

## Starting off on the Right Foot: One Year of Behavior Analysis in Practice and Relative Cost

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### Abstract

Strong evidence exists for the efficacy of behavior analytic approaches with children on the autism spectrum (Carr & Firth, 2005; Weiss 2001, 2005). Many early childhood intervention studies report outcomes based on pre-school populations (Smith, 1999; Casto & Mastropieri, 1986) while outcome studies for younger populations are scarcer. We reviewed one year of instructional outcome data from an early intervention classroom that used applied behavior analysis in concert with verbal behavior. The population served was two and three year olds with pervasive developmental disorder (PDD). Special instruction was provided in individual and in group formats using learn units as the basic unit of instruction. Ninety-five percent of the children in this program progressed to lesser restrictive environments. A cost benefit analysis showed the relative dollar amounts of the learn unit, instructional sessions, and objectives met for one year.

Keywords: early intervention, applied behavior analysis, learn units, cost benefit analysis, pervasive developmental disorder, verbal behavior

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Applied Behavior Analysis (ABA) program models have been effective in the remediation of learning problems for young children with pervasive developmental disorders (PDD) and language deficits for decades (Anderson & Romanczyk, 1999; Cooper, Heron, & Heward, 1987; Lovaas, 1987; Greer, McCorkle, & Williams, 1989; Twyman, 1998; Greer, 2002; Greer & Ross, 2008; Weiss 2001, 2005). Early intensive and behavioral interventions are generally accepted as one of the most effective treatments for children with an autistic spectrum disorder (ASD)<sup>1</sup>. Most public and private schools that serve students with PDD provide instruction in a one to one format which has been the hallmark of many traditional ABA programs. Under these conditions students with disabilities may have few, if any, opportunities to learn in a group setting with their peers. The Children's Center for Early Intervention, Inc. in Brooklyn, New York (CCEI) comprehensively aims to enhance language and communication, social/play, pre-academic skills of young children in one to one and group formats.

CCEI provides ABA services in an environment which combines discrete trial training and natural environment training by delivering learn units across these settings (McGee, Morrier, & Daly, 1999; Weiss, 2001; 2005). This allows each student to benefit from the one to one programming while also including group program instruction. All program intervention methodology is based on the science of the principles of ABA. Special instruction is the primary service that the children receive at CCEI. ABA is applied comprehensively throughout each daily session in concert with the curriculum objectives of verbal behavior (VB) (Greer & Ross, 2008; Kates-McElrath & Axelrod, 2007; Skinner, 1957). State mandated related services (e.g. speech and language therapy, occupational therapy, physical therapy) are provided outside of the classroom as a "pull-out" service. Inside the classroom, the daily ABA structure is two-fold.

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<sup>1</sup> *Clinical Practice Guideline: Report of the Recommendations*. Autism/Pervasive Developmental Disorders, Assessment and Intervention for Young Children (Age 0-3 Years) New York State Department of Health. 5½" x 8½", 322 pages. 1999 Publication No. 4215

Within the classroom, children can receive ABA special instruction in the traditional format, from one teacher (e.g. one to one), or in a group setting. Group was considered a “group setting” referring to the students attending within a group of three or more peers, however, each child still continues to receive one to one individual consequences for all responses. Teachers at CCEI use the same ABA data based conventions when instructing one to one or in a group. One teacher reads a story, or sings a song with imitation opportunities to the group of children, while the assistant teachers will sit behind the children and prompt and reinforce as well as record data in real time. Furthermore, group instruction is individualized and data based in the same way that the one to one programs are applied. Progress is recorded immediately, and then graphed daily. Decisions are made on the graphs based on a data decision protocol (Greer, 2002; Keohane, 1997; Keohane & Greer, 2005), and research based tactics are applied as needed (Greenberg, 2007).

This paper presents a report of one year of data from a center-based early intervention (EI) class at CCEI. We will highlight the program’s behavior analytic components and include the results of the instruction expressed in a cost benefit analysis showing the relative cost in dollars.

### *Population*

The EI children enrolled in the center-based program for the given year ranged in age from twenty-three months to 42 months of age. The verbal behavior, social and cognitive repertoires of each child varied, however, all children had severe delays across these domains. Specifically, verbal behavior functioning ranged from pre-speaker and pre-listener to speaker and listener behaviors. Approximately 80% of the children had severely limited speaker as well as listener skills. Social skills were also severely delayed as is generally characteristic of children having PDD. All children in the center-based program were self-ambulatory. None of the children had serious medical conditions, although one child experienced seizures at the start of the center-based program. Of the 24 students, one child resided in foster care.

