

**A Benefit Cost Study of a new Preschool Program  
Based on Neuroplasticity**

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# A Benefit Cost Study of a new Preschool Program Based on Neuroplasticity

## **Abstract:**

Professor Helen Neville, director of the Brain Development Lab at the University of Oregon, has developed and implemented an experiment to study the effects of a relatively short term, inexpensive add on to Head Start. Using the Head Start program as a baseline, she has performed a series of targeted interventions on preschool children. There were three different interventions which focused on language, attention, and music separately. The innovation in this approach is that these interventions are short and inexpensive, are based on research in neuroscience, and are designed to take advantage of the plasticity of children's brains at this age, in order to provide targeted improvements in cognitive function. Because we are dealing with limited resources and diminishing marginal productivity, we believe that Helen Neville's system of child brain exercise and education is an ideal solution. Specifically tailoring a short pre-k intervention that is proven to deliver developmental results will be a cost effective investment in human capital.

**Approved:** \_\_\_\_\_

Prof. [Bill or Bruce]

Date

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## Introduction

What *one* is --- is what one was and can be:

The more that one was, the more that one is now,

The more that one is, the more that one is yet to be;

True power, and therefore responsibility, lies with *us*.

--- Nathaniel James Blair

Education plays an important role in everyone's life. Recent research shows that early childhood education can play the most influential role of all. It is true that family background is important to children's success, but many studies of early childhood interventions show that a quality preschool program can give at-risk children advantages that they wouldn't have otherwise. The federal Head Start program is just one example of an early education project that is designed to give children from low-income families the opportunity to attend preschool so that they can enter school ready to learn with their peers. Head Start provides a medium quality preschool education that has been shown to produce benefits. Studies have generally shown that Head Start type programs, and programs that increase preschool quality substantially above the head-start levels, have substantial benefits for children, and that these benefits often exceed the costs. However, these interventions are expensive – often doubling the cost of Head Start. Political support for these sorts of expenditures is mixed.

Professor Helen Neville, director of the Brain Development Lab at the University of Oregon, has developed and implemented an experiment to study the effects of a relatively short term, inexpensive add on to Head Start. Using the Head Start program as a baseline, she has performed a series of targeted interventions on preschool children. The sample for this experiment is children aged 3 to 5 who are already enrolled in the Head Start program. The interventions were conducted on groups of 5 to 7 children at a time with one teacher and an aide. There were three different interventions which focused on language, attention, and music separately. The innovation in this approach is that these interventions are short and inexpensive, are based on research in neuroscience, and are designed to take advantage of the plasticity of children's brains at this age, in order to provide targeted improvements in cognitive function.

The purpose of our research is to determine if the interventions proposed by Professor Neville would be cost effective as an add-on to existing Head Start programs. We will estimate the costs of a larger roll-out of this intervention, using information from the actual costs incurred while conducting this experimental intervention. The benefits will be much more speculative in nature, since we do not yet have long term results from the intervention. Projections of the expected benefits will be based on results from reliable existing studies of early interventions, which have a similar design and focus to Professor Neville's project. It is already well documented that the net present value and rate of return on long-term early intervention programs is highly positive. The purpose of this paper will be to assess the potential of this short-term program as it compares to others.

Studies of experimental pre-kindergarten interventions for low income children have repeatedly shown substantial long term behavioral benefits. There is already a nationwide movement, with expected benefits in the billions of dollars per year, to provide preventive services for these children or pre-kindergarten education across the board. The nature and the degree of the benefits vary widely across programs. The most important task now is to address how resources can be most effectively utilized to maximize these benefits. The purpose of this study is to determine the intensity, quality, and methodology of the provided education. It is our hypothesis that providing short yet intensive early interventions will produce the greatest gains because the returns on investment diminish later and with greater levels of investment.

The results of this type of research will be of interest to many groups. Economists, for one, have been increasingly interested in this subject recently. The return on early education is valuable information when you are trying to sustain an economy and create a productive workforce. Others who would be interested in this topic are those working in education; early education is a heavily discussed topic right now. Perhaps most importantly, policy-makers are concerned with this kind of evaluation of early education programs. Projects like this one can give them a better sense of the net benefit to society provided by early education, and allow them to make more informed decisions when they fund programs.

## **Literature Review**

The primary purpose of this literature review is to give a background of the research that has already been done on early childhood programs. This section also includes a brief summary of the literature arguing in favor of early childhood education. The first section contains information about previous interventions; specifically the program design, significant outcomes, and benefit-cost results are emphasized. The three interventions included in this section are the Abecedarian Project, the Perry Preschool Program, and the Chicago Child Parent Centers Project. A table is also included which compares these three programs and Head Start. (See table 1 in appendix) The second section focuses on the Head Start program, for which Professor Neville's intervention is intended to serve as an add-on program. The third section focuses on arguments that have been made in support of early childhood education. The last section outlines the common characteristics that have been found among the most effective early interventions. These interventions explored here are longer than the one proposed by Professor Neville, but the outcomes and results of benefit cost studies show that large benefits accrue based on small improvements in the child's learning environment early in life.

## **Early Childhood Interventions**

Evidence from educational studies shows that there are much higher returns on earlier interventions and the returns are lower for interventions later in life. The cost and effort required to improve cognition increases with age because of decreased plasticity. In addition, the benefit of later improvements in cognition is expected to decrease due the reduction of the improved compounding experiences. Studies repeatedly show inconsistent or negative returns on educational investments later in life. (Anderson 2005), (also see Hanushek, 1996) This result is shown in the benefit cost analyses of previous intervention programs that will be discussed in this section. They show that early interventions are the most cost effective.

There are only a limited number of reliable experiments that have been conducted on early childhood education. Unfortunately, only a few of these experiments have been

studied from an economic standpoint, and even fewer have been subject to a reliable benefit-cost analysis. Two of the most prominent experiments that have been analyzed in this way are the North Carolina Abecedarian Project and the Perry Preschool Program. Another is the Chicago Child Parent Centers project. These three early interventions are described in this section.

## **Abecedarian Project**

The Abecedarian Project began in 1972 with 104 participants from low income families. The program participants were randomly assigned to either the preschool program or a control group. This was a very intensive intervention that had an all day program which operated all year long from infancy until entry to kindergarten. The design of the program was much more intensive than a Head Start-type preschool program; child to teacher ratios were also much smaller than a typical Head Start class. Overall, this program is most comparable to a private preschool. Language development was the primary focus of this particular intervention. So far, the study has followed the participants through age 21. Large amounts of data have been collected on the progress of the participants through their school years and beyond. The Abecedarian Project was studied and put through a benefit-cost analysis by L.N. Masse and W.S. Barnett in their paper “A Benefit Cost Analysis of the Abecedarian Early Childhood Intervention.”

