher	.82	.74
Middle/high school teacher	.81	.79
Special education teacher	.81	.77
Kindergarten teacher	.76	.70

Table 3
BCFS and GWA for Which the Core Teacher Average Is More Than One-Half Standard Deviation Above or Below 350-Occupation Average

BCFS	GWA
Higher	**Higher**
Social perceptiveness Instructing Learning strategies Service orientation Speaking Active listening Monitoring Operations analysis	Teaching others Establishing and maintaining relationships Assisting/caring for others Performing for/working with the public Judging qualities of things, services, people Thinking creatively Developing objectives and strategies Coaching and developing others Guiding, directing, monitoring subordinates Developing and building teams Resolving conflicts/negotiating
Lower	**Lower**
Operations monitoring Product inspection Testing Troubleshooting Management of finances	Drafting and specifying technical devices Inspecting equipment Controlling machines and processes Staffing organizational units Estimating needed characteristics

Table 4

Groupings of Occupational Titles Based on Hierarchical Cluster Analysis Using BCFS and GWA

	Method 1 **BCFS only**	**Method 2** **BCFS and GWA**	**Method 3** **BCFS and GWA, 10 principal components**
Core teacher cluster	Middle school and high school teacher Elementary teacher Special education teacher	Middle school and high school teacher Elementary teacher Special education teacher	Middle school and high school teacher Special education teacher
First cluster added	Adult literacy teacher Occupational therapist Park naturalist Self-enrichment teacher Vocational teacher, postsecondary	Optometrist	Health educator
Second cluster added	Dietetic technician Health educator Training and development manager	Health educator	Optometrist
Third cluster added	Audiologist Medical technologist Nursing instructor Pharmacist Physical therapist Registered nurse Speech pathologist	Adult literacy teacher Self-enrichment teacher Vocational teachers, postsecondary Occupational therapist	Adult literacy teacher Elementary school teacher Occupational therapist Self-enrichment teacher Vocational teacher, postsecondary
Fourth cluster added	Clinical and counseling psychologist Educational, vocational, and school counselor Fire investigator Recreational therapist Child, family, and school social worker	College teacher (15 titles)	Dietetic technician Farm and home management advisor Recreational therapist
Fifth cluster added	Physician assistant Dentist Oral surgeon Optometrist Orthodontist Prosthodontist	Educational psychologist Clinical and counseling psychologist Educational, vocational and school counselor Child, family, and school social worker	Child, family and school social worker Clinical and counseling psychologist Educational psychologist Educational, vocational and school counselor

Identifying Occupations for Compensation Comparisons with K-12 Teaching

	Method 1 **BCFS only**	**Method 2** **BCFS and GWA**	**Method 3** **BCFS and GWA, 10 principal components**
Sixth cluster added	Anthropologist College teacher (16 titles) Technical writer Veterinarian	Dietetic technician Dietician and nutritionist Director of religious education Farm and home management advisor Medical and public health social worker Mental health and substance abuse social worker Mental health counselor Public relations specialist Substance abuse and behavioral disorder counselor	Anthropologist Atmospheric and space scientist College teacher (15 titles) Technical writer
Seventh cluster added		Recreational therapist	Dietician and nutritionist Director of religious education Medical and public health social worker Mental health and substance abuse social worker Mental health counselor Public relations specialist Substance abuse and behavioral disorder counselor Training and development specialist
Eighth cluster added		Audiologist Industrial psychologist Instructional coordinator Management analyst Speech pathologist	Audiologist Fire prevention engineer Medical technologist Nursing instructor Orthodontist Pharmacist Physical therapist Registered nurse Speech pathologist
Ninth cluster added		Anesthesiologists, Medical technologist Nursing instructor Pharmacist Physical therapist Registered nurse	

	Method 1 **BCFS only**	**Method 2** **BCFS and GWA**	**Method 3** **BCFS and GWA, 10 principal components**
Tenth cluster added		Chiropractor Dentist Oral surgeon Orthodontist Physician assistant Podiatrist Prosthodontist	