### *Interdisciplinary model*

CCEI provides services in an interdisciplinary model using ABA, speech and language therapy, occupational therapy, physical therapy, natural environment training, and family support. Our model of ABA is applied to young children with disabilities in an EI program by professional staff that collaborate about effective treatments on a daily basis. The teams work together with a focus on the individual child. Parents are a central part of our interdisciplinary team. We provide family training and family support groups monthly. Parents are encouraged to be active members of the treatment team. Their input is necessary with regard to individual child deficits, family situations, and cultural issues. In addition, parents receive training regarding specific behavioral techniques to foster the generalization of skills in their home and communities through a monthly support group meeting.

CCEI borrows many of the components from CABAS® schools, however the program is based on the that model and incorporated the following CABAS® components in its’ program: LUs<sup>2</sup>, PSI modules<sup>3</sup>, TPRA’s<sup>4</sup> and data decision analysis<sup>5</sup>.

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<sup>2</sup> The Learn Unit, Greer (2002)

<sup>3</sup> PSI Modules are used in CABAS® Schools

<sup>4</sup> TPRA (Ingham & Greer, 1992)

<sup>5</sup> Data Decision Analysis (Keohane, 1997; Greer 2002; Keohane & Greer, 2005).

### *ABA special instruction*

CCEI provides home-based and center-based services. The data reported within this study are limited to the center-based program. Each of the 24 children targeted were enrolled in a 10-hour weekly ABA program. A majority of the children's programs were supplemented by ten hours of homebased ABA special instruction. The specific components of the center-based program were as follows.

#### *Discrete trial training and Learn Units*

Discrete trial training (DTT) using learn units (LU) is an intensive, structured teaching program. Each skill taught was broken down into its simplest elements and smallest step possible for initial acquisition. The skills taught follow a developmentally and behaviorally sequenced curriculum based on the child's Individualized Family Service Plan (IFSP) through the EI program. There is a strong emphasis on the generalization of skills to more natural learning environments. The child was presented with an antecedent stimulus. The child's response (correct) was reinforced by giving positive reinforcement (e.g. verbal praise, a book, toy, edible). The child's response (if incorrect) was given a correction, and appropriate responses were modeled or prompted. Prompt levels may have varied from verbal or physical guidance to repeat the instructional antecedent. Prompts were faded as correct responding increased. As new behaviors were taught to mastery, acquisition tasks were added to each individual child's programs.

DTT is generally therapist directed. Target goals will include attending skills, non-verbal and verbal imitation, self-help skills, academic and social skills. The LU is a three-term-contingency that may occur in a scripted, automated, discrete, captured, interspersed or massed form (Greer, 2002).

#### *Natural environment teaching*

The natural environment teaching (NET) component relies on naturally occurring opportunities in the environment (e.g., group instruction, captured learn units) to promote learning (McGee, et al., 1999; Greer, 2002). Addition of this component emphasized child-directed activities (choices) while still incorporating the stimulus-response-consequence paradigm. Target goals included language, play and social skills. During NET, antecedents that may be child initiated were paired with multiple cues interspersed by the therapists

(Weiss, 2001, 2005).

All goal directed attempts by the child were reinforced to strengthen appropriate responding. The reinforcers were the natural consequences of the desired behavior. This approach began as a small component of a given child's two hour session per day. NET was expanded as they mastered skills, and increased the generalization opportunities.

#### *Verbal behavior*

Skinner (1957) presented the framework for the functionally independent verbal operants which has proven to be invaluable to practitioners setting out to teach communication skills to early learners. VB is a focused approach on teaching the specific components of expressive language (e.g., echoic behavior, mands, tacts, intraverbals) by emphasizing the *function* of a word as opposed to the *form* of a word. This approach has been effective in rapid skill development, functional communication training and reduction of inappropriate behaviors (Kates-McElrath & Axelrod, 2007; Greer & Ross, 2008).

