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Comparison of Academic Achievement between Online vs Traditional Homework: A Meta-Analysis

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Abstract

The purpose of this meta-analysis was to examine prior research that compared the differences between the academic performance of students who undertook online homework as against those that undertook traditional pen and pencil homework. Eighteen experimental and quasi-experimental studies met inclusion criteria for the meta-analysis. Eleven found online homework to produce better academic performance and seven found traditional pen and pencil homework to produce better academic performance. The Random-Effects model was used for this meta-analysis and the overall effect size was found to be 0.06 [-0.19, 0.32]. The comparison between academic performance from online homework as against traditional pen and pencil homework was not statistically significant from the published studies examined.

Key words*: Meta-analysis; traditional homework; online homework; academic achievement.*

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Introduction

The use of on-line teaching tools has grown to accommodate the distance education needs as well as the increasing student numbers. As a consequence of the closure of educational institutions, in Australia and across the globe imposed in response to the COVID 19 outbreak, online teaching and learning experienced an unprecedented increase in demand. However, as the COVID restrictions were removed not all teaching and learning returned to the traditional face to face method. One particular area of interest is the method of dealing with homework as this seems to have become an area that has found favour with the growing on-line approach to education, favoured by a high percentage of universities in Australia, due in no small way to the concern for efficiency of scale to deal with high student numbers.

Controversy has surrounded the contribution of homework to learning in the educational discipline for well over 75 years (Bas, Senturk & Cigerci, 2017; Cooper, Robinson & Patall, 2006; Corno, 2000; Trautwein, Köller, Schmitz & Baumert, 2002). The argument hinges on whether homework provides any real benefit to learning with research exploring possible modifying variables such learning styles, the type of material being studied as well as the age and experience of the students. There is also research that investigates the extent to which homework actually contributes to academic achievement. Within this area there is a body of work that explores the difference between on-line homework and traditional pen and paper on the academic achievements of students.

Literature Review

Certainly, the empirical studies which have examined the impact of homework on academic achievement of students has been fragmented due to the nature and extent of the variables being tested (Cooper, Robinson & Patall, 2006). The common problem was that the research generally compared attitude toward traditional homework versus online homework. The survey of student's personal opinion of the difference made did not provide any statistical analysis of the actual academic achievement – even though there may have been statistical analysis of the response rates (Cooper, Lindsay & Nye, 1998; Richards-Babb, Drelick, Henry & Robertson-Honecker, 2011). Bas, Senturk and Cigerci (2017) conducted a meta-analytic review of research which was broadly based on the effects of homework however what this overlooked was the examination of any differences between the traditional versus online homework. This variation in the literature suggests that there is a need to examine the impact in terms of online versus traditional homework and the academic achievements more carefully and in a way in which the results can be appropriately compared.

The purpose of this study therefore is to evaluate the results of prior research using meta-analysis to provide a comparative assessment.

Method

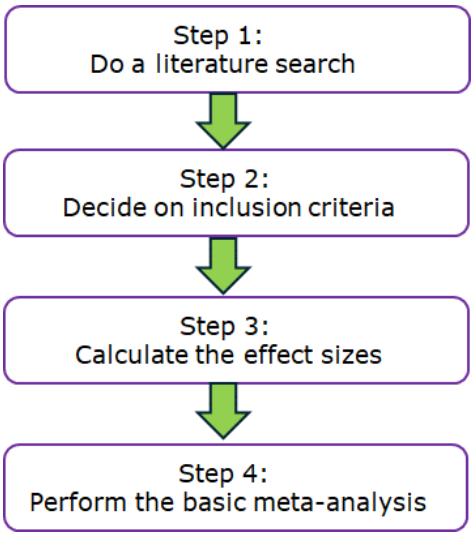
Research design

This study used the meta-analysis method proposed by Glass, McGaw and Smith (1981). Meta-analysis can be defined as a method of statistically analysing quantitative data obtained from many studies, which are independent from each other and reaching a general conclusion about their results (Glass, 1976; Hunter & Schmidt, 2004; Lipsey & Wilson, 2001). Meta-analysis can also be defined as the analysis of other analyses (Lyons, 2003). Meta-analytic procedures require a number of steps: (a) locating all possible studies, (b) coding the studies for salient features and calculating effect sizes,

and (c) carrying out statistical analyses of the effect sizes and interpreting the data acquired (Höffler & Leutner, 2007).

