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Full-Day Kindergarten:
A Review of the Evidence and Benefit-Cost Analysis

The Washington State legislature directed the Washington State Institute for Public Policy (WSIPP) to develop "a repository of research and evaluations of the cost-benefits of various K–12 educational programs and services." [1]

In this report, we analyze a K–12 policy question: do the long-term benefits of full-day kindergarten (in comparison with half-day) outweigh the costs?

We researched this question by reviewing all credible evaluation studies from the United States and elsewhere. We systematically analyzed the studies to estimate whether full-day kindergarten has a cause-and-effect relationship with student outcomes. We then calculated whether the long-term monetary benefits of full-day kindergarten exceed the operating and capital costs.

In this report, we describe our research approach and highlight our findings on full-day kindergarten. An appendix provides technical details.

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Summary

WSIPP updated its 2007 analysis of the research evidence regarding full-day kindergarten.

Over half of Washington's public school kindergarteners attend full-day programs, and the state is expanding funding for this option. In this report, we analyze average impacts on student outcomes from full-day kindergarten across the United States and elsewhere. We also examine whether benefits are likely to exceed costs.

To investigate, we conducted a systematic review of research by collecting all studies we could find on the topic. We screened for scientific rigor and only analyzed studies with strong research methods.

We identified ten credible evaluations of full-day kindergarten's cause-and-effect relationship with student test score outcomes. The studies estimate the relative impact of full-day in comparison with half-day programs.

Improvement in standardized test scores was the only outcome measured in the studies that we reviewed. Other outcomes of interest such as social and emotional learning and high school graduation have not been examined consistently in the research literature.

Our bottom-line findings. Full-day kindergarten leads to higher standardized test scores than half-day programs, but this effect appears to fade out within a few years.

More information about how to sustain the early gains from investments in full-day kindergarten is needed as Washington State continues to expand this option for public school students.

[1] Engrossed Substitute Senate Bill 6386, Chapter 372, Laws of 2006.

I. Research Approach

When WSIPP carries out assignments from the legislature to identify what works (and what does not) in public policy, we implement a three-step research approach.

Step 1: What Works? What Does Not?

In the first research step, we estimate whether various public policies and programs can achieve desired outcomes, such as improved test scores. We carefully analyze all high-quality studies from the United States and elsewhere to identify policy options tried, tested, and found to impact outcomes. We look for research studies with strong evaluation designs and exclude studies with weak research methods.

Our empirical approach follows a meta-analytic framework to assess systematically all credible evaluations we can locate on a given topic. Given the weight of the evidence, we calculate an average expected effect of a policy on a particular outcome of interest, as well as an estimate of the margin of error for that effect.

Step 2: What Makes Economic Sense?

Next, we insert costs and benefits into the analysis by answering two questions:

- How much would it cost Washington taxpayers to produce the results found in Step 1?
- How much would it be worth to people in Washington State to achieve the improved outcome?

That is, in dollars and cents terms, what are the costs and benefits of each policy option?

To answer these questions, we developed, and continue to refine, an economic model that estimates benefits and costs. The model provides an internally consistent monetary valuation so policy options can be compared on an apples-to-apples basis. Our benefit-cost results include standard financial statistics: net present values and benefit-cost ratios.

We present monetary estimates from three perspectives:

a) program participants,
b) taxpayers, and
c) other people in society (for example, we estimate "spillover" effects to society of increases in education).[2]

The sum of the three perspectives provides a "total Washington" view on whether a policy or program produces benefits that exceed costs.

[2] McMahon, M. (2010). The external benefits of education. In Brewer, D.J. & McEwan, P.J., eds. *Economics of education*. Oxford, UK: Academic Press.

Step 3: What is the Risk in the Benefit-Cost Findings?

Any tabulation of benefits and costs involves a degree of risk about the estimates calculated. This is expected in any investment analysis, whether in the private or public sector. To assess the riskiness of our conclusions, we perform a "Monte Carlo simulation" in which we vary key factors in our calculations. The purpose of this analysis is to determine the odds that a particular policy option will at least break even.

Thus we produce two "big picture" findings: expected benefit-cost results and, given our understanding of the risks, the odds that the policy will at least have benefits that are greater than the costs. Readers interested in an in-depth description of the research methods for these three steps can reference our Technical Manual.[3] A brief Technical Appendix is included at the end of this report.

[3] Washington State Institute for Public Policy, (2013). *Benefit-cost technical manual: Methods and user guide.* (Doc. No. 13-09-1201b). Olympia, WA: Author.

II. Full-Day Kindergarten

In the United States, the percentage of students attending full-day kindergarten has steadily increased since the 1970s.[4] In 2012, 76% of students in the United States attended full-day kindergarten, compared with 28% in 1977.[5] Many public school districts have adopted full-day kindergarten as a strategy to support academically at-risk students.

Currently, 11 states and Washington, D.C. fund full-day kindergarten for all students.[6] In most states, however, the decision to offer full-day kindergarten is made at the local level.