### *Group instruction*

DTT/LU delivery and NET procedures continued during group instruction. The main difference is that students were not isolated into specific one to one settings. A group program or group setting consisted of a child engaging with generally three or more of his or her peers during an instructional period (two hours). During the group instruction, teachers may have positioned the children to be seated in a semi-circle arrangement facing the teacher who led the group. Teacher assistants (TA) sat behind each child to prompt, praise, reinforce, and record data throughout the group activity. Group instruction formats may have also occurred in a rectangular seating arrangement around a table for art activities, or on the floor, for music activities using various instruments. Therefore, the children continued to receive LUs parallel to their peers in an approximation of a typical group setting.

### *Teacher training (PSI)*

Staff instruction consisted of personalized systems of instruction (PSI). Treatment packages with decision analysis protocols, direct instruction of research based tactics and frequent observations by the supervisors. Supervisors presented content and modules that were completed weekly which included reading specific chapters in assigned texts, passing written exams on the content of the reading, and the clinical application of the subject matter. Training sessions were scheduled weekly and consisted of the delivery of instruction. Staff also received formal observations of their teaching procedures using the TPRA observation procedures mentioned above.

### *Data decision protocol*

The data decision protocol allowed us to monitor student progress and to make timely data based decisions regarding the next step in instruction, by analyzing the trends in the child's data. Based on the landmark dissertation by Keohane (1997), and subsequent research in Keohane & Greer (2005), the decision analysis protocol enable teachers using ABA to teach 2-3 times more objectives. This is a critical component to best practice ABA programs because it enables teachers to act like strategic scientists of instruction.

Both instructional formats at CCEI are individualized and involve data collection, graphing, data decision analysis, and the application of scientifically based tactics to ensure optimum instructional effectiveness and efficiency (Greer, 2002; Keohane 1997; Keohane & Greer, 2005; Greenberg, 2007).

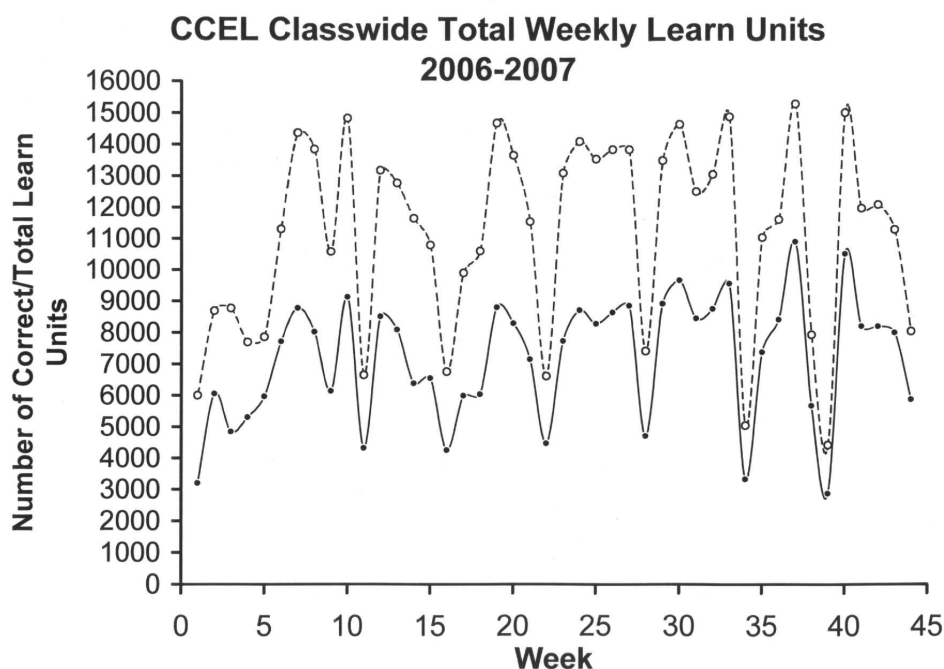
### *Supervision*

The instructional systems at CCEI are established and maintained using techniques from the science such as the Teacher Performance Rate Accuracy (TPRA) observation procedure (Ingham & Greer, 1992). Teacher performance/rate and accuracy (TPRA) measurements were administered through direct teacher and teacher assistant observation by supervisors who are board certified behavior analysts. The child's instruction was measured by dividing the number of three term contingency trials (learn units) by the rate of instruction in minutes. In addition correct responses and incorrect responses are monitored daily to measure response accuracy and learning. Teachers and assistants made graphic displays and analyzed the data daily using the Data Decision Analysis Protocol. Data decisions regarding interventions for decreasing trends or stable rates of responding were accordingly scripted. All data were graphed daily. An important feature of the TPRA is the interobserver agreement measure. This procedure ensures the direct observation and data collection recording techniques of the teachers are calibrated to those of the supervisor. Interobserver agreement ranged between 80% and 100% across all 183 observations.

