Getting on Track Early for School Success: Project Overview

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Team

Committee on Education, University of Chicago

1. Stephen Raudenbush, EdD, PI, *Getting on Track Early for School Success*, Professor, Department of Sociology and Chairman of the Committee on Education, University of Chicago
2. Terese Schwartzman, PhD, Project Director, *Getting on Track for School Success*, Committee on Education, University of Chicago
3. Jennifer Adams, PhD, Senior Assessment Development Associate Literacy; Committee on Education, University of Chicago
4. Janet Sorkin, PhD, Senior Assessment Development Associate Mathematics, Committee on Education, University of Chicago

Academic Departments, University of Chicago

1. Susan Goldin-Meadow, PhD, Professor, Departments of Comparative Human Development and Psychology and Committee on Education, University of Chicago
2. Susan C. Levine, PhD, Professor, Departments of Comparative Human Development and Psychology and Committee on Education, University of Chicago
3. Cassie Freeman, Institute of Education Sciences Fellows, Department of Comparative Human Development, University of Chicago
4. Raedy Ping, PhD, Postdoctoral Scholar, Spatial Intelligence and Learning Center, Department of Psychology, University of Chicago

Academic Departments, Other Universities

1. Ozlem Ece Demir, PhD, Postdoctoral Scholar, Communication Sciences and Disorders, Northwestern University
2. Elizabeth Gunderson, Assistant Professor, Department of Psychology, Temple University

Urban Education Institute (UEI), University of Chicago

1. Molly Branson Thayer, PhD, Director for Strategic Initiatives, Urban Education Institute, University of Chicago
2. Margaret Walsh, MAT, Director of STEP Literacy, Urban Education Institute, University of Chicago

Center for Elementary and Science Education (CEMSE), University of Chicago

1. Debbie Leslie, MAT, Associate Director for Direct Services, Center for Elementary Mathematics and Science Education (CEMSE), University of Chicago
2. Liesje Spaepen, PhD, Curriculum Developer, Center for Elementary Mathematics and Science Education (CEMSE), University of Chicago

NORC, University of Chicago

1. Marc Hernandez, PhD, Senior Research Scientist, Academic Research Centers, NORC, University of Chicago
2. Michael Reynolds, PhD, Senior Deputy Director for Research, Academic Research Centers, NORC, University of Chicago
3. Michele Zimowski, PhD, Senior Survey Methodologist, Department of Statistics and Methodology, NORC, University of Chicago

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Summary

Promoting the development of oral language and the acquisition of numeracy, spatial reasoning, and geometry skills among preschool children is foundational to our work at the University of Chicago. We are developing a coherent system of instruction that begins in pre-K and reliably enables children of all social, ethnic, and linguistic backgrounds to attain high levels of academic achievement by grade 3. At the core of this system are statistically reliable assessments that integrate research and practice and provide information to preschool teachers that is highly relevant to individual, group, and whole class instruction. Our approach is grounded in research demonstrating that focusing on early oral language development positively influences children's later proficiency in reading comprehension, writing, and numerical reasoning (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, Poe, 2003; Dickinson & Neuman, 2006; Dickinson & Tabors, 2001; Griffin, Hemphill, Camp and Wolf, 2004; Scarborough, 2001; Gunderson & Levine, 2011) and that math-related interactions between parents/teachers and children can substantially enhance the development of children's mathematical thinking (Gunderson & Levine 2011; Klibanoff, Levine, Huttenlocher, Vasilyeva & Hedges, 2006; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010).

Recent preschool evaluations find that these oral language and math skills are not sufficiently emphasized in preschool instruction (Castro, Espinosa, & Paez, 2011; Graham, Nash & Paul, 1997; Winton & Buysse, 2005). We seek to change this state of affairs by clarifying instructional goals for early language, mathematics, and academic development in preschool settings, by providing teachers with frequent objective, accurate and valid assessments of children's skills in these domains, and thereby enabling teachers and researchers to develop powerful instructional strategies to foster these skills.

We are in an excellent position at the University of Chicago to accomplish this work, which requires interdisciplinary collaboration between researchers, practitioners and methodological experts. We have an established team of early learning scholars from the Committee on Education, developers of literacy and mathematics early learning tools, from the Urban Education Institute and Center for Elementary Mathematics and Science Education, practitioners from the University's charter schools, and statistical/psychometric experts from NORC, who bring considerable knowledge, experience, and skill to develop our assessment and instruction system. Furthermore, through the piloting and field test work we have done with our pre-K English language and bilingual literacy and mathematics assessments, we have established excellent relationships with community, charter, and CPS teachers and schools.

Over the past three years, with funding from the Foundation for Child Development (FCD), the Kellogg Foundation, the Annie E. Casey Foundation, the McCormick Foundation, and the Chicago Mercantile Exchange Foundation, we have:

- Rigorously reviewed research to identify the domains of early language and mathematics development that are most critical for future academic success
- Surveyed existing literacy and mathematics assessments for young children
- Developed and piloted instructionally relevant assessments for English-speaking children between the ages of 3 and 5 based on cutting-edge research and practical usability in the classroom
- Developed and piloted instructionally relevant literacy and mathematics assessments for young Spanish-speaking dual language learners (DLL) measuring the research-based skills assessed in our English language assessments
- Submitted the English language assessments for independent review by renowned experts in the fields of literacy, mathematics, and early child education and made revisions based on their feedback
- Ensured the assessments align with Illinois pre-K standards, including those for DLL children
- Conducted 2 large-scale field tests of the English language literacy and mathematics assessments (400 3 – 5 year olds for each; approximately 300 items in each) yielding exceptional datasets of highly reliable measures of children's emergent oral language, print-related, and mathematics skills
- Conducted Classical Item and Item Response Theory (IRT) analyses on the literacy assessment field test data
- Conducted research and piloted instructional strategies to promote the development of numerical and geometric and spatial skills in preschool children