Washington State began to fund voluntary full-day kindergarten for schools with the highest poverty levels during the 2007-08 school year. The 2007 Legislature established the goal of funding full-day kindergarten in all public schools by the 2017-18 school year.[7]

Almost half of Washington's public school kindergarteners attend full-day kindergarten. In 2012, 22% were enrolled in a full-day program funded by the state.[8] An additional 25% of Washington kindergarteners attending public

[4] Education Commission of the States. (2005). Full-day Kindergarten: A Study of State Policies in the United States. http://fcd-us.org/sites/default/files/FullDayKindergarten.pdf
[5] Child Trends. (2013). Full-day Kindergarten: Indicators on Children and Youth. http://www.childtrends.org/?indicators=full-day-kindergarten
[6] Children's Defense Fund. (2013). Full-day Kindergarten in the States. http://www.childrensdefense.org/child-research-data-publications/data/state-data-repository/full-day-k/full-day-kindergarten-states-2012.html
[7] RCW 28A.150.315
[8] Office of Superintendent of Public Instruction. (2013). Q&A for State-funded Full-day Kindergarten and the Washington Kindergarten Inventory of Developing Skills (WaKIDS) Webinar. http://www.k12.wa.us/EarlyLearning/pubdocs/QAforSFDKWaKIDSWebinarMay13-2013.pdf

school were enrolled in full-day programs funded by local sources or tuition.[9]

WSIPP previously published findings on full-day kindergarten in 2007.[10] This report updates our analysis of evaluations of full-day kindergarten compared with half-day kindergarten. The studies we include in our analysis meet our minimum standards for scientific rigor (such as having a valid comparison group; see the Technical Appendix for details). These criteria give us increased confidence that any changes in outcomes are caused by the intervention and not by unknown factors.

This analysis examines the short-term impact of full-day kindergarten on standardized academic test scores. Unfortunately, longer-term measures such as high school graduation or labor market outcomes were not measured consistently across studies and, thus, could not be analyzed for this report.

We only examine academic outcomes in this report. "Non-cognitive" outcomes such as social and emotional learning are a growing area of research and of interest to the legislature and educators.[11] However, we could not include these outcomes in our analysis for two reasons. First, the studies we reviewed did not measure social and emotional learning consistently. Second, we do not currently have sufficient data to link full-day kindergarten to social and emotional outcomes and subsequent monetary benefits and costs. As scientific consensus emerges on "non-cognitive" skills, WSIPP's findings will be updated to incorporate monetary benefits from these outcomes.

Meta-Analysis Findings

We identified ten studies that met our criteria for scientific rigor and measured academic test scores of full-day kindergarteners in comparison with half-day. Most studies measured student test scores at the end of kindergarten. A few followed students for additional years (in grades one through five), which allows us to examine whether the early test score impacts persist over time.

The results of our updated meta-analysis are similar to our 2007 findings and are displayed in Exhibit 1. On average, students in full-day kindergarten had significantly higher test scores at the end of the school year in comparison with similar students in half-day kindergarten (effect size=0.16). The initial boost in test scores, however, appears to fade out to almost zero by grades two through five.

This meta-analytic finding represents the average impact of full-day kindergarten for all students, regardless of income level or other characteristics. Since full-day kindergarten is often used as an intervention for disadvantaged students, we also examined the average effect size among low-income students.

The results are similar for low-income students. We estimate a positive effect immediately after kindergarten (effect size=0.12), but, again, the impact fades out to nearly zero by grades two through five.

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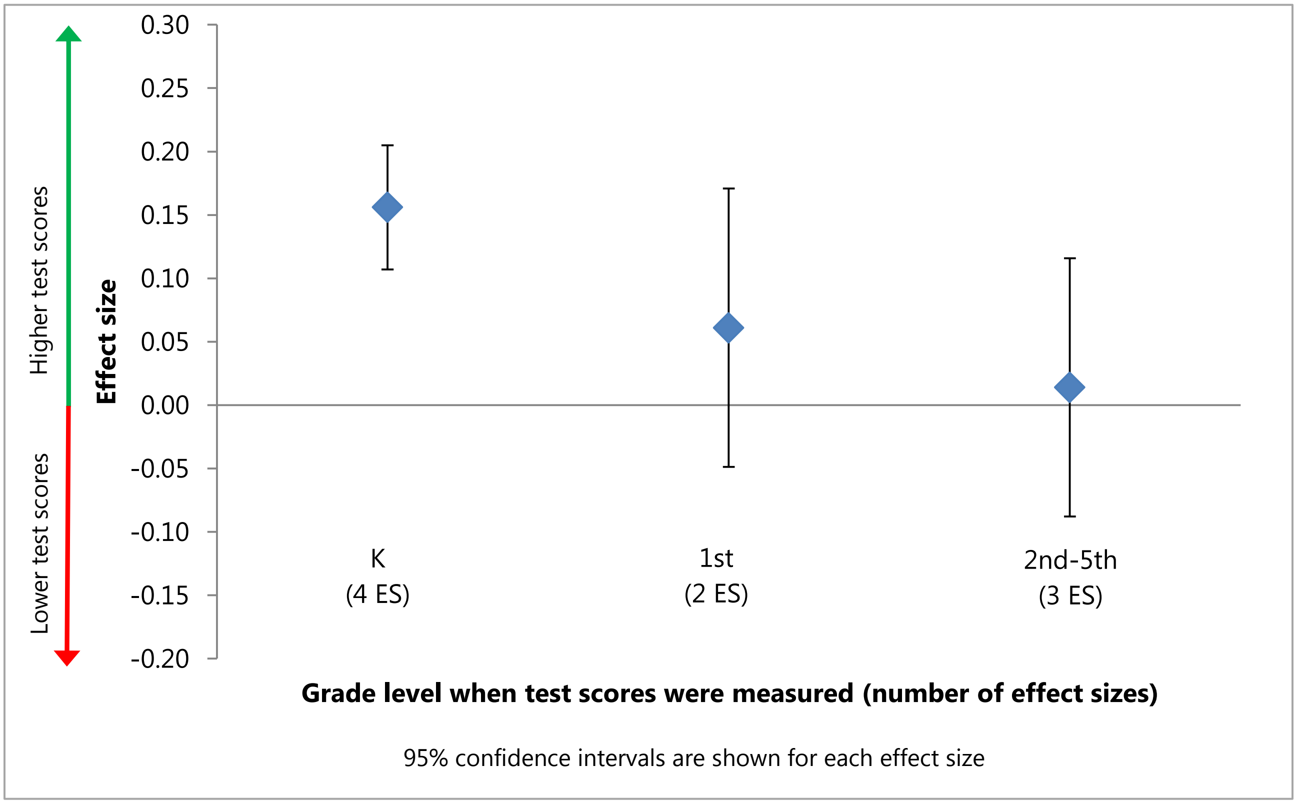
[9] Office of Superintendent of Public Instruction. (2013). October Enrollment Report, 2012-2013 as of 12/10/2012. http://www.k12.wa.us/DataAdmin/GenderEthnicity.aspx