Responsibilities of administrators included overseeing student data and implementation of student programs, monitoring staff performance, PSI module mastery, staff development sessions, and facilitating parent involvement. Overall administration of the program included maintaining interventions, utilizing the principles of applied behavior analysis, intensive direct instruction, curriculum development and implementation, and parent training and support group participation.

### Results

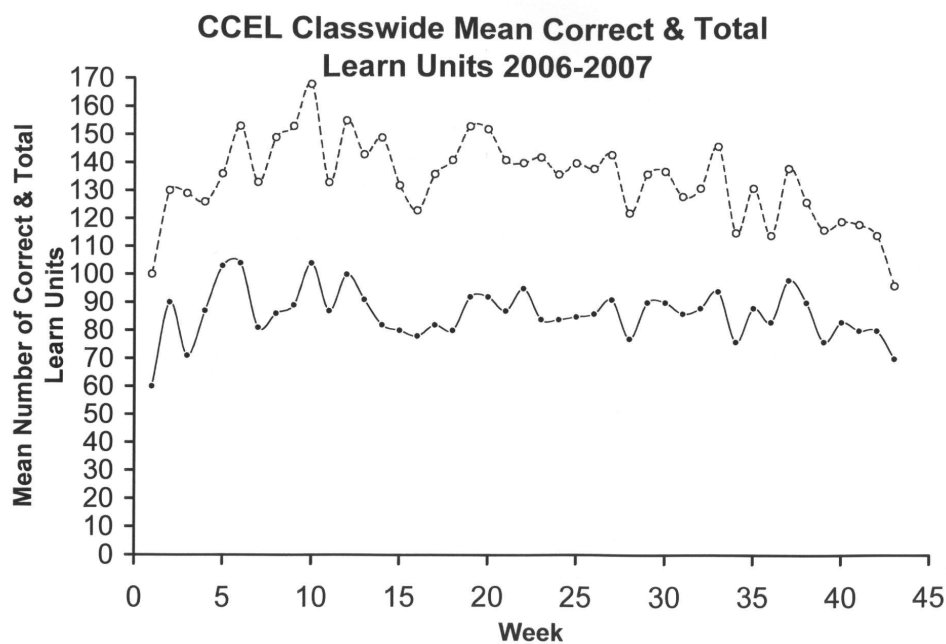
Figure 1 presents the total number of learn units presented and the total number of correct learn units for 24 children, across the 44 weeks of classroom instruction. Visual graphic displays were established and maintained weekly and posted in the classroom each week. The total number of learn units presented was 490,807 and the total number of learn units correctly responded to by the students was 315,680. The mean number of correct learn units was 7175 with a range of 2871, 10904, while the mean number of presented learn units was 11155 with a range of 4413, 15281. The trends are highly variable due to the variation in the number of days per week of school. Most weeks of school were five days; however, due to holidays and the school calendar some were two, three, or four days.



*Figure 1.* Total number of correct (closed circle) and presented (open circle) learn units class wide for each of 44 weeks of instruction (1 year) at The Children's Center for Early Intervention. Instruction occurred across verbal behavior, academic, social, emotional/affective, self-help, and physical/motor areas.

