# Meta – Analysis Research: A Potential Choice for CTE Researchers and Consumers

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**Abstract**

*A search of the ERIC data base, Academic Search Premier, and a review of literature suggests that meta-analysis is ignored by career and technical education (CTE) researchers, a situation that is regrettable but remediable. The purpose of this paper was to provide CTE researchers and consumers with selected procedures and guidelines for conducting meta- analytic research. The highlights presented include an historical overview of meta-analysis, selected meta- analysis procedures, advantages of meta- analysis. The paper caution that CTE consumers and policy makers should be aware of some of the limitations associated with meta- analyses. A key assertion of the paper is that meta- analysis will be most valuable when it is used by those most knowledgeable about the substance of methodology in our field of career and technical education.*

## Introduction

The basis of scientific knowledge can be attributed to the accumulation of research. However, a single study can rarely provide a generalizable answer to research questions within the social sciences domain. Numerous methods have been proposed for cumulating results of research studies. Green and Hutchinson (1996), reported that some of these methods include the narrative review, counting statistically results, and various ways of averaging numerical outcome indices. Meta – analysis is one of the latter methods that is used to quantitatively synthesize research findings.

Grover (1993) stated that:

> Meta-analysis is a method by which one attempts to quantitatively integrate findings from several empirical research studies related to some way to a common general topic. The term was officially coined in 1976 by Gene V. Glass in his presidential address to the American Educational Research Association. (p.3)

According to Boston (2002), "given the growing demand for "evidenced – based research" to guide educational interventions, interest in the research technique of meta-analysis has surged" (p.1). Glass (1976) argues that "meta – analysis refers to the analysis of analyses. I use it to refer to the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p.3).

The use of meta – analytic methods in educational research has been wide spread since the mid - twentieth century (Stewart, 2002). In their meta – analysis study on "The Effects of Participating in Vocational Education," Gonzalo and Kapes (1982), noted that limitations were found in the methodology of the meta- evaluation, including inadequate conceptual framework. However, the use of meta-analysis is not extensively used in the field of career and technical education, as revealed from the review of literature. CTE research has burgeoned over last two decades; both the number of new journals and the proportion of research articles in them attest to this increase. It is important at this moment in the field to integrate findings—to clarify what it is we know and what it is we need to find out. Integration is essential for both CTE researchers and practitioners. It helps CTE researchers to direct future efforts and practitioners to identify teaching and management practices.

The purpose of this paper was to provide CTE researchers, editors, and readers with selected procedures and guidelines for conducting meta- analytic research.

The term meta – analysis is often used as a synonym for research synthesis, however in this paper, it was used to describe the procedures that CTE researchers may use to statistically combine the results of studies. The following objectives were formulated to describe the purpose of this paper:

1. To describe the history of Meta- analysis.
2. To describe selected Meta- analytic procedures.
3. To describe advantages and limitations of Meta – analysis.

## Historical Overview of Meta – Analysis

Although Glass was the first person to coin the term ‘meta – analysis” (as cited in (George, 2001), he was not the first person to discuss techniques for combing results. Early meta- analyses involved combing results from different agricultural science studies (Onwegbuzie & Leach, 2003). Early in the 20$^{th}$ century, researchers such as Karl Person, W. G. Cochran, and R. A. Fisher (as cited in George, 2001), reported that there was a need to consolidate literature in a given field.

Karl Person conducted what was considered the first meta- analysis in 1904 Pearson gathered data from over 10 studies pertaining to evidence on a vaccine against typhoid. For each study he calculated a statistic called correlation coefficient (Cooper, 2007). In 1932, Ronald Fisher, noted that (as cited in Cooper, 2007) “It sometimes happens that although few or [no statistical tests] can be claimed individually as significant, yet the aggregate gives an impression that the probabilities are lower than would have been obtained by chance” (p.3). Fisher was responsible for combining the p- values that were generated from statistically independent tests of the of the same hypotheses (Olkin, 1990). Cooper (2007) argues that these early procedures for combining results of independent studies were not thoroughly utilized.

Cooper (1989) reported that meta- analysis became popularized in the 1970s and 1980s. According to Onwuegbuzie and Leach (2003), “the technique of meta- analysis arose in the 1970s from concerns about imprecise characterization of findings from literature reviews” (p.5). The 1980s produced the appearance of several books primarily focusing on meta- analytic methods. The “Handbook of Research Synthesis” was published in 1994(Cooper & Hedges, 1994). The emphasis of this book was on rigorous research synthesis in the social and behavioral sciences.