[10] Aos, A., Miller, M., & Mayfield, J.. (2007). *Benefits and costs of k–12 educational policies: Evidence-based effects of class size reductions and full-day kindergarten.* (Doc. No. 07-03-2201). Olympia: Washington State Institute for Public Policy.

[11] Recent studies by Duckworth et al., 2013 and Heckman et al., 2006 investigate the association between social and emotional skills in adolescents and future earnings. Duckworth, K., Duncan, G. J., Kokko, K., Lyyra, A., Metzger, M., & Simonton, S. (2012). *The relative importance of adolescent skills and behaviors for adult earnings: A cross-national Study* (DoQSS Working Paper No. 12-03). Heckman, J. J., Stixrud, J., & Urzua, S. (2006). *The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior* (NBER Working Paper 12006).

Exhibit 1

Meta-Analytic Findings for Full-Day Kindergarten (versus Half-Day)



Benefit-Cost Analysis

As noted earlier, we use WSIPP's standard benefit-cost model to determine whether the early gains from full-day programs offset the operating and capital investments necessary to expand the school day for kindergarteners. We estimate that it costs approximately $2,650 per student to expand from half-day to full-day kindergarten. The estimated costs are described in detail in the Technical Appendix. We assume that a portion of full-day kindergarten costs would be offset by lower participation in state-subsidized child care.

We estimate that over their lifetimes, full-day kindergarten participants—because their cognitive skills improved only slightly over the long term—make just $833 more in labor market earnings than half-day kindergarten participants, on average.

These labor market benefits, based on test scores alone, are less than the program cost. Thus, this policy has a relatively low probability of monetarily breaking even (14%).

This unfavorable result for full-day kindergarten depends critically on the degree to which the initial test score gains fade out in later grades. In Exhibit 2 we show benefit-cost analyses for three scenarios: (a) the test score gains fade out as reported in Exhibit 1; (b) the gains fade out at a rate typical of early childhood education programs; and (c) the gains are sustained through the end of high school.[12]

Exhibit 2

Benefit-Cost Results: Full-Day Kindergarten (versus Half-Day)

	Benefits			Costs	Summary statistics		
	Benefits from labor market earnings	"Deadweight" cost of taxation	Net benefits	Net program costs	Benefits minus costs (net present value)	Benefit to cost ratio	Odds of a positive net present value
(a) Full-day kindergarten with test score fadeout as reported in this study	$833	($1,323)	($490)	($2,649)	($3,140)	($0.19)	14%
(b) Full-day kindergarten with typical early childhood education test score fadeout	$4,882	($1,323)	$3,559	($2,646)	$912	$1.35	63%
(c) Full-day kindergarten with no test score fadeout	$16,506	($1,318)	$15,188	($2,648)	$12,540	$5.75	98%

The estimates are present-value, life-cycle benefits and costs expressed in 2012 dollars. See the Technical Appendix for additional detail. Net program costs differ due to the use of uncertainty ranges in the Monte Carlo simulation.

[12] The typical rate of test score decay is described in Kay & Pennucci (2014). Kay, N., & Pennucci, A. (2014). *Early childhood education for low-income students: A review of the evidence and benefit-cost analysis* (Doc. No. 14-01-2201). Olympia: Washington State Institute for Public Policy.

If the test score gains faded out at a rate typical of early childhood education programs, we would expect a $4,882 benefit per participant from increased labor market earnings. In this case, the benefits would outweigh the costs by $912 per participant with a 63% chance that the investment at least breaks even.