The early indicators of success found in this program include significant increases in IQ for program participants in the years following the intervention. Children in the program also scored higher on math and reading tests throughout their school years. Lower rates of grade retention and special education placement were found among the participants versus the control group. The only outcome not found to be significant in this study was a decrease in crime rates among program participants. However, the authors of this study suggest that it is because the area in which this study was conducted has low crime rates to begin with. Another explanation for this lack of significance is the small sample size in this intervention.

Their theory behind the economic benefits of this program is that there are both immediate and long term benefits to the individual and society. They used records from

the sponsor of this program to estimate program costs. Program costs were divided into categories of labor resources and non-labor resources. In calculating the cost they take into account the costs for childcare/preschool services that would be necessary without the program. The marginal cost of the program was calculated as the cost of the intervention minus the cost of care for the control group. They also estimated yearly net costs for the program when operated at various locations such as public preschools and a child care setting. Comparisons were also made between the total annual cost of the Abecedarian Project and the costs of Head Start and the Perry Preschool Program. Ultimately the annual cost of the program per child was found to be approximately \$13,900 (in 2002 dollars). Masse and Barnett cited the cost of the Head Start program from the Department of Health and Human Services to be approximately \$7,000 per child annually. This number shows that the Abecedarian program costs nearly twice as much as Head Start. Providing the Abecedarian intervention to all the eligible Oregon Head Start children would cost more than 254 million dollars<sup>1</sup>.

The benefits to program participants in the form of lifetime earnings are examined in this analysis, as well as future benefits to the children of participants. Their results show that benefits to future generations are economically significant, and so these were included in the final calculation of benefits. The analysis of benefits also includes the effects of this program on health; specifically they focus on whether or not program participants smoke. The authors suggest that data on smoking behavior should be collected as a follow up to interventions such as this one. Social benefits of the program also include an increase in maternal education and earnings for mothers of children who participated in the program. Parents of children in this program experienced benefits; for example, they had higher income, lower welfare, fewer pregnancies, and more education. The total estimate of benefits came to \$135,546 (in 2002 dollars). In the end, they found that the overall annual rate of return on the Abecedarian Project was between 3% and 7%. This rate of return is lower than that for the Perry Preschool Program, primarily because the cost of operating the Abecedarian program was much higher since it was an all day, all year program.

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<sup>1</sup> (7329 [not served] + 10994 [served]) \* 13900 [Annual Cost per] = 254,689,700



## **Perry Preschool Program**

A similar study was done on the Perry Preschool Program, which was conducted in Ypsilanti, MI starting in 1962 with 123 participants over 5 years. Follow-up surveys have been conducted on the program participants at many ages, most recently at age 40. This experiment is similar in form to the Abecedarian project, however there are important differences. For one, the teacher made weekly home visits in addition to the regular preschool program during the week. This was done to ensure that the lessons taught during the day were being reinforced in the home environment. This aspect of the Perry Preschool Program is similar to the experiment conducted by Professor Neville; one of her interventions included a parent component. The educational techniques were based on the children's natural activities and play which were then supplemented by the teacher. More specifically, problem solving and planning techniques were emphasized. Also, children only participated in the program for an average of 2 years, from the ages of 3 to 5. This is unlike the Abecedarian project where participants entered the program around the age of 3 months. The Perry Project was also less intensive in that it was conducted for only 2 and ½ hours a day on weekdays from October through May.

A benefit-cost study of the Perry intervention was done by Lawrence J. Schweinhart in 1996. He used methods similar to those used for the analysis of the Abecedarian project to estimate the benefits and costs. In his paper he calculated a benefit-cost ratio of 7.16 to 1 for the public based on the results from the age-27 follow up, which does not include the direct benefits to each program participant. The Perry intervention was conducted in an area of higher crime rates than the Abecedarian Project, and for this reason the benefit-cost analysis of this project includes a reduced crime rate in its measure of benefits to society. Schweinhart found that the highest benefits came as a result of the reduced number of crimes committed by program participants. Other substantial benefits were the amount saved in schooling due to the decreased need for special education services and less grade repetition. The cost of the Perry Preschool Program was \$15,166 and the benefits to the public were \$195,621 when the program was evaluated at the age-40 follow up (these numbers were calculated in constant 2002 dollars with a discount rate of 3%). The benefit-cost ratio at the age-40 follow up was 12.9, compared to the ratio of 7.16 found at the age-27 follow up, which suggests that the

benefits of programs such as this one continue to increase over the entire lives of the participants.

James Heckman has also done research in this area and came up with his own analysis of this program, among others. Heckman's research found that the average annual rate of return on the Perry Preschool Project was approximately 16%. This can be broken down into a 4% rate of return for program participants and a 12% rate of return to society. He did not calculate a rate of return on the Abecedarian Project because he claimed that the cost-benefit analysis done by Barnett and Masse was "highly speculative." In his paper he also argues that the benefits from programs like this are so high that the program may still be cost-effective even with a decrease in its effectiveness.

### **Chicago Child Parent Centers**

The Chicago Child Parent Centers project is illustrative of the fact that early interventions are the most effective and provide the highest benefits. This program included three interventions at different ages, so that they could compare the resulting benefits between each intervention group. The results of a follow-up cost benefit study done when the program participants were 21 years old shows that the preschool age intervention yielded the highest return per dollar invested. (Reynolds, et al. 2002) The Chicago CPC program is federally funded and operated at many public schools throughout the Chicago area beginning in 1967. It primarily serves children in low income families. The participants in this study were born in 1980, making the results used in this analysis more recent than those of the Abecedarian and Perry Preschool projects. This experiment did not use random assignment, but instead employed a method of "matching" participating children with a set of similarly characterized children to use as a control group of sorts.

There were three different designs of the Chicago CPC program which participants took part in. One was only a pre-K program that was attended from age three to five. Another program was called an "extended intervention" that lasted 4 to 6 years beginning with preschool. There was also a third "school-age" program that was for children in grades 1 through 3. The services provided were similar to those of a Head Start program, and the curriculum focus was basic language and math skills. Language

exercises concentrated on improving word analysis, oral communication, and listening skills. (Reynolds, et al. 2002) Class sizes were small and the program included a parent component, also much like the Head Start program.