Building upon the work we have done, we are ready to take the next steps toward creating our coherent instruction system:

1. Develop a highly innovative, dynamically adaptive assessment design to provide teachers with data tailored to individual students and relevant to instruction
2. Complete the development of the DLL literacy and mathematics assessments
3. Continue to build teacher capacity and provide instructional strategies to teachers to promote the development of critical mathematics and literacy skills

Background and Significance

Conceptual Framework

High quality, early childhood educational experiences have been shown to produce substantial short-term gains in children's early language, literacy, and mathematics skills as well as long-term effects on a wide range of school and behavioral outcomes that persist into adulthood (Camilli, Vargas, Ryan, & Barnett, 2010; Clements & Sarama 2008; Griffin, Case & Siegler, 1994; Schweinhart, Barnett, & Belfield, 2005; Starkey, Klein & Wakeley, 2004). While young children from all backgrounds benefit from well-designed preschool, those from economically disadvantaged households seem to gain the most from high quality early childhood education (ECE) (Barnett, 2008; Burger, 2010).

The proportion of children living in disadvantaged households is increasing as the composition of the population of our young children becomes increasingly more diverse (Espinosa, 2010). Therefore, given the scientific research demonstrating the critical role the first years of life play in influencing future learning, it is important that we identify and promote the features of high quality ECE instruction.

One feature of high quality programs that is essential to effective teaching is the accurate and valid assessment of children's progress (Espinosa and Gutierrez-Clellen, 2013; Espinosa and Garcia, 2012). Teachers need accurate and instructionally relevant e.g., formative, assessment information to individualize and target instruction to each child's unique set of abilities and needs. Individualized instruction however, can only be accomplished through comprehensive, ongoing assessments that are fair, technically adequate, and developmentally valid so that we can determine if children are making progress toward the intended outcomes (Snow & Van Hemmel, 2008). That is, individual child assessments must be linguistically, culturally, and developmentally appropriate in order to assess how children are progressing and what instructional adjustments need to be made.

The need to provide individualized data that informs instruction for each child is especially pronounced for children whose first language is not English – dual language learners (DLLs). The chronic academic underachievement of the DLL population across the nation (Galindo, 2010) and their school readiness gaps at kindergarten entry (Cannon & Karoly, 2007; Lee & Burkham, 2002) underscore the need for more effective assessment approaches that are linked to improved instruction for young DLLs. Young DLLs are often deprived of the opportunity to develop powerful early oral language and mathematical skills in their native language, in part because many dual language learners are living in low-income households with parents who have low educational attainment (Hernandez, 2006).

In order to reduce the "inequality at the starting gate", it is critical that young English speakers and dual language learners from low-income households have access to high quality ECE that focuses on developing oral language and early mathematical skills, while at the same time continuing to build traditionally taught early skills necessary for decoding and number knowledge. Furthermore, effective ECE teachers must be instructed on how to accurately assess young dual language learners' development and achievement in order to individualize and improve the quality of their instruction, and increase academic school readiness. This is a multi-step process that requires that all ECE teachers receive better instruction regarding young dual language learners' linguistic and academic development. They will need to be educated as to understand the importance of home language development for the overall language development and future academic achievement of their students. Ideally, teachers would be prepared to interpret progress in each language. ECE teachers will also need assessment tools linked to state or federal standards that enable them to apply assessment results to individualize instruction.

A critical advantage of the English language and Spanish-English bilingual assessment and instruction system we are building is that it can be administered in short (15-20 minute) sessions and will provide information and strategies to teachers that are not only highly relevant to instruction but that they can share with parents and caregivers. Teachers can talk in detail about a child's skill levels and provide parents/caregivers with specific activities that they can use with their child outside of school. Furthermore, once this system is implemented in the classroom, it has the potential to re-organize the schoolhouse as well as instruction. The system requires collective responsibility among administrators and practitioners across the school to ensure that instruction is based on evidence; that teachers have the technical expertise they need; and that a systemic support exists to help teachers identify learning trends, establish appropriate instructional goals, and implement strategies to move learners. Such a system encourages a school structure that cultivates the possibility for continual improvement of practice.

Research

In recent years, preschool educators have focused on helping children develop early concepts of print, including familiarity with books, knowledge of upper- and lower-case letters and letter-sound correspondence, and word recognition. These earlier developing skills, also referred to as emergent literacy skills, predict later decoding at the beginning of school (Lonigan et al., 2000; Storch & Whitehurst, 2002, National Early Literacy Panel, 2008). Increasingly, schools serving low-income families have adopted early reading programs that reliably teach children to decode familiar text and to read fluently. These are promising developments as systematic, explicit instruction in concepts of print

and word decoding are essential to insure that the vast majority of children become basic readers by grade 2 (National Reading Panel, 2000; National Research Council, 2008).

However, reading success requires both decoding and comprehension skills. As children become skilled readers, they are exposed to increasingly more complex texts and read written text in order to comprehend it. Their earlier developing oral language narrative, syntax, and vocabulary skills play a large role in successful reading in the early elementary years (e.g. Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, Poe, 2003; Dickinson & Snow, 1997; Dickinson & Tabors, 2001; Griffin, Hemphill, Camp and Wolf, 2004; Scarborough, 2001). In essence, reading comprehension is built upon earlier developing oral language skills (both production and comprehension). Developing oral language skills for young bilingual children is also critical. Recent research indicates that bilingual children demonstrate limited oral language skills (lower oral language in both English and Spanish when they enter kindergarten and only modest gains in English during preschool. This research recommends that educators focus on oral language skills during instruction (Páez, Tabors & López, 2007). According to Espinosa (2005), dual language learners require early formative assessments that target oral language and guide instruction.

