
Background / Context:
The Miami Science Museum (Museum), in partnership with the University of Miami (UM) and Miami-Dade County Head Start, developed a comprehensive early childhood science curriculum, assessment tools and professional development program (2004-2008). The curriculum, Early Childhood Hands-On Science (ECHOS), provides both direct and guided inquiry-based science experiences. Findings from the Goal 2 Early Childhood Hands-On Science (ECHOS) pilot study are presented, as well as plans for evaluating the fidelity of curriculum implementation in a follow-up cluster randomized field trial (CRFT) currently under way. The project aimed to: 1) increase Head Start teachers’ confidence and expand their teaching repertoire as they incorporate science into their school readiness programs, and 2) demonstrate that low-income preschool children can learn fundamental science concepts and use of process skills associated with developing scientific habits of mind.

Purpose / Objective / Research Question / Focus of Study:
This research will provide empirical support for the introduction of science process skills at the preschool level, and address the current lack of professional development for preschool teachers in this domain. Our findings have the potential to enhance the field of early childhood education with regard to the potentially important role that explicit science experiences at the preschool level can play to promote early learning, and narrow achievement gaps in school readiness. In addition, the program evaluation will contribute to the knowledge base with regard to the importance of fidelity assessment. By examining the extent to which fidelity to core components of the ECHOS intervention are in place, such as indices of achieved relative intervention strength (Hulleman & Cordray, 2009), the study will identify particular elements of the ECHOS program which may be driving the program effects.

Setting and Population:
ECHOS development and research is conducted in Head Start classrooms located in geographically dispersed Head Start classrooms in Miami Dade County. Miami-Dade County is located on the southeast coast of the Florida peninsula and occupies a total land area of 2,200 square miles. Program settings are varied although primarily urban in nature. A typical family of four that earns an annual income of $20,650 or less qualifies for participation in the program. Classrooms are comprised largely of African-American (55%) and Hispanic (35%) children.

Intervention / Program / Practice:
The ECHOS curriculum consists of nine thematic units. Each unit contains an overview, science background information for the teacher, four science lessons, and 12 integration activities in the domains of language and literacy, mathematics and creative arts. Teachers introduce ECHOS to groups of 6-8 children during a 20-minute time slot, for a minimum of once a week per group. While the teacher is guiding the ECHOS science lesson with a small group, a teacher assistant and/or volunteer engages the other students in activities designed to support integration of science concepts in other domains.

The theory of curriculum underpinning ECHOS is essentially a hybrid curriculum theory. It embraces direct instruction as fundamental to knowledge building, particularly in young children.
from limited English or low-income families, and couples it with guided discovery and inquiry-based science exploration and experiences. The effect of prior knowledge on learning has been well documented (Kirschner, Sweller, & Clark, 2006) as well as the recognition that many children, especially those living in poverty, are often lacking in structured experiences that promote the building of conceptual understanding for school readiness. The ECHOS curriculum was created to meet these needs, using science instruction as the vehicle. ECHOS was designed with the conviction that all children have the right to high-quality early science education, and that early concept development in fundamental areas of science can help to level the playing field in terms of differences in science achievement later in life.

ECHOS supports the notion of re-examining how and when we introduce science education in the United States and challenges the business as usual model of waiting until children are in elementary school to formally introduce science concepts and investigative processes (see Table 1).

Research Design:
During the final year of the Goal 2 project (2008-09 school year), a quasi-experimental pilot study was conducted in 20 Head Start classrooms implementing the ECHOS curriculum, and included an additional 10 non-ECHOS Head Start classrooms using their business-as-usual approach.

Findings / Results:

Preschool Science Classroom Observation Tool (PreSCOT)
- At the beginning of the year (prior to ECHOS implementation), there were no significant differences between ECHOS and non-ECHOS classrooms in science-related behavior ratings of teachers ($t(28) = 0.654, ns$) or for children as a group ($t(28) = 0.343, ns$).
- However, at the end of the year, science-related behaviors in ECHOS classrooms were significantly higher for both teachers ($t(28) = -2.777, p < .01$) and children ($t(28) = -2.683, p < .01$) relative to non-ECHOS classrooms.

Galileo Science
- Children in ECHOS classrooms and children in non-ECHOS classrooms did not have significantly different Galileo scores at the beginning of the year (no baseline differences prior to implementation) ($γ_{001} = 7.00, t = 0.74, ns$).
- However, by the end of the year, ECHOS classrooms exhibited faster rates of growth in Galileo science relative to children in non-ECHOS classrooms ($γ_{101} = 0.79, t = 2.02, p < .05$).

Direct Assessment of Science
- Multilevel analyses were conducted (using HLM6) in order to examine the effects of the ECHOS professional development program on children’s science readiness.
- After controlling for demographic covariates (age, sex, and ethnicity) and pre-test science scores, children in ECHOS classrooms obtained significantly higher scores at the end of the year relative to children in non-ECHOS classrooms, ($γ_{01} = 23.92, t = 3.48, p < .001$).