Five categories of long term benefits have been analyzed for the Chicago CPC study, and they are: 1.) reduced expenditures on grade repetition and special education services; 2.) reductions in criminal justice system costs; 3.) reductions in child welfare expenditures; 4.) avoided costs to potential crime victims; and 5.) increased earnings of participants and the associated increase in tax revenues. The return on each dollar invested into the preschool program was found to be \$7.14. For the “extended intervention” program this number was \$6.11 and for the “school-age” program it was \$1.66. These numbers suggest that the earlier, shorter interventions produce the highest benefits per dollar invested. Not only was the return on investment highest for the preschool program, which could just be attributed to the lower costs of a shorter intervention, but participation in the preschool program was associated with nearly every child outcome measured, while the school age intervention was associated with fewer positive child outcomes. (Reynolds, et al. 2002) Another interesting result of this benefit cost analysis is that the benefit cost ratio for one year of preschool is almost twice as high as the ratio for two years of preschool; these ratios are 12.02 and 5.05, respectively.

The literature on programs such as these has important implications for our project. Since we do not yet have long term results on the effects of Professor Neville’s intervention, we will use the results of these previous studies to link her results to what we expect the long term benefits of her intervention to be.

## **Head Start**

As was shown earlier there have been several studies of high quality early intervention programs that show long term benefits as a result of the programs. However, the focus of a study titled “Longer Term Effects of Head Start” is to examine the long term effects of a federally funded program like Head Start (Garces, Currie, et al. 2002). Head start is generally considered to be of medium success when compared to other more intensive programs. It is important for us to examine the proven benefits of Head Start because it is the platform from which Dr. Neville plans to build her high quality

neurological developmental intervention. Her plan is to make a marginal improvement in the quality of the program in order to increase the amount of benefits that have already been shown to exist. Head Start is not as intensive as the other programs mentioned here, but there are still significant benefits associated with participation in the program.

This study of Head Start does not have the same experimental design as the Perry Preschool or Abecedarian programs, because there is no true control group and the analysis is being done retrospectively. Because of this, there may be some selection bias in the sample for this study. Since there has been no direct follow-up on the children participating in the Head Start program, the authors use the Panel Survey of Income Dynamics (PSID) to analyze the long term benefits. Questions about Head Start participation were added to the PSID in 1995. Family background and home environment can be controlled for using the PSID since it has been conducted over a long period of time on the same set of families. However, omitted unobservables could bias the results.

Other studies have shown that the short term cognitive benefits from Head Start fade out after the children's first few years in school, which is also the case in higher quality intervention programs (see Steven Barnett [1995] and Lynn A. Karoly et al [1998] for more). However, using the PSID to retrospectively look at the long term effects on Head Start participants this analysis shows some significant benefits, primarily for white participants. Four long term outcomes are analyzed: high school completion, college attendance, income, and criminal activity. We believe that even though some of the benefits in cognitive ability fade out with time they still have lasting effects for a participant in the form of general personality traits such as work ethic and other less measurable cognitive benefits that emerge as a result of increased dedication to learning.

The results of the analysis show that there is a significant positive effect on the high school graduation rate for white participants (when controlling for family background by using siblings as a control group). However, there was shown to be no significant effect in this area for African-Americans who participated in Head Start. When looking at college attendance, their results show that when family background is controlled for, children who attended Head Start are 28% more likely to attend college than their siblings who attended no preschool, and about 20% more likely than siblings

who attended other preschools. The siblings control for family background and most other unobservable variables to isolate and confirm the real effect that Head Start has for children. These effects pertain only to white individuals because there were no significant effects found for African-Americans. As for the effect of Head Start on earnings, there was little significant relationship between these two factors. Here they only looked at the earnings of each individual who reported working between the ages of 23 and 25. The authors of this study suggest that at these ages it may be too early to detect long term effects on earnings. The only significant effect of Head Start on earnings was found to be for white children of high school dropouts. The final outcome that is analyzed -- incidence of criminal activity -- is the only one to show significant effects for African-Americans.

This analysis of the Head Start program shows that for white children there are long term benefits in the form of improved education outcomes and higher earnings. For African American children, participation in the Head Start program was shown only to decrease the long term incidence of criminal activity. (Garces, et al. 2002)

There are significant benefits in the very short run for both African American and white children who participate in Head Start. However, these benefits fade out very quickly for the African American children, while white children show retention of benefits over a longer period of time. (Garces, et al. 2002; Currie and Thomas, 1995) The authors attribute this difference to the different environments faced by white and African-American children after the completion of Head Start.

## **Support for Early Childhood Education**

“Learners learn and skill begets skill.” -- James Heckman

### **Economic Productivity Argument**

The importance of early education to the economy has also been studied by James Heckman. He wrote a paper with Dimitri Masterov titled “The Productivity Argument for Investing in Young Children” (2004). Their interest in this topic comes purely from an economic standpoint. They have made the argument that quality early education programs will create a more productive workforce in the future. They see early education as a valuable business investment due to the high returns on human capital that have been shown to occur as a result of experiments on early interventions. In their paper they also state that interventions early in life are more effective than attempts at later intervention, which has also been found in Professor Neville’s research and is backed up by results from programs like the Chicago Child Parent Centers.

### **Benefits to Society Argument**

Some of the highest benefits to society in these studies have come in the form of reduced crime rates. Criminal activity creates an enormous burden on society because of the high costs of the judicial system and incarceration. Increases in education and high school completion are shown to decrease the likelihood that an individual will engage in criminal activities. Therefore, education may have large societal benefits that typically go unnoticed by the individual. Previous studies have found a negative relationship between cognitive ability and unskilled crime. Increasing education and cognitive abilities of children at a young age will reduce the burden on society in the long run by lowering crime. (Lochner and Moretti, 2001) James Heckman has also dedicated time to the study of crime as it relates to early childhood education. He has said that, “Enriched early childhood programs appear to reduce future crime, and in the long run they are the least-cost, most effective way to reduce crime, far more effective per dollar than additional expenditures on police or incarceration.” (Heckman and Masterov, 2005)

## **Evidence from Neuroscience**

The human brain is an organ designed to adapt and reshape in response to experience. Children at the age of two have twice as many neuron connections as adults. From this point until the age of 16, the brain systematically eliminates those neurons that are least efficient, i.e. those stimulated by others least often. This is a critical process in shaping the future ability of the brain. Many other mechanisms are at work during these critical years. Brain malleability is maximized in the first few years of experience, though modifications will still continue at a diminishing degree. Stimulus during this time has lifelong effects on brain development, behavior, learning, and memory. After the critical age, the brain may be restricted from systematic change to making proximate synaptic modifications. (Mundkur 2005)

Janet Currie also explains that the case for early interventions can be made based on evidence from neuroscience. She cites a previous study by Gopnik, Meltzoff, and Kuhl (1999) which shows that the preschool years are a critical period in the formation of neurological connections that can last for a lifetime. Their research shows that early in life the brain undergoes a process of selective “synaptic pruning” where weak connections are eliminated and others are strengthened. This has important implications for our project, because we will be using the evidence of early neurological changes in children to evaluate the long-term benefits of Professor Neville’s intervention.