While the effect of code-related skills such as phonological awareness on reading success is observed in earlier years where children mainly read a text to decode it, comprehension skills play a larger role in later years when children strive to comprehend the text. Thus, if young children during the preschool years learn only the systematic phonics they need to decode basic primary texts, at the expense of simultaneously learning how to comprehend, construct, and express more complicated ideas orally, they will not be prepared when they confront more complicated written text. The view of language skills not becoming fully influential until later grades is supported by the leading theories of reading development, such as the Simple View (Hoover & Gough, 1990) and the Convergent Skills Model of Reading (Vellutino et al., 2007).

Mathematical development in the preschool years is also extremely important for children's academic success. The mathematics knowledge that children bring to the start of school predicts their mathematics and reading achievement at least through the 5th grade (e.g., Duncan, et al., 2007). Recognizing an increasing need to improve mathematical literacy beginning in the early years, the Mathematical Sciences Education Board of the Center for Education at the National Research Council has specified early childhood mathematical domains that are critical for young children to learn and develop: Number, Geometry, Spatial Thinking and Measurement (Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity, Center for Education, 2009).

Traditionally, preschool teachers tend to focus on numeral identification, counting, and canonical shapes when teaching mathematics and are not aware of other critical skills, concepts, and understandings that need to be taught to provide the foundation for future mathematics success. Additionally, they tend to be unsure of what their role can be in helping children develop them. Research shows that preschool teachers can significantly impact the development of these skills and concepts. Klibanoff has shown that while the amount of talk about mathematics in a preschool classroom at the beginning of the year is unrelated to a child's mathematics knowledge, it is significantly related to that child's growth in mathematics knowledge over the course of the year (Klibanoff, et al., 2006). Similarly, a meta-analysis of spatial training studies shows that spatial reasoning skills, which predict success in the STEM disciplines (science, technology, engineering and mathematics), can be reliably improved through specific enrichment experiences (Hand, Uttal, Marulis, & Newcombe, 2008). The greatest improvement in these studies was in the youngest age groups, highlighting the important role teachers play in developing these critical early mathematics skills and concepts.

It is pertinent to ask why oral language development and the development of geometric and spatial skills are so rarely pursued as instructional goals during the preschool years despite their recognized importance for later reading comprehension and success in the STEM disciplines. We reason that preschool educators can pursue the development of these skills as serious instructional goals only if they have access to clear definitions of the components of oral language and geometric and spatial reasoning that instruction should target; and only if, in addition, they have useful tools for assessing children's skills in these areas.

Assessments

Literacy Assessment

Prior to developing our pre-K literacy assessment, we surveyed existing literacy assessment tools for pre-K students. We found that the majority are designed for a wide age range of children and therefore do not have a sufficient number items directly applicable to 3 and 4-year olds to produce reliable measures. Even more important, those oral language skills that research strongly suggests are critical for later reading comprehension are not assessed. Most of the instruments are diagnostic and used primarily to identify relative strengths and deficits in individual children compared to their peers. The instruments do not provide sufficiently rigorous data to develop effective instruction tailored to individual or small groups of children.

Our literacy assessment represents a paradigm shift in what is traditionally assessed and taught in preschool classrooms. The assessment measures oral language skills identified by research as powerful

predictors of later reading comprehension. While preschool teachers tend to emphasize print-based literacy skills related to decoding, our assessment encourages preschool teachers to also promote the development of children's oral language comprehension and expression. It provides preschool teachers with a formative assessment tool based on an integrated, comprehensive approach towards language and literacy learning in preschool that is administered in 15 minutes sessions three times during the year. The assessment comprises 4 oral language domains (language syntax, vocabulary, word morphology, and story grammar) and 3 print-based domains (concepts about print, phonological awareness and letter knowledge). Appendix A details the domains and skills assessed in literacy.

We submitted the literacy assessment for independent review by renowned experts in the field of early literacy and child education. Drs. Catherine Snow and Linda Espinosa conducted the reviews. Dr. Catherine Snow is a Professor of Education at Harvard Graduate School of Education and is an expert on language and literacy development in children. Dr. Linda Espinosa is Professor Emeritus of Early Childhood Education at the University of Missouri. Dr. Espinosa's recent research and policy work has focused on effective curriculum and assessment practices for young children from low-income families who are dual language learners. In her review, Dr. Snow noted, "The assessment is an extremely valuable undertaking. An integrated and feasible assessment of language/literacy skills for formative use by preschool educators represents a great contribution." Dr. Espinosa wrote, "What you have developed is substantial and represents tremendous work." In response to the feedback they provided, we expanded the assessment to include a vocabulary and concept task that introduced a non-fiction component into the assessment and served as a probe of academic language skills. We also expanded the number of items and the range of complexity in the language syntax tasks to more accurately reveal the language syntax potential of young children and promote more complex language in instructional interactions.

The literacy assessment was field-tested among 417 students ranging in age from 37 to 67 months between mid-October and mid-December 2012. The racial and ethnic composition of our field test sample was: 59.6% African American; 20.8% White; 8% Hispanic; and 11.6% Other. The classical item and item response theory (IRT) statistical analyses for all of the measures in the assessment are scheduled for completion by the winter of 2014. A report on the analyses as of August 2013 is located at (website address).

Our pre-K literacy assessment is complimentary with the STEP K–3 Literacy Assessment used nationwide. Together, the assessments will form an integrated pre-K through grade 3 literacy assessment system.