If the test score gains did not fade out over time, the expected benefits from labor market earnings would be $16,506 per participant. In this case, the benefits would outweigh the costs by $12,540 per participant with a 98% chance that the investment at least breaks even.

III. Conclusions and Study Limitations

The weight of the evidence suggests that the benefits of investing in full-day kindergarten are unlikely to outweigh the costs because the initial test score gains are not typically sustained.

One limitation of this analysis is the possibility that the greatest benefits from full-day kindergarten are not measured by test scores alone. The research literature does not consistently measure social and emotional learning or longer-term outcomes such as high school graduation rates.

More information about how to sustain the early gains from investments in full-day kindergarten is needed as Washington State continues to expand this option for public school students. If the initial boost in test scores persisted, full-day kindergarten has the potential to be cost-beneficial with relatively low risk.

Technical Appendix

Full-Day Kindergarten: A Review of the Evidence and Benefit-Cost Analysis

A1. Meta-Analysis Methodology

A1a. Study Selection and Coding Criteria

A meta-analysis is only as good as the selection and coding criteria used to conduct the study.[13] Following are the key choices we made and implemented.

Study Selection. We use four primary means to locate studies for meta-analysis of programs: (1) we consult the bibliographies of systematic and narrative reviews of the research literature in the various topic areas; (2) we examine the citations in the individual studies themselves; (3) we conduct independent literature searches of research databases using search engines such as Google, Proquest, Ebsco, ERIC, PubMed, and SAGE; and (4) we contact authors of primary research to learn about ongoing or unpublished evaluation work. After first identifying all possible studies via these search methods, we attempt to determine whether the study is an outcome evaluation that has a valid comparison group. If a study meets this criterion, we secure a full copy of the study for our review.

Peer-Reviewed and Other Studies. We examine all evaluation studies we can locate with these search procedures. Many studies are published in peer-reviewed academic journals while others are from reports obtained from the agencies themselves. It is important to include non-peer reviewed studies, because it has been suggested that peer-reviewed publications may be biased to show positive program effects. Therefore, our meta-analysis includes all available studies that meet our other criteria, regardless of publication source.

Control and Comparison Group Studies. Our analysis only includes studies that have a control or comparison group or use a quasi-experimental design such as regression discontinuity with multiple, sophisticated controls. We do not include studies with a single-group, pre-post research design. This choice was made because it is only through rigorous studies that causal relationships can be reliably estimated.

Random Assignment and Quasi-Experiments. Random assignment studies are preferred for inclusion in our review, but we also include non-randomly assigned comparison groups. We only include quasi-experimental studies if sufficient information is provided to demonstrate comparability between the treatment and comparison groups on important pre-existing conditions such as age, gender, and pre-treatment characteristics such as test scores.

[13] All studies used in the meta-analysis are identified in the references to this paper. Many other studies were reviewed but did not meet the criteria set for this analysis.

Enough Information to Calculate an Effect Size. Following the statistical procedures in Lipsey and Wilson,[14] a study has to provide the necessary information to calculate an effect size. If the necessary information is not provided, and we are unable to obtain the necessary information directly from the study's author(s), the study is not included in our review.

Mean-Difference Effect Sizes. For this study, we code mean-difference effect sizes for continuous measures following the procedures outlined in Lipsey and Wilson.[15] For dichotomous measures, we use the d-Cox transformation to approximate the mean difference effect size, as described in Sánchez-Meca, Marín-Martínez, and Chacón-Moscoso.[16] We choose to use the mean-difference effect size rather than the odds ratio effect size because we frequently code both dichotomous and continuous outcomes (odds ratio effect sizes could also be used with appropriate transformations).

Outcome Measures of Interest. In this analysis we are interested in academic achievement, long-term outcomes and social and emotional learning. We include standardized, validated assessments of student learning. Reading and math test scores are the most frequently measured outcomes.

Since long-term outcomes and social and emotional learning were not measured consistently in the studies we reviewed, they are not included in this report.

A1b. Procedures for Calculating Effect Sizes

Effect sizes summarize the degree to which a program or policy affects an outcome. In experimental settings this involves comparing the outcomes of treated participants relative to untreated participants. Several methods are used by analysts to calculate effect sizes, as described in Lipsey and Wilson.[17] The most common effect size statistic is the standardized mean difference effect size and that is the measure we use in this analysis.

Weighted Mean Different Effect Size. The mean difference effect size is designed to accommodate continuous outcome data, such as student test scores, where the differences are in the means of the outcome.[18] The standardized mean difference effect size is computed with:

$$(1)\ ES = \frac{M_t - M_c}{\sqrt{\dfrac{(N_t - 1)SD_t^2 + (N_c - 1)SD_c^2}{N_t + N_c - 2}}}$$

In this formula, ES is the estimated effect size for a particular program; M_t is the mean value of an outcome for the treatment or experimental group; M_c is the mean value of an outcome for the control group; SD_t is the standard deviation of the treatment group; and SD_c is the standard deviation of the control group; N_t is the number of subjects in the treatment group; and N_c is the number of subjects in the control group. The variance of the mean difference effect size statistic in equation (1) is computed with:[19]

$$(2)\ ESVar = \frac{N_t + N_c}{N_t N_c} + \frac{ES^2}{2(N_t + N_c)}$$

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[14] In general, we follow the procedures in M.W. Lipsey & D. Wilson. (2001). *Practical meta-analysis.* Thousand Oaks: Sage Publications.
[15] Ibid.
[16] Sánchez-Meca, J., Marín-Martínez, F., & Chacón-Moscoso, S. (2003). Effect-size indices for dichotomized outcomes in meta-analysis. *Psychological Methods*, *8*(4), 448-467.
[17] Lipsey & Wilson, (2001).
[18] Ibid, Table B10, equation 1, p. 198.
[19] Ibid, Table 3.2, p. 72.