Certain types of learning are more likely to occur or are more valuable early in life. One example of this would be language – the structure would be important to learn early. Early language development would maximize syntax and vocabulary absorption from proximate background conversation and facilitate mastery of the language. Prehistorically, humans would not be likely to need complex conversation with others that did not speak their language. Even during interactions outside of their groups, they would be unlikely to encounter a language fundamentally different than their own.

Language exposure during critical early years of childhood development is often required for adequate language acquisition. Exposure during this time is so important that it seems to have a stronger affect on later command of language than general intelligence or the quality of instruction. (Briscoe 2000) There is a 20% drop in the likelihood that adults will rate their language proficiency as very good if they immigrated

at age five compared two about age 1. The drop is nearly 40% if they arrived at the age of 10. After controlling for the length of time lived in the U.S. and other variables such as socio-economic status, the importance of age at immigration is of course slightly diminished. Most interesting is the fact that almost all of the variation associated with the age of immigration occurs before the age of 10 –almost all of which is in the first 5 years. (Stevens 1999) (see figure 1)

## **Characteristics of Effective Interventions**

Janet Currie is an economist who has dedicated much time and effort to the study of early intervention programs. In her paper “Early Childhood Intervention Programs: What Do We Know?” she identifies the most important factors in determining whether or not an intervention will produce lasting benefits. These factors are: long-term increases in IQ, improved attention, and better self-control. A successful intervention should encourage social-emotional and psychological growth as well as improvement in cognition.

As Janet Currie proposed in her paper, self control is a defining characteristic of individuals who have success later in life. Children that are able to delay gratification are more likely to be academically successful and make healthier life choices. The ability to self regulate is a valuable behavioral characteristic which has been shown to make individuals less aggressive and violent. Differences in self control are apparent early in life and tend to last throughout life. (Wulfert, Block, Santa Ana, Rodriguez, and Colsman 2000) The effects of differences in delayed gratification on life can be seen as early as age 4. A study on delay of gratification showed that a preschooler’s ability to self-regulate their desires is significantly linked to certain personality qualities in adolescence, such as coping and competence. “The seconds of time preschool children were willing to delay for a preferred outcome predicted their cognitive and social competence and coping as adolescents, as rated by their parents a decade later.” (Mischel, Shoda, Peake, 1988)

The importance of teaching non-technical skills such as the self discipline needed to delay gratification and avoid crime has gained attention lately. Angela L. Duckworth and Martin E.P. Seligman found that the ability to delay gratification is much better at



explaining variation in “every academic-performance variable” than IQ is. It can account for twice as much variation in GPA. (Duckworth & Seligman December 2005) The problem of not being able to delay gratification becomes even worse in the situations of uncertainty faced by children from low socio-economic backgrounds.

## **Argument for Short and Intensive Intervention**

It is our hypothesis that providing short yet intensive early interventions will produce the greatest gains because the returns on investment diminish later and with greater levels of investment.

In the Chicago CPC intervention three educational periods were evaluated: a pre-kindergarten only group, pre-kindergarten through 3<sup>rd</sup> grade, and 1<sup>st</sup> or 2<sup>nd</sup> through 3<sup>rd</sup> grade. The sample of children that were only given the special intervention before kindergarten showed the highest returns. Very telling is the fact that the second highest return on investment came from the second group that had special instruction from pre-kindergarten all of the way through 3<sup>rd</sup> grade. This method has isolated the group of students that only received the special education between 1<sup>st</sup> or 2<sup>nd</sup> grade through 3<sup>rd</sup> as having the lowest return. The Abecedarian program also had a similar design where they isolated a preschool-only group. The results of this study concur with those of the Chicago CPC study in that the preschool-only group provided the highest returns per dollar invested.

In fact, the Chicago CPC study was first done to make sure that no permanent harm was being done during these sensitive years. The fear of doing damage by early education turned out to be unwarranted; however, the theory behind why the possibility *existed* for doing great harm seems accurate. There are two reasons that we can use to explain why this theory is true, why longitudinal studies of previous programs such as the Abecedarian, Perry Preschool, and Chicago CPC childhood interventions have delivered such substantial benefit.

There are two explanations for the substantial return on investment seen in the longitudinal studies of previous interventions such as the Abecedarian, Perry Preschool, and Chicago CPC.

The first is a cognitive fitness argument as explained in the neuroscience section of the literature review. Studies show that the human brain has the most plasticity before the age of five. This is the age when manipulation is easiest and most durable; shortly afterward the neurological structure will gel.

Even in adults, there is evidence that adult brain structure will evolve after learning to juggle. Previously it was thought that the brain matter in adults is not responsive to stimulus. (Harding et al, 2004) After childhood the brain does continue to develop; however, these changes are limited in scope; certain regions of the brain do not change much after adolescence is reached. (Sowell et al, 1999) This can be seen in the evidence showing that an essential component of normal language development is the exposure that one has before the age of five.

The second explanation is much more of a rational argument. The sum of all that a person is and will be (their actions, personality, and ability) is fully explained by only two variables: the initial biological instructions and how the person uniquely processes their unique external experiences. The relevant variable for explaining the human condition is the experience. This is a powerful factor because each phenomenon compounds in importance by restructuring values, worldview, and expectations about future actions. For example, if the value of planning for the future is taught at a young age it will initiate planning and prime the person for recognition of the reward, further reinforcing the behavior.

Our cognitive bias toward devaluing future experiences is well known and ubiquitous. (Frederick et al, 2002) We believe that experiences, in the form of what we will call intellectual capital, compound in a similar way as financial interest. Firms are willing to pay extra money later to receive assets in the present. In part, this is because the company plans to use the funds now to create something that will be valued at more than the original loan in the future. For the same reason, it will be far more valuable for children to get a taste for education and success early on in life than later. Children must build a cognitive and psychological infrastructure that will be dedicated to further achievement and growth that will allow them to realize their full potential.

A study by Mischel, Shoda, and Peake shows that variation in the cognitive traits of young children, such as the willingness to delay gratification, is persistent and also

associated with an array of other beneficial behaviors later in life. (Mischel et al, 1988)  
This evidence suggests the possibility of dynamic compounding of early traits.