Appendix B demonstrates the specific Illinois Early Childhood Education (ECE) Learning Standards (and goals) with which our pre-K literacy assessment aligns. We used the Illinois State Standards since there is not a strong national consensus around literacy standards for this age group at this time.

Mathematics Assessment

Prior to developing our pre-K mathematics assessment, we surveyed existing math assessments for pre-K students. These assessments fell into two main categories: 1) assessments used by psychologists and researchers (e.g., *Early Math Diagnostic Assessment*, The Psychological Corporation, 2002; *Woodcock-Johnson III Tests of Achievement* (Woodcock, McGrew, & Mather, 2001), *Test of Early Mathematics Ability* (Ginsburg & Baroody, 2003); and 2) assessments used by teachers (e.g., *Pre-K Everyday Mathematics Baseline and End-of-Year Assessments* (Bell et al., 2008), *Child Assessment Portfolio* (Teaching Strategies, 2010), *Tools for Early Assessment in Mathematics* (Clements, Sarama, & Wolfe, 2011). Though the assessments used by psychologists and researchers are often grounded in research and yield detailed descriptions of what children know and can do in particular mathematical domains, the assessments require an extensive level of training to administer and produce data that have limited instructional utility. Many of the mathematics assessments currently used by teachers are too closely linked to a particular curriculum to be broadly useful to a wider group of preschool teachers. A common issue across current assessments is that they focus mainly on numeracy skills. If they do assess other mathematical skills, they combine items across the domains into at the most 3, but often only 1, validated test score, so that teachers do not receive information about children's strengths and weaknesses across different types of math skills. Further, even if these assessments are intended to be used "formatively", they can take up to 40 minutes to administer, and any retesting that occurs during the year must either use the same assessment or a different version with the same number of equivalent items.

We have developed a formative mathematics assessment for 3- to 5- year olds that covers content including but also beyond numeracy and that can be administered by classroom teachers three times a year in a short amount of time (15 – 20 minutes). As with the literacy assessment, the pre-K mathematics assessment represents a paradigm shift in the type of mathematics traditionally presented to preschool children. It goes beyond the traditional emphasis on numbers to assess skills in four mathematical domains: numeracy (e.g., the concepts of cardinality and successor function); geometry and spatial thinking; measurement; and algebraic thinking. The assessment is innovative in other respects as well. It measures not only content, but also cognitive processes such as spatial reasoning and pattern detection. It assesses mathematics vocabulary since research indicates that math talk—both to and by children—is a crucial vehicle for developing mathematical concepts. Finally, because we know that for some children, particularly those from low-income and dual language households, we can better assess their conceptual

knowledge when we use tasks that do not demand knowledge of mathematical vocabulary, the assessment uses "non-verbal" methods of measuring abilities, such as having children show how many object there are using their fingers. The assessment encourages teachers to provide instruction that promotes reasoning skills, mathematical vocabulary, and content knowledge beyond the traditional focus on numbers. Appendix C details the domains and skills assessed in mathematics.

Experts in the field of early mathematics and child education also reviewed the mathematics assessment. The two reviewers for the mathematics assessment were Drs. Elizabeth Casey and Kelly Mix. Dr. Casey is a Professor in the School of Education at Boston College. She is an expert in spatial and mathematics skills, early childhood education and methods for the teaching of problem-solving and critical thinking skills. Dr. Kelly Mix is Professor of Educational Psychology at Michigan State University. Dr. Mix's research focuses on the development of number concepts and mathematical reasoning. She is particularly interested in the emergence of these ideas in early childhood. In her report, Dr. Mix wrote, "The assessment is exceptionally well grounded as is, both theoretically and practically, and I am looking forward to seeing the final product. This is an outstanding effort that addresses a critical need." Dr. Casey noted, "The assessment is excellent and is an important contribution to the field. You have a lot of potential within this assessment tool to provide a process-based analysis of performance as well as an outcome-based assessment by recording error patterns and individual differences in the strategies used by children within the different tasks. This would be extremely useful for educators and researchers." Both reviews confirmed that the assessment covered the appropriate mathematics domains and variables for 3 and 4 year olds. Based on their feedback, we added the ability to analyze error patterns and capture the range of strategies used by children during the assessment in order to provide more information for teachers.

The pre-K mathematics assessment was field-tested among 400 students ranging in age from approximately 40 to 70 months between early February and early April 2013. Because we were able to field test the literacy and mathematics assessments in the same 10 CPS schools, the racial and ethnic composition of our field test sample is the same as for literacy: 59.6% African American; 20.8% White; 8% Hispanic; and 11.6% Other. Analyses of the mathematics field test data are scheduled to begin in the winter of 2014.

We intend our preschool assessment to be relevant for integration with a wide range of pre-K math curricula. However, we are in the advantageous position of being closely connected with the Center for Elementary Mathematics and Science Education (CEMSE) at the University of Chicago, which authors the *Everyday Mathematics* curriculum. *Everyday Mathematics* is used in many thousands of elementary

school classrooms around the country. Thus the prekindergarten *Everyday Mathematics* curriculum will serve as a test bed for connecting the assessment to a widely-used instructional system.

Appendix D demonstrates the specific Illinois Early Childhood Education (ECE) Learning Standards (and goals) with which our pre-K mathematics assessment aligns. As with literacy, we used the Illinois State Standards since there is not a strong national consensus around mathematics standards for this age group at this time.