Table 5

Groupings of Occupational Titles Based on Hierarchical Cluster Analysis Using BCFS and GWA: Within-Occupation Standardization

	Method 4 **BCFS only**	**Method 5** **BCFS and GWA**	**Method 6** **BCFS and GWA, 16 principal components**
Core teacher cluster	Elementary teacher Middle and high school teacher, academic and vocational	Elementary teacher Middle and high school teacher, academic and vocational Special education teacher	Elementary teacher Middle and high school teacher, academic and vocational Special education teacher
First cluster added	Special education teacher Kindergarten teacher Preschool teacher Recreational therapist	Adult literacy teacher Self-enrichment teacher Vocational teacher, postsecondary	Adult literacy teacher Self-enrichment teacher Vocational teacher, postsecondary
Second cluster added	Nursing instructor, postsecondary Registered nurse	Anthropologist Audiologist College teacher (19 titles) Speech pathologist	Nursing instructor Physical therapist Registered nurse
Third cluster added	Adult literacy teacher Occupational therapist Self-enrichment teacher Vocational teacher, postsecondary	Nursing instructor Physical therapist Registered nurse	Kindergarten teacher Preschool teacher Recreational therapist
Fourth cluster added	Anthropologist Audiologist College teacher (19 titles) Dietetic technician Speech pathologist Technical writer Veterinarian	Occupational therapist	Dietetic technician Dietician and nutritionist Audiologist Speech pathologist

Identifying Occupations for Compensation Comparisons with K-12 Teaching

	Method 4 **BCFS only**	**Method 5** **BCFS and GWA**	**Method 6** **BCFS and GWA, 16 principal components**
Fifth cluster added	Child, family and school social worker Clinical and counseling psychologist Dieticians and nutritionist Educational psychologist Educational, vocational and school counselor Epidemiologist Farm and home management advisor Health educator Instructional coordinator Medical scientists except epidemiologist Mental health counselor Management analyst Psychiatrist Public relations specialist Substance abuse/behavioral disorder counselor Training and development manager	Kindergarten teacher Preschool teacher Recreational therapist	Occupational therapist Optometrist
Sixth cluster added		Child, family and school social worker Clinical and counseling psychologist Dietetic technician Dietician and nutritionist Educational psychologist Educational, vocational and school counselor Farm and home management advisor Health educator Medical and public health social worker Mental health and substance abuse social worker Mental health counselor Substance abuse/behavioral disorder counselor Psychiatrist Public relations specialist	Anthropologist College teacher (19 titles)

Identifying Occupations for Compensation Comparisons with K-12 Teaching

	Method 4 **BCFS only**	**Method 5** **BCFS and GWA**	**Method 6** **BCFS and GWA, 16 principal components**
Seventh cluster added			Child, family and school social worker Clinical and counseling psychologist Educational psychologist Educational, vocational and school counselor Equal employment opportunity representatives and officer Farm and home management advisor Health educator Lawyer Medical and public health social worker Mental health and substance abuse social worker Mental health counselor Substance abuse and behavioral disorder counselor Psychiatrist Public relations specialist

Table 6
Occupational Titles in Job Zones 4 and 5 by Distance from Core Teacher Titles: Closest 20%