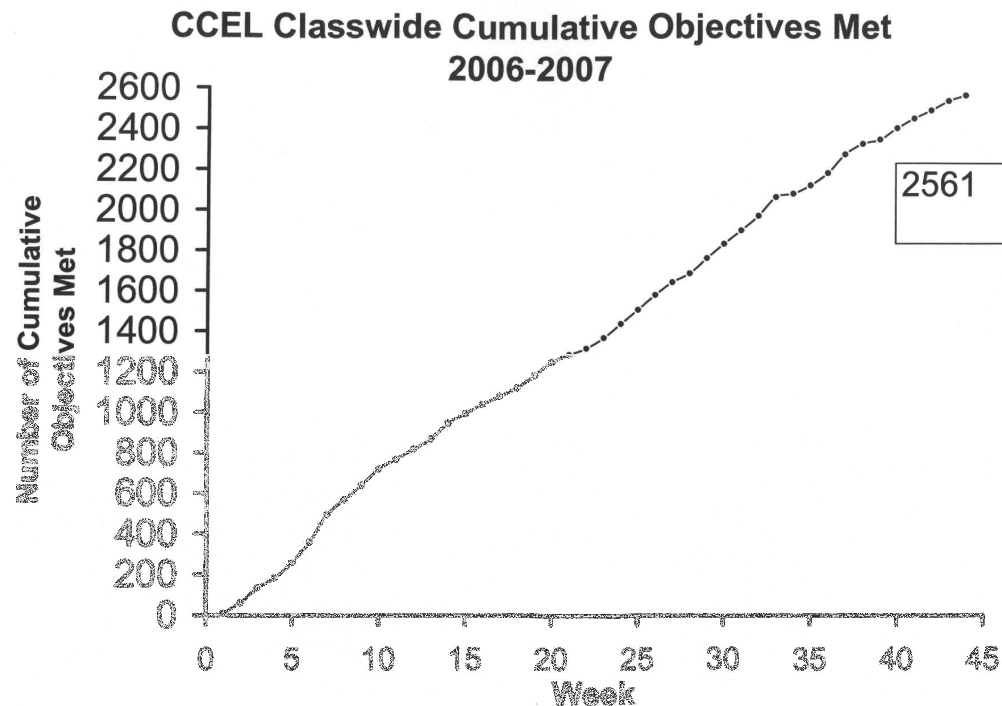
Figure 2 shows the mean number of learn units correct and presented for each child per day, across each of 44 weeks. The mean number of correct learn units per child per day across the year was 86

with a range of 60, 104. The mean number of learn units presented per child per day across the year was 134 with a range of 100, 168. The trends are variable due to the variation in allocated instruction time which ranged from 30 minutes per two-hour session (one day of school), to 90 minutes (based on related service delivery).



*Figure 2.* Mean correct (closed circle) and mean presented (open circle) learn units per day for each child for each of 44 weeks of instruction across all instructional areas.

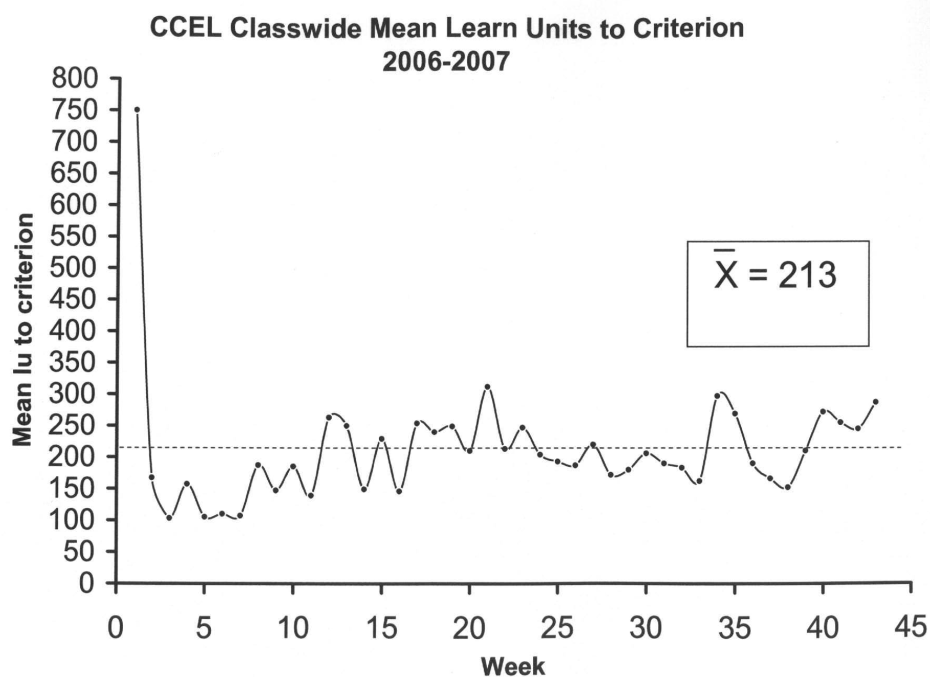
Cumulative objectives met were counted weekly as the total number of programs that each student mastered (90% accuracy across two consecutive sessions). Instructional sessions were 20 LU each (see Figure 3). Objectives met were counted as the sum of all instructional programs across all instructional areas. The objectives met were counted as short term objectives and long term objectives. Prompted and unprompted responses resulted in the sum of all objectives met for each week. The total cumulative objectives mastered for all 24 children across the year was 2561. The average per child (N=24) resulted in 107 objectives met per child across the year.