In some random assignment studies or studies where treatment and comparison groups are well-matched, authors provide only statistical results from a t-test. In those cases, we calculate the mean difference effect size using:[20]

$$(3)\ ES = t\sqrt{\frac{N_t + N_c}{N_t N_c}}$$

In many research studies, the numerator in equation (1), M_t - M_c, is obtained from a coefficient in a regression equation, not from experimental studies of separate treatment and control groups. For such studies, the denominator in equation (1) is the standard deviation for the entire sample. In these types of regression studies, unless information is presented that allows the number of subjects in the treatment condition to be separated from the total number in a regression analysis, the total N from the regression is used for the sum of N_t and N_c, and the product term N_tN_c is set to equal $(N/2)^2$.

Pre/Post Measures. When authors report pre- and post-treatment measures without other statistical adjustments, we start by calculating two between-groups effect sizes: (a) at pre-treatment and, (b) at post-treatment. Then, we calculate the overall effect size by subtracting the post-treatment effect size from the pre-treatment effect size.

Adjusting Effect Sizes for Small Samples. Since some studies have very small sample sizes, we follow the recommendation of many meta-analysts and adjust for this. Small sample sizes have been shown to upwardly bias effect sizes, especially when samples are less than 20. Following Hedges,[21] Lipsey and Wilson[22] report the "Hedges correction factor," which we use to adjust all mean-difference effect sizes, (where N is the total sample size of the combined treatment and comparison groups):

$$(4)\ ES'_m = \left[1 - \frac{3}{4N - 9}\right] * \ ES_m$$

Adjusting Effect Sizes and Variances for Multi-Level Data Structures. Most studies in the education field use data that are hierarchical in nature. That is, students are clustered in classrooms, classrooms are clustered within schools, schools are clustered within districts, and districts are clustered within states. Analyses that do not account for clustering will underestimate the variance in outcomes at the student level (the denominator in equation 1 and, thus, may over-estimate the precision of magnitude on effect sizes). In studies that do not account for clustering, effect sizes and their variance require additional adjustments.[23] There are two types of studies, each requiring a different set of adjustments.[24] First, for student-level studies that ignore the variance due to clustering, we make adjustments to the mean effect size and its variance,

$$(5)\ ES_T = \ ES_m * \sqrt{1 - \frac{2(n-1)\rho}{N-2}}$$

[20] Ibid, Table B10, equation 2, p. 198.

[21] Hedges, L. V. (1981). Distribution theory for Glass's estimator of effect size and related estimators. *Journal of Educational Statistics, 6*(2), 107-128.

[22] Lipsey & Wilson, (2001), equation 3.22, p. 49.

[23] Studies that employ hierarchical linear modeling, or fixed effects with robust standard errors, or random effects models account for variance and need no further adjustment for computing the effect size, but adjustments are made to the inverse variance weights for meta-analysis using these methods.

[24] These formulas are taken from: Hedges, L. (2007). Effect sizes in cluster-randomized designs. *Journal of Educational and Behavioral Statistics, 32*(4), 341-370.

(6) $V\{ES_T\} = \left(\frac{N_t + N_c}{N_t N_c}\right)[1 + (n-1)\rho] + ES_T^{\,2}\left(\frac{(N-2)(1-\rho)^2 + n(N-2n)\rho^2 + 2(N-2n)\rho(1-\rho)}{2(N-2)[(N-2) - 2(n-1)\rho]}\right)$

where ρ is the intraclass correlation, the ratio of the variance between clusters to the total variance; N is the total number of individuals in the treatment group, N_t, and the comparison group, N_c; and n is the average number of persons in a cluster, K. In the educational field, clusters can be classes, schools, or districts. We used 2006 Washington Assessment of Student Learning (WASL) data to calculate values of ρ for the school-level (ρ = 0.114) and the district level (ρ = 0.052). Class-level data were not available, so we use a value of ρ = 0.200 for class-level studies.