Bilingual Assessments

Despite the tremendous recent growth in the population of young DLL children, the corresponding development of a range of different types of assessments for young DLL learners has lagged far behind. Recent research highlights the unique linguistic, social, and cultural characteristics of young dual language learners that need to be considered when conducting assessments and when interpreting the results (Espinosa and Garcia, 2012). First and foremost, teachers need to assess the proficiency level of young DLLs in both their home language and in English, using a variety of informants, multiple sources of data collected over time, and a team that includes at least one member who is fluent in the child's home language (Espinosa and Gutierez-Clellan, 2013). To adequately address the child's early language and cultural experiences these assessments should provide sufficient information about the family and the child's language environment at home in order to carefully consider the specific contextual factors influencing each child's development and individualize instruction. Finally, in order to create the enriched language and mathematical learning classrooms, preschool teachers of DLL children need validated tools that enable them to define, observe, and assess emergent language skills and to promote high levels of children's listening comprehension and expressive language in each of their languages.

During the past three years, we developed and pilot-tested assessments of the same skills in the English language literacy and mathematics assessments for dual-language learners whose native language is Spanish but who are learning English. These assessments enable assessors to present tasks to children in Spanish while allowing children to display their knowledge using either Spanish or English or a mixture of the two languages. We therefore call this a "bilingual assessment." According to our survey of existing assessments for young dual language learners, this type of instructionally relevant, individual child assessment that focuses on these specific aspects of language and mathematics development and is validated on dual language learners in the United States has not been developed. While there are language assessments validated for monolingual Spanish speakers, and a few language assessments that are conceptually scored (allow for either language to be used), there are none that are completed by

classroom teachers and yield data on each language separately as well as how the two languages are operating together.

We pilot-tested our bilingual assessments in two CPS schools with 17% of student body identified as Limited English Proficient at one school and 8% identified as Limited English Proficient at the other. Twenty-nine Spanish-English bilingual students participated in the literacy assessment pilot and twenty-one Spanish-English bilingual students participated in the mathematics assessment pilot.

Our bilingual literacy and mathematics assessments cover the same research-based domains as are covered in the English language assessments with modifications based on cultural and linguistic variants. These assessments are distinctive in that they address key limitations of existing assessments used for young dual language learners. First, the Spanish language items are not direct translations from English. They were developed concurrently with the English language items, taking into account cultural and linguistic differences. Second, the assessments have been piloted with young, Spanish-English bilingual children, a high percentage of whom can be regarded as at risk of academic difficulty. Most normative samples for bilingual assessments have a smaller than expected representation of both low-income and young children. Finally, the assessments enable young DLL learners to demonstrate their current skill levels in both L1 (primary language) and L2 (secondary language).

Our bilingual assessments meet the Illinois State Early Childhood Standards for dual language learners: 1) Use and maintain the native language in order to build upon and develop transferable language and literacy skills; and 2) Maintain the native language for use in a variety of purposes.

Instructional Strategies - Mathematics

Between 2011 and 2013, members of our team evaluated instructional strategies designed to enhance skills that underlie the later emergence of proficiency in math and science. This evaluation was part of the project, *From the Classroom to the Lab and Back*, funded by the McCormick Foundation and the Chicago Mercantile Exchange. It draws upon research from two sources: (1) a seminal study of children's language development from the second year of life until age 10 supported by funding from the National Institute of Child Health and Human Development; and (2) the work of the National Science Foundation-supported "Spatial Intelligence Learning Center" (SILC) which involves collaborative work with the Chicago Public Schools. The outcomes of this research demonstrated that early caregiver language at home and in the pre-K classroom can provide a strong impetus for children's development of early number sense and spatial reasoning (Gunderson & Levine 2011; Klibanoff, Levine, Huttenlocher, Vasilyeva & Hedges, 2006; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010. Further,

caregiver interactions with children using toys, blocks, puzzles, and board games can support the early development of numerical and spatial reasoning (Levine, Ratliff, Huttenlocher, & Cannon, 2012).

Our instructional work integrates practitioner and research perspectives to design optimal mathematics teaching strategies for preschool students. The team started in the classroom, working with teachers to identify important instructional dilemmas that preschool teachers face as they seek to promote mathematics concepts and skills. They then tested alternative instructional strategies in rigorous laboratory experiments. The instructional strategies developed draw from three basic tools that researchers and practitioners have found to be effective in facilitating learning: *language*, *gesture*, and *highly aligned comparison*.

Highly aligned comparison, for example, is a strategy in which children are shown two aligned entities and encouraged to identify their similarities and differences (Gentner, 2010). The team tested the impact of highly aligned comparison on children's learning of the relationships between consecutive numbers (for example, that 5 is one more than 4 because it comes right after 4 in the count list) and on their learning of shape categories (for example, examining the similarities between two shapes that are both triangles but that look very different). Initial results suggested that highly aligned comparison helps children improve their understanding of the related concepts, but that the success of the strategy depends on specific levels of ability or on types of comparison. For example, the team found that the strategy helped children who already knew the cardinal principle (or that the last number reached when counting a set of objects represents the numerosity of the whole set) learn about the relationships between consecutive numbers, but that it did not help children who did not yet know this principle. In the context of shapes, the team found that contrasting examples (this is a triangle, but this is *not* a triangle) helped children learn shape categories, but comparing shapes (this is a triangle and this is a triangle) did not.

The team also studied points in children's learning trajectories when certain instructional strategies may prove more successful than others. In particular, they examined situations in which gesture or language may be more or less helpful in teaching cardinal number. To do this the team analyzed situations in which children raise a certain number of fingers to show how many objects are in a set, and, at the same time, say a different number word (e.g., when shown 3 stickers and asked how many there are, they hold up 3 fingers but say the word "four"). They found these "gesture-speech mismatches," were more likely to occur in response to set sizes for which children could not accurately produce the correct number when asked for that amount, and that in these situations children's gesture responses were more accurate than their verbal responses. These findings raise the hypothesis that when children "mismatch", or show a

different number of fingers than the number word they say, they may be ready to learn the meaning of the next number in their count list. The team will test this theory in upcoming studies.