A statistical study by Ross and Wu (1996) supports the theory of cumulative advantage from compounding educational experiences. Even when controlling for variables such as income, they showed that the advantage of education for health increases with age. Highly educated individuals diverge from those with low education by a function of time.

It is not uncommon for summary studies examining the effects from many programs to quote benefits with large spreads. This is consistent with what we would expect to see from the compounding effect of small variations in education curriculum, or maybe from other inconsistencies in program methodologies.

From this evidence we believe that the most cost effective method of pedagogical instruction is one that is relatively short yet intensive, with a focus on improving the brains of young children. Efforts undertaken later or for a longer duration will face diminishing (though likely still positive) returns.

## **Helen Neville's Intervention Results**

So far Professor Neville has only short term results on the success of her interventions. However, as we argue above, there is evidence that short term improvements in language skills and non-verbal IQ can lead to more substantial benefits in the future. Professor Neville has results from four different tests: core language, expressive language, receptive language, and non-verbal IQ. All children who participated in the study were pre and post-tested in these categories. The results are reported in raw scores, standardized scores, and percentile rankings.

Two control groups, a small and a large, were used to isolate different benefits in the program. The large control group used students that took part in the normal Head Start class only. Both of these controls use the same Head Start modeled education but have different class sizes. The difference between the large and small groups isolates the benefits associated with using the normal Head Start curriculum with the individual attention that comes from smaller groups. The small group control will be used to isolate what benefits are created by the targeted interventions that differ from Head Start.

The results show positive changes in the mean differences of pre and post-test scores for all cases except the attention intervention and large group control for the non-verbal IQ measure. The attention intervention was the most effective at improving core language scores. The language intervention was most effective at improving expressive language skills, which is a logical result. The small group control showed the greatest improvements in receptive language skills, with the attention intervention results a close second. Finally, the language intervention was also the most effective at improving non-verbal IQ. These results show that the language intervention was generally the best at improving scores; the intervention showed the greatest improvements for two out of the four tested categories.

While these are preliminary short term results, from small samples, the most likely conclusion is that the intervention is successful in making improvements in the preschoolers' cognitive abilities. Preliminary results from brain imaging and cognitive response times do seem to confirm that the intervention has had neurological effects that appear to be beneficial. The altered brain functioning is being linked to adults in an attempt to show that the neurological changes are indeed associated with beneficial traits later in life.

From the preliminary results, we would expect to see an increase in non-verbal IQ of about 8 points, almost one standard deviation. This estimated increase is under the assumption that there is an additive effect of the outcomes because every child participates in all three intervention activities. These gains in IQ are primarily a result of the language intervention group. The Perry Preschool intervention produced a 12-point gain in total IQ after the end of the two year preschool program. (See figure 2 in appendix) If only the nonverbal IQ gains were compared to Helen Neville's program they might be more comparable. The Abecedarian intervention showed a full 4.5 point improvement in IQ. (See figure 3 in appendix) Even just the nonverbal improvement in the participants of Helen Neville's program is higher than this. The Abecedarian produced a 3-7% rate of return and the Perry Preschool showed 16%.

## **Benefits & Costs**

This section will cover the analysis of benefits and costs for Professor Neville's intervention. Analysis of benefits is quite speculative since we do not yet have long term results. Rather than put a monetary value on the benefits at this early stage, we will describe the type of benefits that can be expected from this type of intervention. However, we created a table of benefits that were found in previous benefit cost studies to use as a comparison. The costs section estimates the actual cost of the intervention done by Professor Neville, and we also explore a few alternative scenarios for the design of the intervention.

### **Benefits**

Using the initial results from Professor Neville's intervention, we can make some speculations as to what the future benefits might be. Her program produced gains in non-verbal IQ in only 8 weeks that are sufficient enough to expect even greater increases if the intervention program was implemented long-term. The total gain in non-verbal IQ from all three interventions combined was approximately 8 points after only 8 weeks of the program. We can compare these improvements with those from the Perry Preschool Project which also has long term results and proven benefits. As was stated in the previous section, the Perry intervention produced a 12 point gain in total IQ by the end of the two year preschool program. Based on preliminary results it seems reasonable to assume that if Professor Neville's intervention was extended it would produce results similar to the Perry program. Even if the early gains in IQ fade out, there are still long term benefits, evidenced by the Perry program. We can link benefits from the Perry program to the expected benefits from Professor Neville's intervention because they are quite similar in intensity and quality. From programs such as these there are short, medium, and long term successes that can be expected and which translate into monetary benefits to both the individual and society. These are listed below with brief explanations as to their meaning and importance. To give a better sense of the magnitude of the medium and long term benefits Table 2 in the appendix lists the explicit monetary benefits quoted in previous benefit cost studies of the Abecedarian, Perry, and Chicago programs.

We believe that the fadeout issue is not necessarily a problem. Positive experiences and improved ability at an early age could make a huge difference for a child about to move into a larger school atmosphere. A 15 point increase in IQ is about 1 standard deviation in intelligence. A 4 year old in the 20<sup>th</sup> percentile could become above average by the time that he or she arrives in school. This would facilitate participation and interest in the curriculum as well as make the learning experience positive instead of something to be feared or disregarded as useless. This translates in less direct but still measurable benefits such as writing and math ability and later educational achievement and reduced crime. Dr. Neville's sub-programs do not focus simply on IQ improvement; there are longer term goals such as planning, coordination, emotional intelligence and critical creative thinking. This is supported by a recent Michigan School Readiness Program which found that "Program participants were rated as being more interested in school, more likely to have good attendance, more likely to take initiative, had stronger backgrounds in reading, math, thinking, and problem-solving, and were better at working with others."

### **Short term success**

**IQ** – Short term gains in IQ have been shown to be a good indicator of cognitive improvement even if the changes fade out after a few years. Professor Neville's intervention has already shown success in this measure.

**Verbal skills** – Verbal skills are also quite necessary for early success in school, and this intervention has already made gains in this area.

**Math skills** – A solid foundation in basic math skills at an early age will be an advantage for young children who are about to enter school. Professor Neville does not yet have a measure of results in this area.

**Attention** – A child's ability to pay attention is crucial in school, especially in the early years when they are laying the foundation for the rest of their education. Attention is the focus of one part of this intervention.

### **Medium term success**

**Special education** – Previous intervention studies have shown that a large portion of the economic benefits come from reduced need for special education by the program

participants. Special education can be very costly, and studies show that once placed in special education children are not likely to leave the program, so prevention of the need for these services is a successful cost-savings mechanism.