The software package JASP was used to conduct the meta-analysis. This is a free and open-source program designed to perform statistical analysis and is supported by the University of Amsterdam. The particular version of the package used was (JASP, 2024, Version 0.18.3). The formulation of effect sizes for the studies were ascertained using the readily available software applications provided by effect size calculator of Campbell Collaboration. [1]

Diagram 1.
Basic Steps in Conducting a Meta-Analysis



Source: Adapted from Field and Gillett, 2010

Data sources

The studies used in this meta-analysis were determined from examination of the literature derived from the search of the databases of ERIC, EBSCOhost, PROQuest, and Google Scholar. Initially this resulted in a large number of papers and these were examined carefully to determine the existence of data pertaining to the two types of homework (online versus traditional) and the measurement of academic achievement. For a study to be included in this research, certain criteria had to be met. Specifically, the study had to provide the relationship between the homework activity against a measure of academic achievement. The number of studies was subsequently reduced to eighteen that met these criteria and were subsequently used in the meta-analysis process the list of the studies is presented in Table 1.

[1] https://www.campbellcollaboration.org/escalc/html/EffectSizeCalculator-Home.php

Table 1.
List of Studies included in the Meta-Anlaysis

Number	Authors	Year
1	Kodippili & Senaratne	2008
2	EL Hajjaji & Ouardaoui	2017
3	Kirkham & Laing	2023
4	Bonham et al	2003
5	Richards-Babb et al	2011
6	Arora et al	2013
7	Dufresne et al 1	2002
8	Dufresne et al 2	2002
9	Dufresne et al 3	2002
10	Dufresne et al 4	2002
11	Dufresne et al 5	2002
12	Emerson et al	2011
13	Demirci 1	2006
14	Demirci 2	2007
15	Demirci 3	2006
16	Demirci 4	2007
17	Chua-Chow et al	2011
18	Palocsay et al	2008

Results

General characteristics of the studies

The general characteristics of the studies in relation with the effect of homework on students' academic achievement were as follows:

- the effect of homework on students' academic achievement was accounted for in the research;
- this was utilized to establish effect sizes, standard errors and variance;
- the studies in this meta-analysis specifically contained the effect of homework on students' academic achievement;
- all the studies were published academic journal articles.

Thirteen studies from the total 18 studies had positive effect sizes, whereas five studies had a negative effect size. Table 2 presents the number of students in each study that were in the categories online homework (OLH) and pen & pencil homework (PPH) otherwise known as the traditional homework method. A tick (✔) in the column OLH or PPH indicates which group was found to have the higher academic achievement. The final column of the table contains the effect size (ES) as calculate for each study.

Table 2.
General Characteristics of the Studies

#	Authors	Year	OLH	PPH	ES
1	Kodippili & Senaratne	2008	34 ✔	38	-0.0525
2	EL Hajjaji & Ouardaoui	2017	36 ✔	49	0.168
3	Kirkham & Laing	2023	171	140 ✔	0.7771
4	Bonham et al	2003	117 ✔	112	0.0752
5	Richards-Babb et al	2011	2587 ✔	3685	0.0439
6	Arora et al	2013	59 ✔	51	0.6588
7	Dufresne et al 1	2002	402 ✔	311	0.3269
8	Dufresne et al 2	2002	108	146 ✔	-0.1428
9	Dufresne et al 3	2002	162 ✔	159	0.3387
10	Dufresne et al 4	2002	515 ✔	181	0.4845
11	Dufresne et al 5	2002	400 ✔	181	0.7432
12	Emerson et al	2011	20	39 ✔	0.4847
13	Demirci 1	2006	41	37 ✔	-1.2162
14	Demirci 2	2007	48	46 ✔	-0.8669
15	Demirci 3	2006	48 ✔	42	0.2422
16	Demirci 4	2007	47	46 ✔	-0.7785
17	Chua-Chow et al	2011	621 ✔	580	0.2211
18	Palocsay et al	2008	72	27 ✔	-0.722

✔ indicates the group found to have the highest level of achievement in the particular study.

There are two models commonly used in meta-analysis the fixed effects model and the random effects model and each makes different assumptions relating to the observed differences among the studies.

- **Fixed effects model**: this assumes that all studies share a common true ES i.e. the data is homogeneous. All factors that could influence the ES are the same in all the study samples and therefore very little heterogeneity. Between-study differences are assumed to be due to chance and thus not incorporated into the model. Therefore, each study included in the meta-analysis is estimating the same population treatment effect, which, in theory, represents the true population treatment effect. Subsequently, more weight is given to studies with large samples sizes as they are assumed to provide more information.