Between 2013 and 2015, *From the Classroom to the Lab and Back* will move forward in several ways. First, we will conduct new lab studies that test the strategies in new content areas. Second, as we identify successful strategies, we will bring them back to the classroom by incorporating them into prekindergarten and kindergarten math lessons. Third, we will begin to merge our math strategies and our assessment work by incorporating the strategies and lessons into the professional development and support materials for the assessment. This will provide teachers with concrete strategies and methods to advance learning, having determined children's specific skill levels through the assessment.

Building Upon Our Work

Develop a Highly Innovative, Dynamically Adaptive Assessment Design for Classroom Use

A crucial challenge confronts anyone who wishes to transform a bank of test items for the purpose of formatively evaluating past instruction and guiding next instructional steps. Specifically, while up to two hours of assessment time are generally regarded as essential to provide highly reliable measures of skill in a broad domain such as literacy or mathematics, the best new systems of data-driven instruction provide teachers with no more than 20 minutes of assessment time with each child at each assessment administration.

To address this challenge, we will implement a highly innovative plan to use our large bank of assessment items to provide a "dynamically adaptive" system in which past assessment results determine which items will be included in subsequent, individually tailored assessment booklets. We will develop a computer program to generate assessment booklets that, over time, are increasingly individually tailored to each student, based on that student's prior performance and individual growth trajectory. For a child's first assessment, where little is known about the child's current skill levels, we will use our field test database to create an assessment booklet that includes the most age-appropriate items. The results of this first assessment, in combination with standard expected growth, will enable us to construct a second assessment that is more highly tailored to the child's individual skill levels. The third assessment, incorporating the results of the prior two assessments and standard expected growth, will be even more tailored. Each tailored assessment booklet, therefore, will capture all the items for a particular skill within

each child's zone of proximal development, leading to increasingly sharp inferences about each student's response to instruction and overall growth.

This design does not alter the teacher-student (one-on-one) administration of our assessments. It relates only to the scoring and presentation of data. Teachers will administer these assessments within 15-20 minutes three times a year with results of each assessment immediately available for use in guiding an instructional plan for each child over the subsequent time interval.

We have funding to build our innovative assessment design for the English language and Spanish-English bilingual literacy assessments. We are seeking funds to develop this dynamically adaptive system for the English language and bilingual mathematics assessments.

Fully Develop our Spanish-English Pre-K bilingual Literacy and Mathematics Assessments

With funding from the Foundation for Child Development (FCD), we will conduct a large-scale field test (n=400/each) of all of the items in the pre-K bilingual literacy assessment and the language dependent items in the bilingual mathematics assessment in the fall of 2014. We will use a normative sample of children exhibiting a range of proficiency in Spanish since we want to better understand how these children are developing their Spanish and English language skills simultaneously. The assessment data generated from the field test will allow for in depth psychometric analyses parallel to that conducted on the English-only data.

Our bilingual assessments will inform teachers about the level of each child's development in English, in Spanish, or in either language. We also plan to document 1) whether the child code-switches (i.e., interjects words or phrases from one language while speaking in another), 2) in which language (Spanish or English), and 3) any discernible patterns of code-switching. Data on DLL code-switching has never been reported for a large diverse sample of preschoolers, hence our research will provide insights on how young bilinguals make use of each language to communicate and express themselves. As part of the field tests of these assessments, we intend to ask parents/guardians to complete a questionnaire that solicits information about the child's home language environment.

We have funding to fully develop the Spanish-English bilingual literacy assessment and are seeking funds to fully develop the Spanish-English mathematics assessment using the data from the 2014 field-test of the language dependent items in the Spanish-English mathematics assessment.

Build Teacher Capacity to Improve Effective Pre-K Teaching

In all of our work we remain keenly aware that teachers are the most important facilitators of learning in classrooms (Bowman, Donovon, & Burns, 2000; Hamre & Pianta, 2007; Pianta, Belsky, Vandergrift, Houts, & Morrison, 2008). According the National Association for the Education of Young Children (NAEYC), equipping teachers with information about children's learning trajectories in general and the learning trajectories of individual children in particular, are crucial to helping them to facilitate student learning (NAEYC, 2009). Without understanding what skills are important and how they develop, teachers may miss opportunities to draw critical connections, focus on rote skills in isolation rather than broader concept development, or may not recognize when a child is struggling with a particular concept or skill.

Our assessments, in and of themselves, play a key instructional role for teachers because they emphasize the literacy and mathematics skills identified by research as predictive of future academic success and are designed to provide highly individualized data on each child's skill level. However it is also imperative to provide an accompanying professional development and support system that will ensure accurate and informed use of the assessments and the resulting data, explain our assessments' conceptual frameworks and the developmental trajectories that emerged from field-testing the instruments, and provide effective instructional strategies that teachers can use to facilitate a child's movement along these trajectories.

We have funding to develop the professional development and support materials for the English language and Spanish-English bilingual literacy assessments. We are seeking funds to develop these materials for the English language and Spanish-English bilingual mathematics assessments.

Contacts and Related Papers

For further information, please contact:

Stephen Raudenbush, Professor, Department of Sociology, the College, and the Harris School of Public Policy Studies; Chair, Committee on Education, University of Chicago, raudenb@uchicago.edu

Terese Schwartzman, Project Director, Committee on Education, University of Chicago, tschwartzman@uchicago.edu

Jennifer Adams, Senior Assessment Development Associate for Literacy, Committee on Education, University of Chicago, jadams@uchicago.edu.