Based on first 10 principal components of BCFS and GWA: Cross-occupation standardized	Based on first 16 principal components of BCFS and GWA: Within-occupation standardized
Vocational teacher, postsecondary	Adult literacy and remedial teachers
Occupational therapist	Self-enrichment education teacher
Health educator	Vocational teacher, postsecondary
Optometrist	Nursing instructor, postsecondary
Adult literacy and remedial teacher	English language and literature teacher, postsecondary
Self-enrichment education teacher	Foreign language teacher, postsecondary
Physical therapist	Kindergarten teacher
English language and literature teacher, postsecondary	Health specialties teacher, postsecondary
Foreign language and literature teacher, postsecondary	Art, drama, and music teacher, postsecondary
Librarian	Physical therapist
Art, drama, and music teacher, postsecondary	Educational, vocational, and school counselor
Educational, vocational, and school counselor	Clinical psychologist
Archivist	Chemistry teacher, postsecondary
Clinical psychologist	Anthropology and archeology teacher, postsecondary
Anthropology and archeology teacher, postsecondary	Area, ethnic, and cultural studies teacher, postsecondary
Area, ethnic, and cultural studies teacher, postsecondary	Social science teacher, postsecondary (5 titles)
Social science teacher, postsecondary (5 titles)	Recreational therapist
Recreational therapist	Health educator
Dietetic technician	Speech-language pathologist
Registered nurse	Audiologist
Farm and home management advisor	Occupational therapist
Police detective	Physics teacher, postsecondary
Preschool teacher	Dietetic technician
Audiologist	Preschool teacher
Speech-language pathologist	Mathematical science teacher, postsecondary
Mathematical science teacher, postsecondary	Agricultural sciences teacher, postsecondary
Park naturalist	Biological science teacher, postsecondary
Counseling psychologist	Forestry and conservation teacher, postsecondary
Historian	Counseling psychologist
Director, religious activities and education	Child, family, and school social worker
Kindergarten teacher	Optometrist
Child, family, and school social worker	Registered nurse
Physician assistant	Instructional coordinator
Criminal investigator and special agent	Veterinarian
Agricultural sciences teacher, postsecondary	Educational psychologist
Biological science teacher, postsecondary	Dietitians and nutritionist
Forestry and conservation teacher, postsecondary	Farm and home management advisor
Health specialties teacher, postsecondary	Computer science teacher, postsecondary
Public relations specialist	Psychiatrist
Dietitians and nutritionist	Engineering teacher, postsecondary
Dentist	Substance abuses and behavioral disorder counselor
Technical writer	Mental health counselor
Orthodontist	Medical and public health social worker
Medical and clinical lab technologist	Mental health and substance abuse social worker
Pharmacist	Choreographer
Educational psychologist	Director, religious activities and education
Fire protection and prevention engineer	Anthropologist
Law clerk	Social and community services manager
Audio-visual collections specialist	Epidemiologist
Audio and video equipment technician	Medical scientist except epidemiologist

Identifying Occupations for Compensation Comparisons with K-12 Teaching

Based on first 10 principal components of BCFS and GWA: Cross-occupation standardized	**Based on first 16 principal components of BCFS and GWA: Within-occupation standardized**
Film and video editor	Lawyer
Anthropologist	Physician assistant
Nursing instructor and teacher, postsecondary	Broadcast news analyst
Training and development specialist	Podiatrist
Reporters and correspondent	Audio-visual collections specialist
Instructional coordinator	Audio and video equipment technician
Music director	Training and development manager
Substance abuses and behavioral disorder counselor	Public relations specialist
Mental health counselor	Athletic trainer
Medical and public health social worker	Dancer
Mental health and substance abuse social worker	Technical writer
Coroner	Park naturalist
Coaches and scout	Training and development specialist
Broadcast news analyst	Poets and lyricist

Table 7
3-Year Weighted Average OES Annual Wage for Comparison Groups

Comparison group	3-year weighted average annual wage
Method 1 – BCFS	$41,329[a]
Method 2 – BCFS and GWA	$48,464
Method 3 – BCFS and GWA, principal components	$42,657
Method 4 – BCFS	$42,619[a]
Method 5 – BCFS and GWA	$45,105
Method 6 – BCFS and GWA, principal components	$49,871[b]
K–12 teachers	$42,194
K–12 teachers, adjusted to 12 months[c]	$50,513

[a]OES wage data not available for one occupational title—training and development manager. [b]OES wage data not available for one occupational title—equal employment opportunity rep and officer. [c]OES weighted average annual wage multiplied by 12/10.