Grade retention – Much like special education, grade retention is costly and can be prevented. Intervention studies show a considerable reduction in the number of program participants who repeat a grade.

High school achievement and graduation – Intervention program participation has been linked to better overall academic achievement and higher rates of high school completion. This serves as a benefit both to individual students and to society.

### **Long term benefits**

College attendance – college attendance creates a more productive workforce for the economy, and therefore produces net benefits, even after accounting for the high costs of attending college.

Employment – Preschool interventions are shown to increase the probably that its participants are employed. This is a benefit to both the individual and the economy because there are more people employed.

Income (Tax revenue) – This outcome is closely associated with employment. Not only are intervention participants employed more of the time, they also have been shown to have higher earnings. This not only beneficial to the individual in the form of higher income, but it is beneficial to society as a whole because it results in higher tax revenue.

Benefits to posterity – Some studies of early interventions have shown that the benefits of a quality preschool education translate into benefits for the children of program participants. These benefits tend to be smaller than other, but still substantial enough to include in the analysis.

### **Costs**

In order to calculate the costs of implementing the intervention designed by Professor Neville we used many numbers from the actual costs they incurred while

conducting their experimental interventions. Obviously, costs for a full-scale roll out will be different. We used several different sets of assumptions in order to get a range of plausible cost estimates.

The different cost scenarios we have proposed were recommended by Professor Neville and others who conducted the experiment. It is important that the quality and content of the intervention not be compromised and that the assessment of benefits (which are based on the quality of the intervention) be accurate. The following descriptions of alternative scenarios allow us to make a better estimate of the lower and upper bounds of the cost of this intervention. There is also a description of the design of the training session below.

### **Low Cost Scenario**

For one Head Start classroom of 18 students, the children will be divided into three groups of six. Each of the three groups will be in divided sections of the classroom to minimize distractions. The regular Head Start teacher will be in control of one group, the aide the second group, and an additional hired teacher will be in charge of the third group. There will also be an additional aide to assist in the intervention if necessary. All teachers and aides will be trained in the methods necessary to properly implement the intervention just as it was designed. The three groups of children will go through the interventions simultaneously, for 40 minutes. This arrangement will be the most cost effective, because it minimizes the time needed to conduct the intervention for all 18 students, while maintaining the quality of the intervention. Also, it does not require an additional classroom but may still make use of one if it is available.

### **High Cost Scenario**

In this case, we will assume that there is a need for an additional classroom in order to conduct the intervention. This means having the additional cost of renting that classroom, assuming that one is available in the first place. Now we would have to hire a teacher and an aide to conduct the intervention in the separate room. Another aide is necessary due to a Head Start policy prohibiting teachers from being alone with the children. In this scenario 6 children would be pulled out of the class of 18 for a 40 minute intervention. This would require three 40 minute sessions in order to serve all 18



students in a Head Start classroom. This arrangement is more costly because it requires paying for an additional classroom and using more time to complete the intervention.

### **Alternative Scenario**

Using two additional classrooms, with a teacher and an aide for each room, and pulling out 6 children into one room, and 6 into the other, leaving the last 6 in the original Head Start room. Then the intervention would be conducted for 40 minutes. This minimizes time, but has the additional cost of extra classrooms and a teacher and aide.

### **Training Session**

Implementing this intervention would require a training session to prepare the teachers in the methods used for the intervention. Each training session would train 6 teachers. It is designed in this way so that the teachers can actively participate in the intervention activities in groups of 6, just as the children would. This way they can learn to conduct the interventions by participating in the activities themselves. The training session would be a week long, with each day of training lasting 6 hours. A week long training session would ensure that the teachers understand both the theory and the practical aspects of the intervention so that they can implement a high-quality intervention.

The actual costs were broken down into categories of labor costs, materials costs, classroom costs, and training costs. Labor costs include the salaries of the teacher and teacher's aide. Materials costs are for the actual materials needed to conduct the intervention. Classroom costs are just the cost of renting a classroom to carry out the intervention, and possibly paying a maintenance fee for the room. Finally, training costs include the cost of paying someone to train the teachers and aides and materials necessary for the training session.

Where the numbers come from...

#### Labor Costs

Oregon preschool teacher's hourly wage (mean): \$11.56 (Bureau of Labor Statistics)

Estimated teacher's hourly wage plus benefits: \$15.03  
Estimated teacher's aide hourly wage plus benefits: \$13.00

Materials Costs

Intervention materials: \$50.00

Classroom Costs

Monthly rental fee: \$800.00

Training Costs

Estimated trainer's hourly wage plus benefits: \$18.79  
Training materials: \$20.00

\*\*Benefits are estimated to be 30% of the hourly wage

Using the costs listed above we calculated estimates for the low and high cost scenarios using a spreadsheet. This spreadsheet is attached in full in the appendix, and relevant pieces of it are shown below. The numbers for the low and high cost scenarios were calculated for one Head Start classroom of 18 students for an intervention lasting 8 weeks. The cost of the program in the low-cost scenario was found to be \$37.31 per student. The high-cost scenario was found to have a cost of \$247.41 per student. The large difference in these costs is primarily due to the high cost of renting a classroom in the high-cost scenario. However, if this intervention was permanently implemented as part of the Head Start curriculum, it is reasonable to assume that the rental cost would be significantly discounted or that the entire cost of the extra room would be absorbed by Head Start. Therefore, the estimate for the high-cost scenario is likely an upper bound on the actual cost of this program.

The cost of the training session was calculated with the assumption that each session would train 6 teachers. The amount of the cost was found to be \$584.10 per teacher. This cost may seem relatively high, compared to the costs of the actual

intervention, but an intensive training session will create well-trained teachers that can carry out a higher quality intervention.