*Figure 3.* Cumulative number of objective met, class wide for each of 44 instructional weeks across all instructional areas for 24 children. The total for the year was 2561 objectives taught. Each objective resulted from student responding to 90% accuracy (correct) across two consecutive 20 learn unit instructional sessions.

Learn units per objective were a measure of the average number of learn units needed to be presented by the teacher to move a child to perform at the predetermined level of mastery (90% accuracy across two consecutive sessions). The mean for the year resulted in 213 learn units per objective with a range of 103, 750. The trend started off high due to the nature of baseline conditions of instruction which occurs at the start of the new school year. The trend was relatively stable throughout the year (see Figure 4).





*Figure 4.* Mean number of learn units per objective met class wide ( $n=24$ ) for each week across 44 weeks of instruction. The overall mean across the year was 213 learn units per objective.

Supervisors conducted TPRA observations on the head teacher and teacher assistants each week. These observations resulted in a measure of interobserver agreement calculation (Cooper et al., 1987). The number of agreements was divided by the sum of the number of agreements and disagreements. Point to point correspondence of data collection procedures was used as a calibration technique through the TPRA. Vocal and written feedback resulted from each TPRA as well. The total number of TPRA observations conducted by one supervisor was 183. There were nine staff assigned to work in the EI class. The mean number of observations per staff was about 20 (see Figure 5). Results are summarized in Table 1.



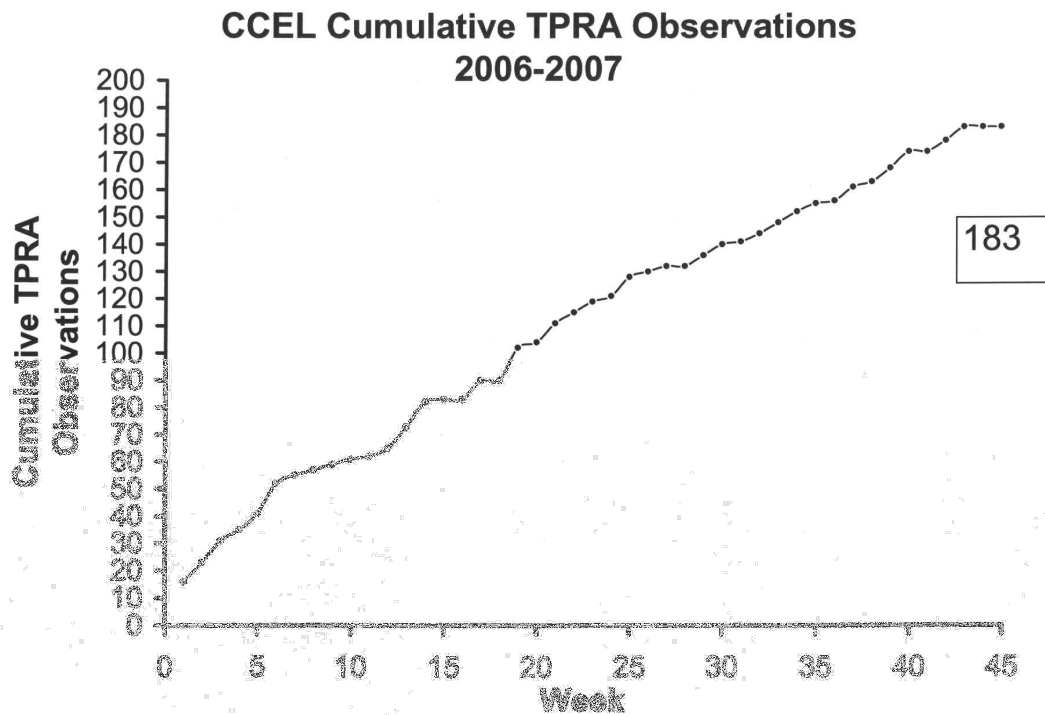


Figure 5. Cumulative number of TPRA observations by one supervisor class wide across one head teacher and eight teacher assistants for 44 instructional weeks.