Janet Sorkin, Senior Assessment Development Associate for Mathematics, Committee on Education, University of Chicago, jesorkin@uchicago.edu

Marc Hernandez, Senior Research Scientist, NORC at the University of Chicago, Hernandez-Marc@norc.org

Related Papers:

1. "Research and Practice in the Field of Early Literacy Learning." (November 2013). Getting on Track Early for School Success: www.norc.org/gettingontrack

2. "Literacy Assessment Field Test Data Analysis: Evaluation Report." (November 2013). Getting on Track Early for School Success: www.norc.org/gettingontrack

3. "Research and Practice in the Field of Early Mathematics Learning." (November 2013). Getting on Track Early for School Success: www.norc.org/gettingontrack

4. "From the Classroom to the Lab and Back: Instructional Strategies to Improve Children's Early Math Skills." (November 2013). Getting on Track Early for School Success: www.norc.org/gettingontrack

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Appendix A: Literacy Assessment Domain Map

Super ordinate Domains	**Oral Language**									**Print-Based Literacy**					
Domain	Language Syntax				Story Grammar		Vocabulary		Word Morphology	Phonological Awareness		Concepts About Print	Letter Knowledge		
	Receptive		Expressive		Receptive	Expressive	Expressive	Expressive	Expressive	Receptive	Expressive	Receptive	Expressive		
Variable/ Score	Receptive Language Syntax (in sentences)	Receptive Language Syntax (in story)	Expressive Language Syntax Diversity Verbs Nouns Modifiers Conjunctions	Frequency counts for Syntax types See scoring sheet for types	Receptive Story Grammar	Expressive Story Grammar Setting statement Initiating event Goal Attempt Internal state Outcome	Expressive Vocabulary Total words Total Unique words Rare words	Expressive Vocabulary	Expressive Word Morphology	Receptive Rhyming	Expressive Rhyming	Receptive Concepts about Print Book Print Word Letter	Expressive Upper Case Letter Knowledge	Expressive Lower Case Letter Knowledge	Phonemic Awareness
Task	Listening Comprehension	Story Comprehension	Wordless Picture Book Narration	Wordless Picture Book Narration	Comprehension Questions from Wordless Picture Book Narration	Wordless Picture Book Narration	Wordless Picture Book Narration	Vocabulary and Concepts Tasks	Word Morphology	Rhyme ID	Rhyme Production	Concepts about Print Booklet	Upper Case Letter ID	Lower Case Letter ID	Letter Sound

Appendix B: Pre-K Literacy Assessment Alignment with IL Early Learning Standards

ILLINOIS STATE GOAL 1: : Read with understanding and fluency	PRE-K ASSESSMENT TASKS							
	Listening Comprehension	Narration of Wordless Picture Book	Comprehension Questions	Word Morphology	Story Comprehension	Concepts About Print	Phonological Awareness	Letter Knowledge
Learning Standard A: Apply word analysis and vocabulary skills to comprehend selections								
1.A.ECa Understand that pictures and symbols have meaning and that print carries a message	X	X	X	X		X		
1.A.ECb Understand that reading progresses from left to right and top to bottom.						X		
1.A.ECd Identify some letters, including those in own name								X
1.A.ECe Make some letter-sound matches								X
Learning Standard B: Apply reading strategies to improve understanding and fluency.								
1.B.ECa Predict what will happen next using pictures and content for guides		X		X				
1.B.ECb Begin to develop phonological awareness by participating in rhyming activities							X	
1.B.ECc Recognize separable and repeating sounds in spoken language						X	X	
Learning Standard C: Comprehend a broad range of reading materials.								
1.C.ECa Retell information from a story		X						
1.C.ECb Respond to simple questions about reading material.			X					
1.C. ECc Demonstrate understanding of literal meaning by making comments					X	X		

ILLINOIS STATE GOAL 4: Listen and speak effectively in a variety of situations	PRE-K ASSESSMENT TASKS							
	Listening Comprehension	Narration of Wordless Picture Book	Comprehension Questions	Word Morphology	Story Comprehension	Concepts About Print	Phonological Awareness	Letter Knowledge
Learning Standard A: Listen effectively in formal and informal situations								
4.A.EC Listen with understanding and respond to directions and conversations	X		X		X	X		
Learning Standard B: Speak effectively using language appropriate to the situation and audience								
4.B.EC Communicate needs, ideas and thoughts		X	X		X			

ILLINOIS STATE GOAL 5: Use the language arts to acquire, assess and communicate information	PRE-K ASSESSMENT TASKS							
	Listening Comprehension	Narration of Wordless Picture Book	Comprehension Questions	Word Morphology	Story Comprehension	Concepts About Print	Phonological Awareness	Letter Knowledge
Learning Standard A: Locate, organize, and use information from various sources to answer questions, solve problems, and communicate ideas.								
5.A.EC Seek answers to questions through active exploration	X		X		X			
Learning Standard B: Analyze and evaluate information acquired from various sources								
5.B.EC Relate prior knowledge to new information	X	X	X	X	X	X	X	X
Learning Standard C: Apply acquired information, concepts and ideas to communicate in a variety of formats								
5.C.EC Communicate information with others		X	X	X	X	X		

Appendix C: Mathematics Assessment Domain Map

Domain	Number										
Variable	**Cardinality & Enumeration**			**Count List Fluency**		**Number Transformation**		**Number Relations**			**Written Numeral Knowledge**
Task(s)	Give a number	What's on this card--manual	One-to-one labeling	Count as high as you can	Flexible counting	How many in the cup--concrete	How many in the cup--abstract	Which is more—hands	Hand/dot ordering	Which is more—spoken numbers	Written numeral identification
Math Vocab Required	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Items per task	15	10	4	1	10	9	6	8	2	10	13