Preschool Teacher Attitude and Beliefs about Science (P-TABS)
- Teachers in ECHOS classrooms felt more comfortable teaching science at the end of the year than at the beginning ($t(49) = -2.137, p < .05$), and had more positive attitudes and beliefs toward how science can benefit preschool children at the end of the year ($t(49) = -2.861, p < .01$). Teachers in non-ECHOS classrooms showed no changes on either variable from the beginning to the end of the year.

Conclusions:
Based on these very promising results, the project is now conducting a cluster randomized field trial to test the full efficacy of the ECHOS science curriculum. For the CRFT, ninety classrooms have been selected to participate in the study, 45 randomly assigned to the Treatment Group and 45 to the business-as-usual Control Group. Head Start centers will be selected that have at least 2 teachers with similar demographic characteristics (e.g., gender, education level, years teaching) and who have had no prior experience with ECHOS. Approximately 1800 children across two cohort years (450 Treatment in each cohort; 450 Control in each cohort) will participate. Classrooms will be stratified by sex and age with equal numbers of boys and girls from each classroom. Classrooms will be chosen with sufficient number of children representing African-American and Hispanic children to include ethnicity as a variable in the analyses.

**Intervention Fidelity.** Of particular interest in this study, and its implications for future scale up of the program, is the examination of teacher fidelity to core components of the ECHOS intervention. We define intervention fidelity as the extent to which the core components of the ECHOS curriculum are implemented as designed. To this end, we have developed two sets of fidelity indices to capture key aspects of intervention fidelity (i.e., dose, exposure, quality, and participant responsiveness; O’Donnell, 2008). First, we are capturing fidelity to core components in both treatment and control conditions. This will allow us to create indices of achieved relative intervention strength across treatment and control conditions (Hulleman & Cordray, 2009). Second, we will collect in-depth fidelity measures from treatment-only classrooms to further assess the relationship between core component implementation and student outcomes. These measures of intervention fidelity will require an in-depth knowledge of ECHOS, and as such can only be captured by observers with an extensive knowledge of ECHOS. Our fidelity assessment will focus on the extent to which:

- **Pedagogical changes occur:** Modeling of science processes and concept construction, use of guided inquiry and direct instruction, reinforcement of concepts in other domains (i.e., math, language, creative arts).
- **Teacher comfort level and acquisition of knowledge of key science concepts increase:** Acquired during workshops, through teacher science background materials and reinforced by doing the lessons in class.
- **Teacher adherence to the ECHOS lesson:** Following the specified unit and lesson sequence, as well as small group delivery format.
- **Children are engaged in the process of science:** Hands-on investigation, use of measuring tools, classroom evidence that children were engaged in data collection (e.g., various displays such as charts, graphs, observational drawings, plants, bulletin boards, entire walls.).
- **Classroom environment is structured to promote science learning:** Designated science area and materials are present and accessible to children.

The fidelity assessments will include a mix of classroom observations, teacher interviews, and teacher surveys. We will compute indices of achieved relative strength for the fidelity assessments collected in both treatment and control classrooms. Our analyses will include descriptive analyses of the differences between ECHOS and non-ECHOS classrooms, as well as more causal analyses such as replacing the treatment assignment variable with our indices of achieved relative strength. The fidelity analyses will enable us to identify core components of the ECHOS curriculum that are driving the effects. In addition, it will also highlight aspects of the
curriculum that are more or less difficult to implement, and thus provide key feedback in terms of intervention development.
Appendices

Appendix A. References


Appendix B. Tables and Figures

Table 1: ECHOS Intervention and Expected Impacts

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Impact on Teacher Knowledge/Skills</th>
<th>Impact on Teacher Practice</th>
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<tbody>
<tr>
<td>• ECHOS Professional Development for teachers and teacher assistants</td>
<td>• Improved science content knowledge</td>
<td>• Increased confidence in teaching science</td>
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<tr>
<td>• ECHOS Curriculum, including 9 units, with 4 lessons and 12 integration</td>
<td>• Improved ability to guide science-related explorations</td>
<td>• Opportunity for feedback and reflection</td>
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<tr>
<td>activities cards each</td>
<td>• Increased understanding of importance of their role as facilitators of science learning</td>
<td>• Increased small group management skills</td>
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<tr>
<td>• Site visits including modeling, feedback and support</td>
<td>• Expanded repertoire of instructional strategies</td>
<td>• Opportunity for teacher assistants to play an enhanced instructional role</td>
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Curriculum Implementation

• Teachers deliver one weekly, 20-minute ECHOS science lesson to small groups of children
• Teacher assistants conduct two weekly, 20-minute ECHOS integration activities in creative arts, literacy and mathematics with small groups of children

Impact on Children

• Increased science readiness (content knowledge and science processing skills)
• Increased emergent literacy/language readiness
• Increased mathematics readiness
• Increased identification with science/self-efficacy for science
• Increased excitement, interest, motivation to learn science