**Description of Selected Meta-Analytic Procedures**

There are several elements of meta- analysis that should be addressed when conducting meta- analysis research. However, the purview of this section will focus on the following elements of meta- analysis – definition of the problem, identification of studies, effect size estimation, and homogeneity testing.

*Define the problem*: define the variables of interest both conceptually and operationally. This should be done so that relevant and irrelevant studies can be distinguished.

*Collect the research evidence:* Identify the total number of studies that have examined the relationship of interest. This can be done through databases such as ERIC and Academic Search Premier. A valid meta- analysis requires a representative survey of the research literature. A major problem that could occur when doing a literature search relates to the "file drawer problem" (Rosenthal, 1979). George (2001) reported that a common example of the "file drawer problem" include studies that are lost to the researcher in the process of doing a meta- analysis. L'Hommedieu, Menges, and Brinko (1988), noted that the studies that fall into the file drawer are the ones that do not show statistically significant differences among groups and subsequently are not accepted by peer reviewed journals. Other examples of "file drawer problem" are: unpublished research reports, research from other fields, dissertations, and master's theses.

*Effect Size Reporting*: After studies have been obtained and read, measures of effect size estimates of each finding should be calculated. The typical way of reporting meta- analytic results is by an index of effect size. Cohen (1969) described effect sizes as the "degree to which a certain phenomenon exists in a population" (p.9). Snyder and Lawson (1993) reported that, "effect sizes or magnitude of effects inform readers how much of the criterion variable can be controlled, predicted, or explained" (p.335). Researchers are encouraged to report their effect sizes (American Psychological Association, 2001; Gordon, 2001; Kotrlik & Williams, 2003, Warmbrod, 2001). According to Thompson (as cited in Moore, 1999), doing so, is more likely, to increase the chances that the research will be included in future meta- analytic studies.

Determination of an ideal or appropriate measure of effect size is based on the data, and statistical models used in studies selected in the meta – analysis (George, 2001). The major families of effect sizes commonly used in meta- analyses are *r* and *d*. The *r*, is symbolic of the Pearson product moment correlation; measures the relationship between between two variables. The *d*, was developed by Cohen (1988), hence the term, Cohen's *d*; measures the standardized difference between two means, and the unit for the size of difference is expressed in standard deviations (Quintana & Minami, 2006). Table 1 shows selected examples of effect size choices.

**Insert Table 1 about here**

Effect sizes are generally interpreted in the same way that z scores are interpreted. Cohen (1988) proposed the following descriptions: .20 is small; .50 is medium; and .80 is large. Quintana and Minami (2006), reported that the following metrics are recommended for continuous variables: *r, d, eta*, and *omega*. They also suggested the use of odds ratio for dichotomous variables. Hommedieu, et al (1988) noted that:

> Computing effect sizes from *F*- and *T* – values will usually yield a more conservative individual figure, however, due to reporting and publication biases that favor tests showing statistically differences, the overall mean effect size may be inflated when *T*- values are used. (p.128)

*Homogeneity Testing:* Moore (1999) argues that if commonalities exist among studies, it is appropriate to unite estimates of effect sizes. Moore (1999), noted that "a common problem arises when studies do not have a common population effect size. Combining estimates of effect sizes for these studies would result in deception" (p.13). Rosenthal and Rubin's study (as cited in Moore, 1999), provide a test to determine homogeneity of effect size. Onwuegbuzie and Leech (2003) proposed using the Q-statistic as a common statistical technique of testing for homogeneity of effect sizes.

## Advantages of Meta- Analysis

Sindelar and Wilson (1984, p.84) argued that meta – analysis appears to be superior when compared to traditional methods of summarizing literature (example the voting method) in several ways, such as: increased objectivity; freedom from arbitrary levels of statistical significance, and potential to relate independent variables to effect size. Wiersma (2000) noted that, “studies on the same research topic typically vary in measures, designs, and statistics used and meta- analysis provides a common base for comparing results” (p.372).