Second, for studies that report means and standard deviations at a cluster level, we make adjustments to the mean effect size and its variance:

(7) $ES_T = ES_m * \sqrt{\frac{1 + (n-1)\rho}{n\rho}} * \sqrt{\rho}$

(8) $v\{ES_T\} = \left\{\left(\frac{N_t - N_c}{N_t N_c}\right) * \left(\frac{1 + (n-1)\rho}{n\rho}\right) + \frac{[1 + (n-1)\rho]^2 * ES_T^{\,2}}{2n\rho(K-2)}\right\} * \rho$

We do not adjust effect sizes in studies reporting dichotomous outcomes. This is because the d-Cox transformation assumes the entire normal distribution at the student level.[25] However, when outcomes are dichotomous, or an effect size is calculated from studies where authors control for clustering with robust standard errors or hierarchical linear modeling, we use the "design effect" to calculate the "effective sample size."[26] The design effect is given by:

(9) $D = 1 + (n-1)\rho$

The effective sample size is the actual sample size divided by the design effect. For example, the effective sample size for the treatment group is:

(10) $N_{t(eff)} = \frac{N_t}{D}$

A1c. Adjusting Effect Sizes for Study Design, Research Involvement and Study Setting

In this report we show the results of our meta-analyses calculated with the standard meta-analytic formulas described above. Typically, we list the "Adjusted Effect Size" that is used in the benefit-cost analysis in our reports. These adjusted effect sizes, which are derived from the unadjusted results, may be smaller, larger, or equal to the unadjusted effect sizes we report. In this analysis we considered adjusting effect sizes for research design, researcher involvement in the intervention, and laboratory (not "real world") settings. For a full description of the rationale for these adjustments see WSIPP's Technical Manual.[27]

Since the studies we reviewed for our analysis of full-day kindergarten all had similar research designs, we could not conduct a meta-regression to determine if there were systematic differences due to research design.
We, therefore, made adjustments for research design based on our analysis of early childhood education

[25] Mark Lipsey (personal communication, November 11, 2007).
[26] Formulas for design effect and effective sample size were obtained from the Cochrane Reviewers Handbook, section 16.3.4, Approximate analyses of cluster-randomized trials for a meta-analysis: effective sample sizes. http://www.cochrane-handbook.org/
[27] Washington State Institute for Public Policy, (2013). http://www.wsipp.wa.gov/TechnicalManual/WsippBenefitCostTechnicalManual.pdf

programs.[28] For early childhood education programs we found that research design did predict the magnitude of the effect size, thus no adjustments were made for this factor in the full-day kindergarten analysis. None of the full-day kindergarten studies took place in a setting that was not a "real world" environment and no researchers were involved in the implementation of these studies; therefore, no adjustments were made for these conditions.

In this report, we refer to all effect sizes as weighted average effect sizes since no adjustments were made for study design, researcher involvement, or study setting.

Computing Weighted Average Effect Sizes, Confidence Intervals, and Homogeneity Tests. Once effect sizes are calculated for each program effect, and any necessary adjustments for clustering are made, the individual measures are summed to produce a weighted average effect size for a program area. We calculate the inverse variance weight for each program effect and these weights are used to compute the average. The calculations involve three steps. First, the standard error, SE_T of each mean effect size is computed with:[29]

$$(11)\ SE_T = \sqrt{\frac{N_t + N_c}{N_t N_c} + \frac{ES^2}{2(N_t + N_c)}}$$

Next, the inverse variance weight w is computed for each mean effect size with:[30]

$$(12)\ w = \frac{1}{SE_T^2}$$

The weighted mean effect size for a group with i studies is computed with:[31]

$$(13)\ \overline{ES} = \frac{\sum(w_i ES_{T_i})}{\sum w_i}$$

Confidence intervals around this mean are then computed by first calculating the standard error of the mean with:[32]

$$(14)\ SE_{\overline{ES}} = \sqrt{\frac{1}{\sum w_i}}$$

Next, the lower, ES_L, and upper limits, ES_U, of the confidence interval are computed with:[33]

$$(15)\ \overline{ES_L} = \overline{ES} - z_{(1-\alpha)}\left(SE_{\overline{ES}}\right)$$

$$(16)\ \overline{ES_U} = \overline{ES} + z_{(1-\alpha)}\left(SE_{\overline{ES}}\right)$$

In equations (15) and (16), $z_{(1-\alpha)}$ is the critical value for the z-distribution (1.96 for α = .05). The test for homogeneity, which provides a measure of the dispersion of the effect sizes around their mean, is given by:[34]

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[28] Kay & Pennucci, (2014).
[29] Lipsey & Wilson, (2001), equation 3.23, p. 49.
[30] Ibid., equation 3.24, p. 49.
[31] Ibid., p. 114.
[32] Ibid.
[33] Ibid.
[34] Ibid., p. 116.

$$(17)\ Q_i = \left(\sum w_i\, ES_i^2\right) - \frac{(\sum w_i\, ES_i^2)}{\sum w_i}$$

The Q-test is distributed as a chi-square with k-1 degrees of freedom (where k is the number of effect sizes).

Computing Random Effects Weighted Average Effect Sizes and Confidence Intervals. Next, a random effects model is used to calculate the weighted average effect size. Random effects models allow us to account for between-study variance in addition to within-study variance.[35] This is accomplished by first calculating the random effects variance component, v:[36]

$$(18)\ v = \frac{Q_i - (k-1)}{\sum w_i - (\sum wsq_i / \sum w_i)}$$

Where wsq_i is the square of the weight of ES_i. This random variance factor is then added to the variance of each effect size and finally all inverse variance weights are recomputed, as are the other meta-analytic test statistics. If the value of Q is less than the degrees of freedom (k-1), there is no excess variation between studies and the initial variance estimate is used.