Domain	Geometry & Spatial Thinking								
Sub-Domain	**Shape**					**Spatial Transformations**		**Spatial Relationships**	
Variable	**Shape Knowledge**		**Shape Analysis**			**Mental Rotation**	**Shape Composition**	**Spatial Relationship Analysis**	**Positional & Relational Vocabulary**
Task(s)	Shape/part ID	Shape sorting	Match shape to part	Find shape using verbal criteria	Footprints	Animal rotation	Pattern block puzzles	Spatial analogies	Match term to picture
Math Vocab Required	Yes	Yes	No	Yes	No	No	No	No	Yes
Items per Task	10	46	12	10	8	20	15	21	19

Domain	**Measurement**	
Variable	Size Ordering	Measurement and Quantity Vocabulary
Task	Ordering & insertion	Match term to picture
Math Vocab Required	Minimal	Yes
Items per Task	12	31

Domain	**Algebraic Thinking/ Pattern Detection**			
Variable	Repeating Patterns			Growing Patterns
Task	Duplication	Extension	Abstraction	Extension
Math Vocab Required	Minimal			Minimal
Items per Task	4	8	4	10

Appendix D: Alignment of Illinois Early Learning Development Standards with Our pre-K Mathematics Assessment

GOAL 6: Demonstrate and apply a knowledge and sense of numbers, including numeration and operations.	**PRE-K ASSESSMENT VARIABLES NUMBER DOMAIN**					
	Cardinality & Enumeration	**Count List Fluency**	**Number Operations**	**Number Relations**	**Written Numeral Knowledge**	**Quantity Vocabulary**
Learning Standard A: Demonstrate beginning understanding of number, number names and numerals.						
6.A.ECa Count with understanding and recognize "how many" in small sets.	X					
6.A.ECb Use subitizing (the rapid and accurate judgment of how many items there are without counting) to identify the number of objects without counting in sets of four or less	X			X		
6.A.ECc Recognize and describe the concept of zero.					X	
6.A.ECd Connect numbers to quantities they represent using physical models and representations.					X	
6.A.ECe Differentiate numerals from letters and recognize some written numerals.					X	
6.A.ECf Verbally recite numbers from 0 – 10		X				
Learning Standard B: Begin to construct sets, add and subtract to create new numbers						
6.B.ECa Recognize that numbers (or sets of objects) can be combined or separated to make another number.			X			
6.B.ECb Show understanding of how to count and construct sets of objects of a given number (between 5 and 10).	X					
6.B.ECc Identify the new number created when sets are combined or separated.			X			
6.B.ECd Solve simple mathematical problems presented in a meaningful context.			X			
Learning Standard C: Begin to make reasonable estimates of numbers.						
6.C.ECa Estimate number of objects in a set.				X		
Learning Standard D: Compare quantities using appropriate vocabulary terms.						
6.D.ECa Make comparisons of quantities.				X		
6.D.ECb Describe the comparison with appropriate vocabulary, such as more, less, greater than, fewer, equal to or same as.						X

GOAL 7: Explore measurement of objects and quantities	PRE-K ASSESSMENT VARIABLES—MEASUREMENT DOMAIN	
	Size Ordering	Measurement & Quantity Vocabulary
Learning Standard A: Measure objects and quantities using direct comparison methods and non-standard units.		
7.A.ECa Compare, order, and describe objects according to a single attribute.	X	X
7.A.ECc Use vocabulary that describes and compares length, height, weight, capacity and size.		X

GOAL 8: Identify and describe common attributes, patterns and relationships in objects.	PRE-K ASSESSMENT VARIABLES—MEASUREMENT & PATTERN DOMAINS			
	Size Ordering	Measurement Quantity Vocabulary	Repeating Patterns	Growing Patterns
ILLINOIS STATE GOAL 8:				
Learning Standard A: Explore objects and patterns.				
8.A.ECa Sort, order, compare and describe objects according to characteristics or attribute(s).	X	X		X
8.A.ECb Recognize, duplicate, extend and create simple patterns in various formats.			X	X
Learning Standard B: Describe and document patterns using symbols.				
8.B.ECa With adult assistance, represent a pattern by verbally describing it or by modeling it with objects or actions.			X	

ILLINOIS STATE GOAL 9: Explore concepts of geometry and spatial relations.	**PRE-K ASSESSMENT VARIABLES—GEOMETRY & SPATIAL THINKING DOMAIN**					
	Shape Knowledge	**Shape Analysis**	**Mental Rotation**	**Shape Composition**	**Spatial Relationship Analysis**	**Positional & Relational Vocabulary**
Learning Standard A: Recognize, name and replicate common shapes.						
9.A.ECa Recognize and name common two- and three-dimensional shapes, and describe some of their attributes.	X	X				
9.A.ECb Sort collections of two- and three-dimensional shapes by type (e.g., triangles, rectangles, circles, cubes, spheres, pyramids).	X					
9.A.ECc Identify and name some of the faces of common three-dimensional shapes using two dimensional shape names.		X				
9.A.ECd Combine two-dimensional shapes to create new shapes.				X		
9.A.ECe Think about/imagine how altering the spatial orientation of a shape will change how it looks.			X			
Learning Standard B: Demonstrate an understanding of location and ordinal position, using appropriate vocabulary.						
69.B.ECa Show understanding of location and ordinal position.					X	X
9.B.ECb Use appropriate vocabulary for identifying location and ordinal position.						X