- **Random effects model:** this assumes a distribution of the treatment effect for some populations. i.e. that the different studies are estimating different, yet related, intervention effects. Therefore, heterogeneity cannot be explained because it is due to chance. This model assigns a more balanced weighting between studies.

Classical Meta-Analysis

Table 3.
Residual Heterogeneity Estimates

		95% Confidence Interval	
	Estimate	**Lower**	**Upper**
τ^2	0.288	0.154	0.725
τ	0.537	0.393	0.852
I^2 (%)	97.443	95.320	98.967
H^2	39.105	21.369	96.821

As both the τ^2 and I^2 (%) show excess variance (heterogeneity) between the studies the use of a **random-effects model** is thus supported as the most appropriate for this meta-anlaysis. Accordingly, the Random-Effects model has been used to produce this meta-analysis (Restricted ML method).

Table 4.
Fixed and Random Effects and Coefficients

	Q	**df**	**p**
Omnibus test of Model Coefficients	0.232	1	0.630
Test of Residual Heterogeneity	239.201	17	< .001

Note. *p* -values are approximate.
Note. The model was estimated using Restricted ML method.

Coefficients

					95% Confidence Interval	
	Estimate	**Standard Error**	**z**	**p**	**Lower**	**Upper**
intercept	0.063	0.132	0.482	0.630	-0.195	0.321

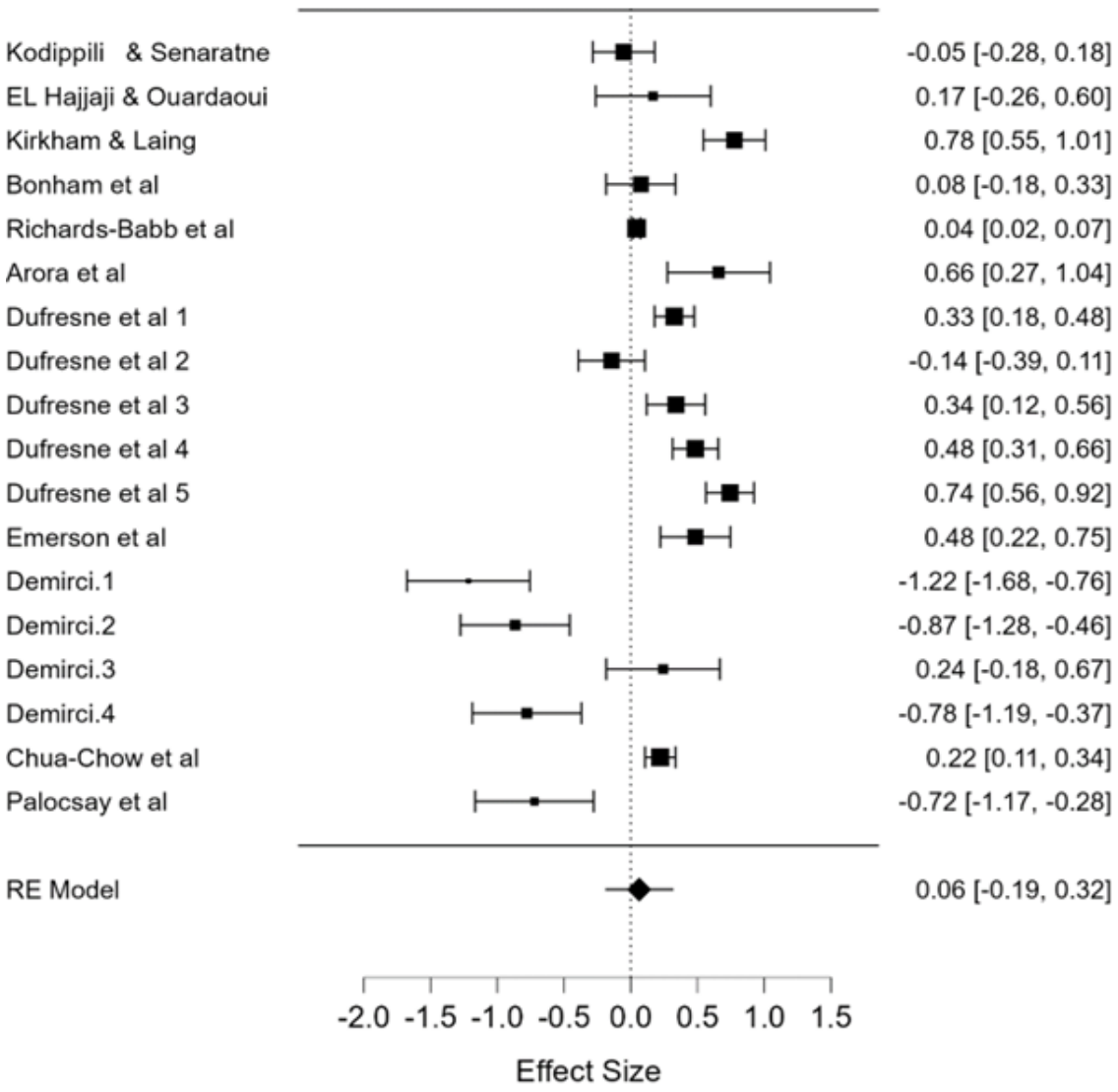
Note. Wald test.