A2. Full-Day Kindergarten Meta-Analysis and Cost Estimation

Meta-analysis

We located ten evaluations of full-day kindergarten (versus half-day programs) that met our criteria for meta-analysis. Three studies used state or school district data; seven studies used the Early Childhood Longitudinal Program Kindergarten Class of 1998-99 (ECLS-K), a large national study that followed a cohort of children from kindergarten to middle school.[37] To account for the use of the same data set, we computed an average effect size for the seven studies that used ECLS-K data and included this summary effect size in the meta-analysis. Thus, for the immediate post-kindergarten measurement, four effect sizes are included: the ECLS-K summary effect and the three state/district effects.

We reviewed all studies included in the previous full-day kindergarten meta-analysis using our criteria for scientific rigor and method for coding effect sizes. Seventeen studies that were included in the previous WSIPP analysis were not included in the current analysis because they did not meet the criteria for strong research design or provide sufficient information to compute an effect size.[38]

Some of the studies followed students in later grade levels. Exhibit A1 presents meta-analytic results for students at the end of kindergarten, first grade, and later grades (two through five). At the end of the kindergarten school year, students in full-day kindergarten had higher test scores (unadjusted ES = 0.16), on average, than students in half-day programs. That impact, however, appears to fade out in subsequent years (unadjusted ES = 0.01 in grades two through five).[39]

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[35] Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods, 1*(2), 97-111.
[36] Ibid., p. 134.
[37] http://nces.ed.gov/ecls/kindergarten.asp
[38] After re-reviewing the studies in our 2007 analysis, we concluded that a number of the studies did not have adequate comparison groups or sufficient statistical controls to include in our current review.
[39] Another recent meta-analysis of full-day kindergarten had similar findings. Cooper, H., Allen, A. B., Patall, E. A., & Dent, A. L. (2010). Effects of full-day kindergarten on academic achievement and social development. *Review of Educational Research, 80*(1), 34-70.

Exhibit A1

Meta-Analysis Results: Full-Day Kindergarten Impacts on Test Scores
(in Comparison with Half-Day Programs)

	Follow-up time (end of school year)	No. effect sizes	Weighted average effect size	Standard error	p-value	Combined N in treatment group
All students	Kindergarten	4	0.16	0.03	0.00	53,818
	First grade	2	0.06	0.06	0.28	39,566
	2^{nd}-5^{th} grades	3	0.01	0.05	0.27	27,100
Low-income students	Kindergarten	2	0.12	0.03	0.00	48,870
	First grade	2	0.00	0.04	0.98	33,339
	2^{nd}-5^{th} grades	2	0.00	0.04	0.99	21,184

Since the relationships in the economic literature between test scores and labor market earnings are based on test scores late in high school, it is critical to adjust earlier measurements of test scores appropriately for use in the benefit-cost model. Typically, the magnitude of gains in standardized test scores of children who participate in an educational intervention does not remain constant over time. WSIPP has modeled test score decay or "fadeout" based on our meta-analysis of early childhood education programs.[40] To calculate the impact of full-day kindergarten on test scores at the end of high school we use the effect size at the highest grade level of measurement in the studies we reviewed and then use the fadeout model to estimate the test score decay to age 17. Using this methodology, we estimate the impact of full-day kindergarten on test scores at the end of high school as 54% of the 2^{nd}-5^{th} grade effect size.

We also estimate effect sizes at the end of high school for two hypothetical cases of fadeout in order to calculate the benefits and costs for these scenarios. In the first hypothetical scenario we assume that test scores fadeout is the same as a typical early childhood education program. Using the model of early childhood education program fadeout described above, we estimate the impact of full-day kindergarten on test scores in the hypothetical scenario as 31% of the end of kindergarten effect size. The second hypothetical scenario assumes a case where there is no test score fadeout. For this scenario we use the effect size at the end of kindergarten as the effect size at the end of high school.

[40] Kay & Pennucci, (2014).

The Per-Student Cost of Full-Day vs. Half-Day Kindergarten

We use the same estimates as in our previous report on full-day kindergarten for the average per-student cost of moving from half-day to full-day kindergarten. We estimate both operating and capital costs on a per-participant basis.

The cost estimate is driven by the following seven parameters, shown at the bottom of Exhibit A2:

1) Average annual teacher salary in an average classroom (non-wage benefits included, 2012 dollars)
2) Total number of public kindergarten students in Washington (or any geographic sub-unit)
3) Average kindergarten students per classroom
4) Average square feet per average K–12 classroom
5) Construction cost for K–12 classrooms (dollars per square foot, 2012 dollars)
6) Length of bonds for new construction
7) Interest rate on bonds.

The difference in operating costs is estimated as simply the difference in average teacher salary (and non-salary compensation) for a full-time equivalent (FTE) teacher, given an average kindergarten class size. This estimate does not include any estimated effects on pupil transportation costs of moving from half-day to full-day kindergarten. The capital cost calculations estimate the number of additional classrooms needed, times the number of square feet per student, and the cost per square foot of new construction. This product is then financed over an assumed bond term and interest rate. The result is then divided by the student population to estimate a per-student capital cost.