In the field of education, meta- analyses can be easily identified because of its ERIC descriptor. Meta- analyses also provide extensive reference lists that assist with the synthesis of results. The process of meta- analysis generally generates ample information pertaining characteristics of the study (Wiersma, 200). According to Gay, Mills, and Airasian (2006):

> A central characteristic that distinguishes meta- analysis from traditional approaches are the emphasis placed on making the review as inclusive as possible. Thus, reviewers are encouraged to include results typically excluded, such as those presented in dissertation reports and unpublished works. (p.55)

Kavale’s research on meta- analysis (as cited in Onwuegbuzie & Leech, 2003), revealed the following advantages of meta- analysis:

1. It uses quantitative – statistical methods for organizing and extracting information from large databases.

2. It eliminates study selection bias –no pre- judgments about research quality are made.
3. It makes use of all information—study findings are transformed to commensurable expressions of effect magnitude.
4. It detects interactions—study characteristics that may mediate findings are defined measured, and their covariation is studied.
5. It seeks general conclusions—practical simplicity that does not obscure an important interactive finding is sought. (pp. 11-12)

**Limitations of Meta- Analysis**

Although there are many benefits of meta- analysis, there are also some concerns and criticism to this technique. Several researchers (Chambers, 2004; George, 2001; McNeil & Newman, 1994), have documented disadvantages in conducting meta – analysis. One of the most common disadvantages is called the “apples and oranges” comparison. George (2001) suggests that this limitation involves the concept that, “meta- analysis is combing and comparing different independent variables and different dependent variables” (p.9). Some researchers (as cited in Chambers, 2004) suggest that, “aggregating results that use different research technique is inappropriate because they are too dissimilar” (p.36). McNeil and Newman (1994) argued that results should not be combined if there are significant differences. Chambers (2004) noted that it is fairly easy to rectify this limitation by the mechanism of coding for different techniques and conducting various tests to determine if outcomes are too dissimilar.

A second limitation is the use of data from poorly executed studies. Validity issues can be a major concern with poorly designed studies. George (2000) stated that, “one study might use measures that yield reliable and valid dependent variable scores, while another might select variable measures with scores that is unreliable or valid” (pp.9-10).

A third limitation is publication bias as to which articles get published. As noted earlier, Rosenthal (1979) described this limitation as the “file drawer problem.” Onwuegbuzie and Leech (2003) noted that with this limitation, “statistically non- significant findings are less likely to be retrieved, and thus less likely to be included in meta- analyses than are statistically significant findings” (p.13).

Another limitation is the use of multiple non- independent findings from the same study. Chambers (2004) recommends that, “it is important that one calculate effect sizes that are independent, so it is a common practice for researchers to use only one effect size for each study” (p.36). Wolf (1986) argued that separate meta- analyses should be conducted for different types of outcome variables.

## Summary and Concluding Remarks

Meta – analysis combines data from many studies into a single index. It enables researchers to summarize results of many studies on a particular question or problem. A central characteristic that distinguishes meta- analysis from more traditional approaches is the emphasis placed on making the review as inclusive as possible. “Meta- analysis is not done by including five or so studies; some include upwards of sixty to seventy studies" (Wiersma, 2000, p.374). The most widely used index is the average effect size. Effect size is a numerical way of expressing the strength or magnitude of a reported relationship. By using the effect sizes from numerous studies that share a hypothesis, a researcher can make a reasonable generalization in regards to relationship between variables. CTE researchers are strongly urged to report effect sizes in manuscript and tables when reporting statistical significance.

It is important that CTE consumers and policy makers know about some of methodological problems associated with meta-analyses. Meta- analysis will be most valuable when it is used by those knowledgeable about the substance of methodology of research in our field.

Kavale (2001) stated that:

> Future research is quiet likely to remain a generally unorganized, decentralized, and non- standardized process without regard to how it may fit together into a comprehensive whole. For this reason, we will likely continue to need research synthesis methods, such as meta- analysis, to make research findings believable. (p.182)

Although the theory of meta- analysis is complex, application of the method is relatively simple, particularly considering the benefits that can be derived from it. Researchers in CTE have generated much data over the years. Therefore, it is now time to apply meta – analysis to draw conclusions that will stand the test of time.

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Table 1

*Selected Examples of Effect Size Choices*

| Effect Size | Common Application | Formula |
|---|---|---|
| $R^2$ | regression | $SS_{EXPLAINED}/SS_{TOTAL}$ |
| Omega$^2$($\omega^2$) | *ANOVA* | $(SS_{BETWEEN} - (k - 1) \times MS_{WITHIN})/(SS_{TOTAL} + MS_{WITHIN})$, <br> Where *k* is the number of groups |
| Cohen's *d* | *t* or *ANOVA* | $(M_{EXPERIMENTAL} - M_{CONTROL})/SD_{POOLED}$ |