1. When we refer to PCA transform without reducing the dimension (i.e. the number of features does not change), it's by convention a (de-correlating) rotation of the data computed by:

$$X_{pca} = E^T X$$

So that the data points will be decorrelated after the rotation. The covariance matrix of X_{pca} only has diagonal entries non-zero.

2. When we refer to PCA transform without reducing the dimension with whitening, it's one extra step:

$$X_{pca-whitened} = diag(1/sqrt(L))E^T X$$

Where L is the eigenvalues. This will make sure the covariance matrix is not only a diagonal matrix but also an identity matrix.

3. When we refer to PCA transform with dimension down to k, the reducing-dimension transformation is

$$X_{k.pca} = E_k^T X$$

which gives you transformed data with reduced dimension. The basis vectors of the k-dim space are the eigenvectors. E_k is the first k eigenvectors (columns) in the matrix E, and they correspond to the k biggest eigenvalues.

But the PROJECTION is defined as:

$$X_{k.projected} = E_k E_k^T X$$

The transformation here is equivalent to projecting data points into a lower-dimensional (k-dim) space without changing the basis vectors (still using basis of the original space).