Table 1: Results of 44 weeks of instruction at The Children’s Center for Early Intervention 2006-2007(N=24)

Figure	Variable	Total	Mean	Range
1	Class wide learn units correct	315680	7175	2871, 10904
	Class wide learn units presented	490807	11155	4413, 15281
2	Mean correct learn units per day		86	60, 104
	Mean presented learn units per day		134	100, 168
3	Cumulative objectives met per week	2561	58 (per week)	
4	Mean learn units per objective		213	103, 750
5	Cumulative TPRA observations	183	20 (per teacher)	

### *Cost Benefit Analysis*

Increasingly, school districts, municipalities, and private schools are being forced to look much more closely at their finances and need to consider the annual cost of educating a given child. As schools and their populations are growing, their budgets are shrinking in an inversely proportional direction. Some have proposed a cost benefit analysis of educational programs so that schools can be compared using a common measure (Greer, 2002; Greer, 1994). The learn unit lends itself appropriately to an analysis based on cost using dollars (e.g. tuition costs in dollars, fee for service contracts). The number of objectives met or taught by the teacher can be instrumental for comparison purposes to assess both the effectiveness and efficiency of an educational program.

More recently, cost-effective reports have been performed on interventions to treat conduct disorders in elementary students (Olchowski, Foster, & Webster-Stratton, 2007). Olchowski et al. (2007) provide a tiered analysis based on different hypothetical budgets to treat inappropriate behaviors, however, no measures of direct student academic responses were reported.

In the present study, the cost benefit analysis was based on a few constant variables. First, the 2006-2007 school years showed a gradual increase in the number of enrolled children in the EI classroom. There were three sessions of two hours each. Each two hour session had a maximum enrollment of eight children. After a few months, there were a total of 24 children in the EI classroom which was the maximum number of children. Each day that a given child attended there given session, it was billed at the constant rate from the New York City Department of Health Early Intervention Program. The daily session rate was \$107. The percentage of mandated sessions versus the number of billed sessions ranged from about 80% to 99% on a normal five day school week. That is, the attendance in the class was variable as might be expected with a young population of children.

The costs needed to be estimated due to that fact that related services were performed as a pull-out service. That is, in any given two hour session, a child was to be pulled out of their ABA instruction (e.g. one to one, group) for either one or two 30-minute therapy sessions. The therapy sessions did not contribute to the data collection and ABA instruction that the children received, so this time was excluded from the allocated instructional time. Allocated instructional time (Stallings, 1980) has been used to assess the difference between the time a child is in school compared to the time the child is being presented instruction in school. For the purposes of this study, 75 minutes was the duration of time used each day to present ABA instructional learn units. It was estimated that in any give two hour session (120 minutes), the child was out of the ABA room for an average of 45 minutes of that time. This equated to an estimated allocated ABA instructional time of 75 minutes per child per day, or 62.5% of the total 120 minutes.

From the time period of September 2006 through June 2007, inclusive, there were a total billable number of 3225 sessions. Each session cost \$107. The product of 3225 sessions multiplied by \$107 equals \$345,075. From the time period of July 2007 through August 2007, inclusive, there were a total number of 617 billable sessions. Each session cost \$107. The product of 617 sessions multiplied by \$107 equals \$66,019. Therefore, the sum of \$345,075 and \$66,019 is \$411,094. The total cost of tuition for all 24 children to have attended the EI classroom for one year was \$411,094.

Using the allocated time number from above, it was estimated that 62.5% of the total cost of \$411,094 is \$256,933.75. The cost per learn unit and the cost per objective and other variables is presented in Table 2.

Table 2 : *Cost benefit analysis for The Children's Center for Early Intervention 2006-2007 EI class based on an actual two hour session per diem cost of \$107 and estimated allocated instructional time of 62.5% of each two hour session (75 minutes of ABA per day and, N=24)*

Variables and projected (compounded) variables	Cost in dollars (2006-2007)
Total cost for each learn unit presented (490,807)	\$.52
Cost per 20 learn unit instructional session	\$10.40
Cost per objective (2561 total for year)	\$100.33
Cost per day of the mean number of learn units correct for one student	\$44.72
Cost per day of the mean number of learn units correct for 24 students	\$1073.28
Cost per day of the mean number of learn units presented for 24 students	\$69.68
Cost of the mean learn units per objective (213)	\$1672.32
Total cost (compounded) for all objectives (2561)	\$110.76
Total cost (compounded) for all learn units	\$283,656.36
Cost per supervisor TPRA observation	\$256,945.13
	\$1404.00

### *Discussion*

Much attention recently is being given to “best practices” in education (Prizant & Rubin, 1999; Steege, Mace, Perry, & Longenecker, 2007; Weiss, 2005). Using components from the research literature is a generally acceptable way of ensuring high quality service where children are learning consistently. The present report reviews various systems in a package format and the correlated outcomes across 24 children.