### Low Cost Program

one 40-minute session round up to one hour including set-up, etc..	
one additional teacher	\$15.03
one aide	\$13.00
no extra room needed	
Teacher's wage 4 days a week for 8 weeks	\$480.90
Fidelity checks: 2 per 8 weeks, 3 in the same room (2x3)	\$112.71
Intervention materials	\$50.00
Total	\$671.63
<b>Total per student (18 students per class)</b>	<b>\$37.31</b>

### High Cost Program

three 40-minute sessions equals 3 hours total per day, multiply hourly wage by 3	
one additional teacher (for 3 hours)	\$45.08
one teacher's aide (for 3 hours)	\$39.00
extra room needed	\$800.00
Teacher's wage 4 days a week for 8 weeks	\$1,442.69
Teacher's aide wage 4 days a week for 8 weeks	\$1,248.00
Fidelity checks: 2 per 8 weeks, 3 interventions	\$112.71
Intervention materials	\$50.00
Cost of extra room for 8 weeks	\$1,600.00
Total	\$4,453.40
<b>Total per student (18 students per class)</b>	<b>\$247.41</b>

### Training Costs:

For full day of training - 1/2 theory, 1/2 hands on	
For 6 teachers at once	
Trainer's hourly wage (teacher's wage + 25%)	\$18.79
Teacher's wage	\$15.03
Materials (videos, etc.)	\$20.00
Assume a week (5 days) w/ 6 hour days of training:	
Trainer's wage	\$563.55
Teachers' wages	\$2,705.04
Materials	\$20.00
Total	\$3,288.59
<b>Total per teacher (6 teachers)</b>	<b>\$548.10</b>

## Conclusions

From this evidence we believe that the most cost effective method of pedagogical instruction is one that is relatively short but intensive, with a focus on improving the brains of young children. Efforts undertaken that are later or longer will face diminishing (though likely still positive) returns. Because we are dealing with limited resources and diminishing marginal productivity, we believe that Helen Neville's system of child brain exercise and education is an ideal solution. Eight weeks of intensive training will cause proven measurable changes in the cognition of three and four year olds at a very low cost. These changes in intelligence and psychology will have a lasting impact on achievement that is expected snowball with time.

Previous interventions explored in this paper are longer than the one proposed by Professor Neville, but the outcomes and results of benefit cost studies show that large benefits accrue based on small improvements in the child's learning environment early in life. The types of stimulus will affect the changes to brains and psyches of children taking part in an educational program. Some changes are also known to have greater lasting benefit than others. Specifically tailoring a short pre-k intervention, that is proven to deliver developmental results, to target these effects would be a cost effective investment in human capital.

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## Appendix

**Table 1:** Comparison of Previous Studies and Professor Neville's Intervention

	<b>Program focus</b>	<b>Short Run</b>	<b>Medium Run</b>	<b>Long Run</b>	<b>Rate of Return</b>
<b>Abecedarian</b> 1972-1985 N=117	Full-day Cognition Fine motor skills Social development Language	IQ Reading/math skills Maternal employment & earnings	IQ Grade retention Special education	High school completion College enrollment Health (smoking)	7%
<b>Perry Preschool</b> 1962-1967 N=123	Half-day Based on children's natural play Planning skills	IQ Language Behavior	IQ Special education Juvenile delinquency Teen pregnancy Academic achievement	Employment High school completion Arrests Income Welfare use	16%  7.16 to 1 benefit cost ratio at age 27 follow up 12.9 to 1 at age 40 follow up
<b>Chicago CPC</b> 1967-present N=1539	Half-day program Basic language and math skills	Reading/math skills	Grade retention Special education Crime/delinquency	High school completion Arrests	18%  \$7.14 per dollar invested at age 21 follow up
<b>Head Start</b> (retrospective analysis using PSID) 1965-present N=4000	Half-day Learning skills Social skills Health status	Vocabulary	Academic performance (vocabulary tests) Grade retention Immunization Height	High school completion College enrollment Income Criminal activity	
<b>Professor Neville's Intervention</b>	Language Attention Music Overall cognition	Core, receptive, expressive language skills Non-verbal IQ			Comparable to Perry



**Table 2:** Summary Table of Benefits  
 Benefits per participant in 2002 dollars (some in 2000 dollars) with 3% discount rate


**Figure 1:**

AGE AT IMMIGRATION AND SECOND LANGUAGE PROFICIENCY

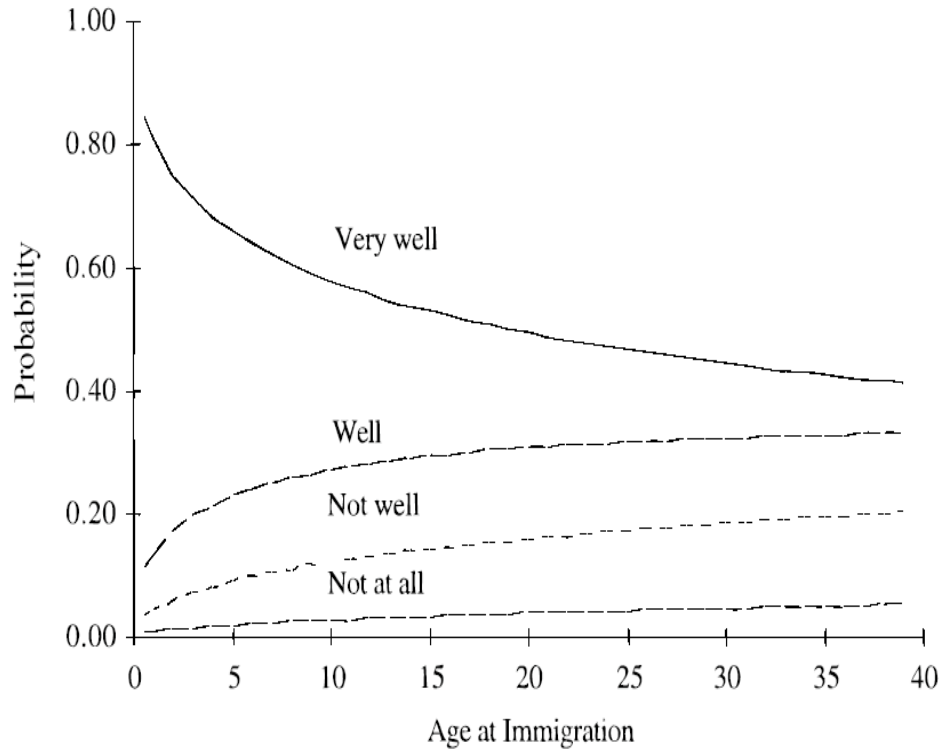


FIGURE 5: Predicted probabilities of immigrants speaking English “very well,” “well,” “not well” or “not at all” by age at immigration to the U.S. net of length of residence and other social and demographic variables.