We also estimate the offsets to child-care costs for students who attend school for full-day, rather than a half-day. Washington State's Department of Health and Human Services provides subsidized child care to families whose income is up to 200% of the federal poverty level through the Child Care Subsidy Programs (CCSP). We calculated the reduction in the use of CCSP based on the percentage of children eligible for free or reduced-priced meals and the assumption that 50% of eligible children would use subsidized child care (Exhibit A3). We estimate that an average of $505 in child care subsidies per student are distributed to half-day kindergarten students that are not distributed to full-day kindergarten students.

Exhibit A2

Per-Student Cost Estimates of Full-Day Kindergarten (Versus Half-Day)

	Half-day k	Full-day k
Students in cohort (October 2012 headcount)	80,923	80,923
Full-time equivalent (FTE) teacher per classroom	0.5	1
Average kindergarten class size	20	20
FTE teachers needed	2023	4046
Teacher cost per student (includes marginal non-teacher salary operating expenses)	$ 2,518.56	$5,037.12
Difference in operating cost per student		*$ 2,518.56*
Number of classrooms needed	2,023	4,046
Total square footage of classroom	3,641,535	7,283,070
Change in square footage		3,641,535
Construction cost for change in square footage		$686,611,424
Annual payment to capital		$51,186,437
Capital payment per student		*$632.53*
Total cost per student to expand from half-day to full-day kindergarten		***$ 3,151.09***
Assumed parameters in cost calculation		
Average annual teacher salary in an average classroom (non-wage benefits included, 2012 dollars. Source: OSPI, School District Personnel Summary Files, Table 19)	$83,952	
Marginal non-teacher salary operating expenses (as percent of teacher salaries)	20%	
Average kindergarten class size	20	
Average square feet of classroom space per student	90	
Construction cost for K–12 classrooms (dollars per square foot, 2012)	$188.55	
Length of bonds for new construction	25	
Interest rate on bonds	5.50%	

Exhibit A3

Per-Student Cost Estimates of a Half-Day of State-Subsidized Child Care

	Half-day child care
Average school year per-student cost of half-day child care at a center or licensed family home	$2063.96
Percentage of students who are eligible for free and reduced-price meals*	48.91%
Estimated percentage of eligible families who use child care subsidies	50%
Average per-student annual cost of state subsidized child care	***$504.74***
Assumed parameters in cost calculation	
Days in the school year	180
Average cost per day of child care at a center or licensed family home for school-aged children**	$11.74

* Office of Superintendent of Public Instruction. (2012). 2012-2013 Washington Public School Free and Reduced-Price Meal Eligibility. http://k12.wa.us/ChildNutrition/Reports/FreeReducedMeals.aspx

**Department of Early Learning. (2013). Child Care Subsidy Rates. http://www.del.wa.gov/publications/subsidy/docs/ChildCareSubsidyRates.pdf

Exhibit A4

Summary of Per-Student Full-Day Kindergarten Costs

Full-day kindergarten (vs. half-day)	Comparison (half-day child care)	Summary	
Annual cost	Annual cost	Net program costs	Uncertainty (+ or – %)
$3,151	$505	$2,646	10%

The figures shown are estimates of the per-student costs to implement full-day kindergarten in Washington State. The uncertainty range is used in Monte Carlo risk simulation, described in WSIPP's Technical Manual.

Benefit-Cost Results

Exhibit A5 summarizes our benefit-cost results. The estimates are present-value, life-cycle benefits and costs expressed in 2012 dollars. The economic discount rates and other relevant parameters are described in detail in WSIPP's Technical Manual.[41]

Exhibit A5

Main Benefit-Cost Results

Benefit-cost summary			
(a) Full-day kindergarten program benefits		**Summary statistics**	
Participants (labor market earnings)	$433	Benefit to cost ratio	($0.19)
Taxpayers	$185	Benefits minus costs	($3,140)
Other	$215	Probability of a positive net present value	14%
Other indirect*	($1,323)		
Total	($490)		
Costs	($2,649)**		
Benefit minus cost	($3,140)		
(b) Full-day kindergarten with typical early childhood education test score fadeout (hypothetical)		**Summary statistics**	
Participants (labor market earnings)	$2,540	Benefit to cost ratio	$1.35
Taxpayers	$1,083	Benefits minus costs	$912
Other	$1,258	Probability of a positive net present value	63%
Other indirect*	($1,323)		
Total	$3,559		
Costs	($2,646)**		
Benefit minus cost	$912		
(c) Full-day kindergarten with no test score fadeout (hypothetical)		**Summary statistics**	
Participants (labor market earnings)	$8,597	Benefit to cost ratio	$5.75
Taxpayers	$3,667	Benefits minus costs	$12,540
Other	$4,242	Probability of a positive net present value	98%
Other indirect*	($1,318)		
Total	$15,188		
Costs	($2,648)**		
Benefit minus cost	$12,540		

*Adjustment for deadweight cost of program. See WSIPP's Technical Manual for further detail.
**Does not match Exhibit A4 due to the use uncertainty ranges in Monte Carlo simulation.

[41] Washington State Institute for Public Policy, (2013). http://www.wsipp.wa.gov/TechnicalManual/WsippBenefitCostTechnicalManual.pdf

A3. Studies Used in the Meta-Analyses

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