The results or outcome of a meta-analysis is the forest plot which provides a graphical display of the statistical relationship of the effect sizes relative to a point of zero. The characteristics are typical considered as indicating the following:

- For confidence intervals entirely on the positive side of zero, these studies are considered to show a statistically significant positive effect.
- For confidence intervals entirely on the negative side of zero, these studies are considered to show a statistically significant negative effect.
- For confidence intervals that include zero, these studies are considered to show an effect that is not statistically significant.

The Forest plot presented in Diagram 2 shows the weighted effect sizes (the size of the squares reflects the weight of each study) and CIs used to determine the combined ES (diamond). In this instance the overall effects of the homework have a significant positive effect on academic achievement scores (ES = 0.09).

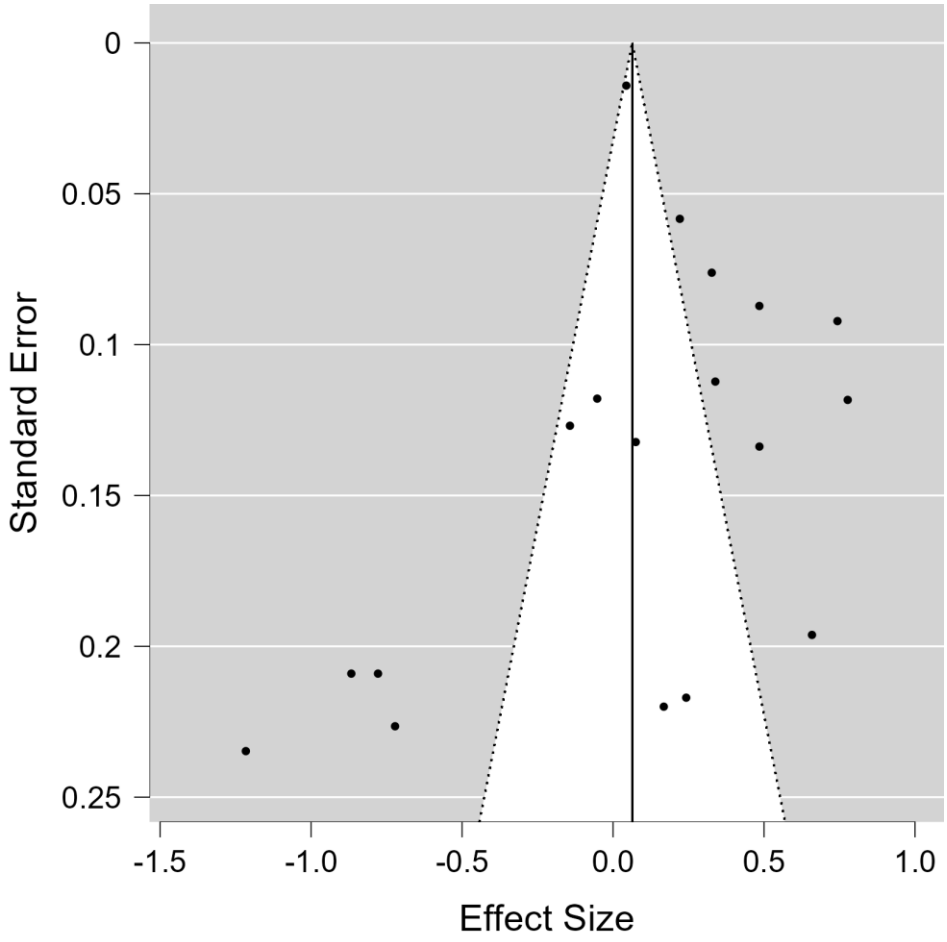
Diagram 2.
Forest Plot



The forest plot shows that the research results of the studies were contradictory or ambiguous. With some studies having statistically significant positive effects whilst others have statistically significant negative effects as well as studies that that are statistically not significant. To overcome this type of result the meta-analysis generates a combined effect or overall effect size (shown in Diagram 2 as the RE Model). The combined effects size is considered to be a more powerful significance test because it generates a more useful and more convincing result than a single study. The combined effect size generated by the meta-analysis shows a confidence interval that includes zero, and subsequently this is not statistically significant. The overall effect size being 0.06 [-0.19, 0.32].

The funnel plot presented in diagram 3 shows that the observed effects sizes appear not to be symmetrically distributed around the vertical axis (based on the overall effect size estimate, in this case, 0.06) and do not lie within the 95% confidence triangle. This is interpreted as indicating that the difference between two groups is negligible, even if it is statistically significant (Cohen, 1992).

Diagram 3.
Funnel Plot



Publication bias is concerned with the possibility that research studies reporting statistically significant results are more likely to be published than those that reported a statistically not significant result. This would potentially cause the combined effect size to be larger than it might otherwise be in reality. To address this issue the funnel plot is used as an indicator of publication bias. Asymmetry is often reported as being indicative of publication bias. This plot is accompanied by the 'Rank Correlation Test' for funnel plot asymmetry (Table 5) which in this case is not-significant (p=.069).

Table 5.
Rank Correlation Test

Rank correlation test for Funnel plot asymmetry		
	Kendall's τ	**p**
Rank test	-0.315	0.069

An examination of the left-right symmetry of the plot as depicted in Diagram 3 denotes that there is, in fact, a small sample bias.