Figure 2:

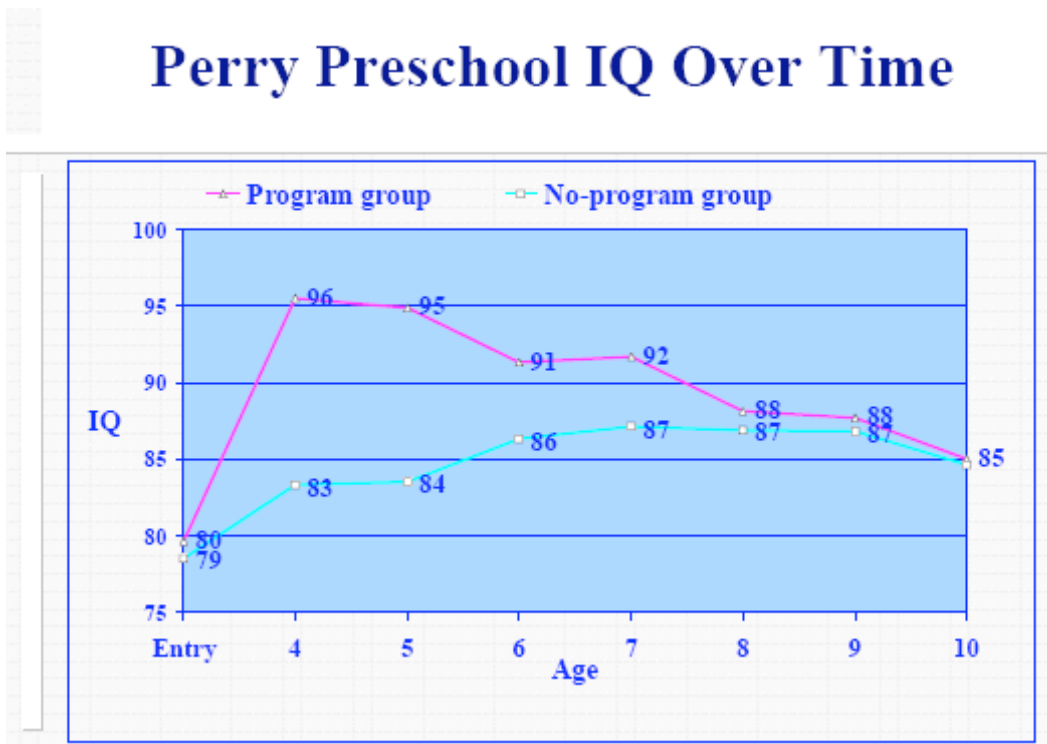
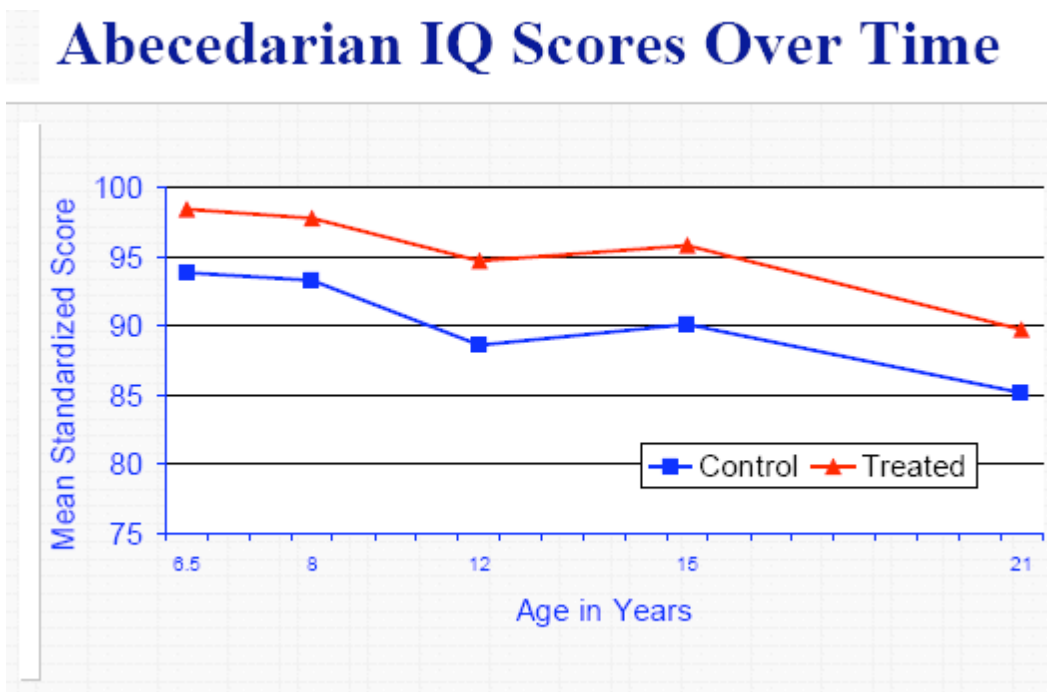


Figure 3:



# Costs Spreadsheet

\*\*\*estimates or assumptions are in blue\*\*\*

Program design: 6 children, 1 teacher, 1 aide  
40 minutes/day, 4 days/week

Low Cost: use existing Head Start room

High Cost: use additional room for intervention

## Costs

for one Head Start classroom of 18 children, 8 weeks

### Labor costs

Teacher Salaries:

dependent on qualifications, certification  
english vs. bilingual?

Preschool teachers hourly wage (mean) \$11.56

benefits (assume 30% of wage) \$3.47

**Total hourly wage (teacher) \$15.03**

Teacher's Aide hourly wage \$10.00

benefits (assume 30% of wage) \$3.00

**Total hourly wage (aide) \$13.00**

Fidelity checks

Direct Assesment (twice per intervention period) \$18.79

this is just trainer's hourly wage, 1 hour = 1 fidelity check

two days of observing, same length as intervention

cost is paying the trainer to do the fidelity checks

### Materials Costs

Materials for intervention \$50.00

### Classroom Costs

available room - monthly rental fee + maintenance \$800.00

for high cost scenario only

### Training Costs:

For full day of training - 1/2 theory, 1/2 hands on	
For 6 teachers at once	
Trainer's hourly wage (teacher's wage + 25%)	\$18.79
Teacher's wage	\$15.03
Materials (videos, etc.)	\$20.00
Assume a week (5 days) w/ 6 hour days of training:	
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### Low Cost Program

one 40-minute session	
round up to one hour including set-up, etc..	
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no extra room needed	
Teacher's wage 4 days a week for 8 weeks	\$480.90
Fidelity checks: 2 per 8 weeks, 3 in the same room (2x3)	\$112.71
Intervention materials	\$50.00
Total	\$671.63
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### High Cost Program

three 40-minute sessions	
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Cost of extra room for 8 weeks	\$1,600.00
Total	\$4,453.40
<b>Total per student (18 students per class)</b>	<b>\$247.41</b>

Most schools don't have extra room --> low cost scenario  
 1/6 or 2/6 would have an extra room to rent --> high cost scenario