The package included PSI modules, the TPRA observation procedure, learn units, group instruction, data decision protocol, and direct instruction of research based tactics. Many of these components are found in CABAS® schools, however those schools have components that CCEI does not have. Significant gains in student learning can be found in many schools that apply behavioral components such as those mentioned above. Those components were included in this report.

For example, a CABAS® school will typically teach using about 100 (or fewer) learn units per objective. At CCEI over the past year, 213 (on average) learn units were needed to teach each objective. This difference equates to approximately 10 instructional sessions of 20 LU each to teach each objective, compared to 5 instructional sessions of 20 LU each to teach each objective. It is apparent that this difference, compounded across many months, adds up rapidly. These figures represent the difference between efficient instruction, as compared to best practice.

The reason for the disparity could be due to the limitations of CCEI and components not reported in the present study. Frequency of supervision meetings, number of TPRA observations, and training of staff issues, the university consultation component, and other unknown systems may be responsible for the difference in results. These differing components constitute the limitations of the data reported herein.

In another study using preschool aged students, Greenberg (2007) applied a teacher training package to teachers using ABA. The learn unit cost was calculated across three teachers of three separate classrooms. In that program, the cost per learn unit for Teacher 1 was successfully lowered after exposure to a treatment package, to \$1.70, Teacher 2 \$3.14, and Teacher 3 \$2.61. Costs per 20 learn unit instructional sessions were \$33.99 for Teacher 1, \$62.78 for Teacher 2, and \$52.36 for Teacher 3.

Greer (1994) calculated the cost of instruction and objectives for the Fred S. Keller preschool. Results found learn units to cost in the range of \$.60 to \$.70. Objectives had been calculated to cost in the range of \$55.58 to \$155.55. Over a five- year period, the cost per objective had decreased as instruction had become more efficient. The results of the present study were found to be relatively similar to that of Greer's, not withstanding monetary inflation adjustments.

In the present study the cost per learn unit were, \$.52, while the cost per 20 learn unit instructional session was \$10.40, and objectives were \$100.33. Instruction, then, was found to be slightly more efficient in the CCEI program than the instruction provided by the teachers in Greenberg's study, and similar to the data found by Greer (1994). This difference could possibly be explained by the frequency of supervision, or increased number of TPRA observations conducted, or the increased presence of the supervisor. Without the learn unit to be utilized in a cost benefit analysis, there are few, if any, ways to objectively compare and evaluate whole classrooms or whole schools. Table 3 shows these results for a comparison.

Table 3: *Comparison of relative cost of learn units and objectives from three ABA studies*

Research study	Cost per learn unit	Cost per objective
Greer (1994)	\$.84	\$55.58
Greenberg (2007)	\$1.70	---
Greenberg & Martinez	\$.52	\$69.68

Furthermore, when we tracked the 24 children in the EI program we found the following results. Four of the children continued in the EI class. Due to their age and EI regulations, they continue to be eligible for EI services. One student stayed in the same type of intensive one to one program, but at home as a preschooler. Ten children moved on to preschools having a ratio known in the Board of Education as 8:1:3 (students, teacher, teacher assistants), while seven moved on to 6:1:3 ratio classrooms. Out of the 24 children who attended the class, 20 moved on to other programs, 19 to lesser restrictive programs, and one to a similar one to one program, at home. Therefore, 95% of the children moved on to lesser restrictive environments. It is projected that a few of the 24 children will be able to move on to other lesser restrictive programs, or the general education setting.

In summary, it can be projected that the monetary savings observed will be exponential and are likely to reach hundreds of thousands of dollars when compounded across years. Given the number of students who remain eligible to receive special education until 21 years old in America, the savings can

be dramatic. Future research on the longitudinal effects and educational benefits of intensive ABA programs, and their cost effectiveness is warranted.

We advocate for an increase in the application of ABA systems to interdisciplinary programs and that the cost benefit analysis is used to compare outcomes using a similar unit of analysis. Future research should test for generality of treatments across settings (external validity) as well as generality of treatments across populations.

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The BAO organization is responsible to its membership to develop resources that the membership will find useful in everyday research, education, and application of the science of behavior analysis.

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