Diagram 4.
Radial Plot

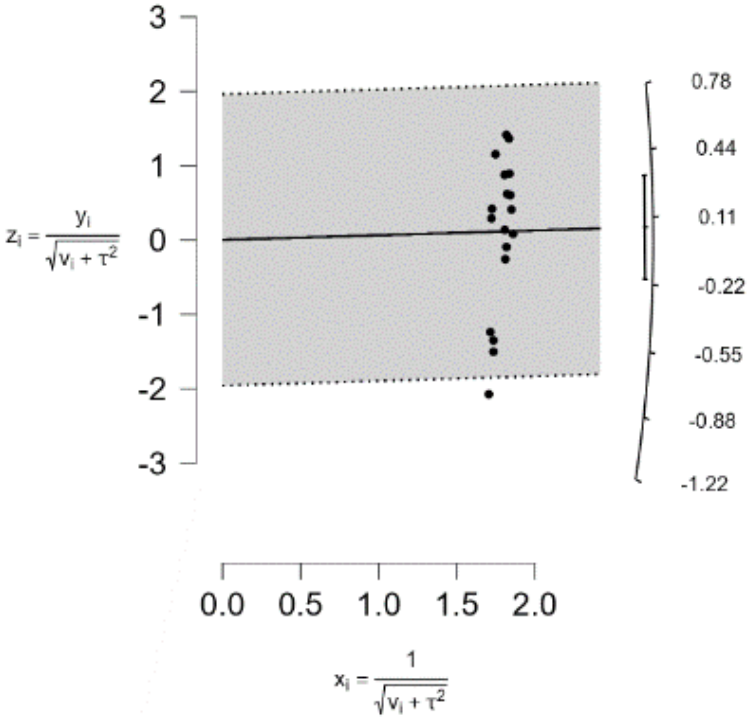


Diagram 5.
Normal Q-Q Plot

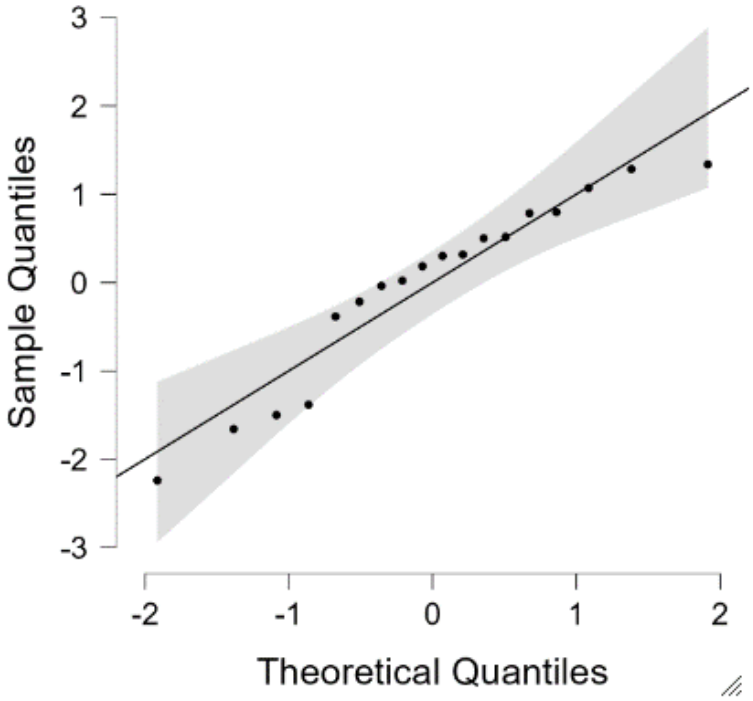
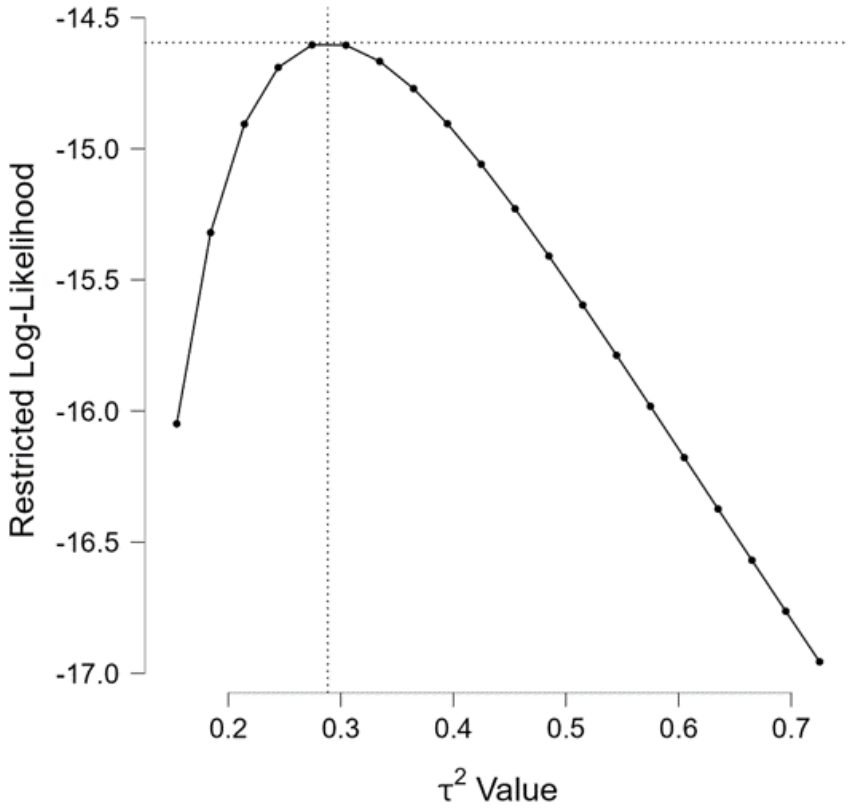


Diagram 6.

Log-Likelihood for τ^2 - Profile Plot for τ^2



Summary

With the overall effect size being 0.06 [-0.19, 0.32] the indication is that the difference between two groups is negligible. The analysis of the published studies shows that neither online homework nor traditional pen and pencil homework have sufficient differences to conclude that one method I superior to the other. Effectively, there was no real difference between Online Homework and Traditional pen and paper Homework when it comes to academic achievement.

The results of this study may lead to a paradigm shift in the way homework is pedagogically conceptualized in the higher education sector. Given the rather small number of studies this is an area that would benefit from greater attention and more diverse studies. Perhaps the suitability of the homework method OLH and PPH may need to be weighed against the student's personal learning style or cognitive preferences.

There may well be moderating variables that were not considered in some studies such as the academic level of the students in the groups. An academic level would normally be identified as being represented by Grade Point Average. Whilst some studies did have this variable whilst others did not and it is therefore an issue for future research consideration. Another concern was the small number of research papers that examined the relationship between academic achievement and homework method. There was higher proportion of studies that focused on the attitude of students to the different methods of homework and more concerning the perceived learning outcomes – without any evidence or measurement.

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