Designing Curriculum and Building Minds: Developing Readiness for Science-related Skills and Dispositions

Final Report

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Introduction

This report presents the results of a three-way comparison study focused on the social and cognitive effects of a strategically designed curriculum around the use of construction-based manipulative toys. It focuses specifically on how this curriculum amplifies the affordances of ROK Block toys in spurring development of Latino pre-school children attending three Head Start programs in Southern California. Drawing on socio-historical theory and cognitive science, the study explores how these theoretically grounded curricular activities and materials show promising results for prompting preschool children's school readiness and science-related skills and concepts; critical elements for success in K-12 education. This is an important finding given that Latinos are dramatically under-represented in science, technology engineering and math (STEM) fields.

The Latino bilingual learner population has grown enormously over the last decades, yet Latino academic achievement and preparation for higher education remains persistently low. Latino students face enormous obstacles that obstruct their ability to acquire a quality P-12 and postsecondary education. We argue that one of these obstacles is the lack of access to social (Stanton-Salazar, 2001) and cultural capital (Bourdieu, 1986), particularly embodied in materials, activities and knowledge sources that are a common fare among more endowed peers. This is particularly true because a disproportionately large number of Latinos live in conditions of poverty and attend low-performing, under-resourced schools. Low-income Latino youth have relatively limited access to access to high quality educational resources and expertise required for academic success (Valenzuela, 1999) as well as adequate access to the Internet and other educational tools at home and at school (Fairlie, 2007; Fairlie et al., 2010). As a response to this dramatic situation, this study sought to examine how deliberately designed, theoretically informed curricular activities around a toy that has shown much promise in a pilot study, could spur socio-cognitive development and engagement.

Pilot Study

The present study builds on the findings of a-year-long pilot study conducted in the 2009-2010 academic year. The pilot study explored the ways in which theoretically informed adult-assisted play with construction-based manipulative toys organized bilingual elementary school age children's perception to "see" and think scientifically in the context of an after-school educational activity. Specifically, the pilot study focused on the acquisition of cognitive skills related to the fields of science, engineering, and math. It showed that play with the Rokenbok construction toys required children to look for a piece of visual information while holding their attention as they made connections across symbols and objects. We found that construction depended upon cognitive processes that embodied a patterned perception that identified, completed, and extended theoretical relations essential for building know-how to construct operable and sturdy structures. In learning to use external visual literacy models—the company's instructions and examples on the box covers—the playful and cognitively challenging activity promoted the acquisition of competencies for working with the types of visual displays commonly employed at all levels of scientific field—e.g., structured perception, sequential and linear thinking, visual reasoning. It became evident that the children in the sample benefitted from opportunities to develop this type of literacy competency—that is, opportunities to practice "reading" pictorial graphic displays to form physical objects in what we have labeled and example of visual literacy skills.

Although we recognized the inherent potential of the Rokenbok toy system for scaffolding children's cognitive skills, we recognized that the children in this particular case, did not naturally use the pictorial instructions to assist them in building operable constructions through the first four weeks of unstructured play. That is, they were not using a literacy model to guide their actions. The data showed that initially, the children did not perceive the individual blocks as part of an interconnected larger system that could be realized through an organized step-by-step progression. Acknowledging, that this was not a cognitive deficit but rather a lack of familiarity with the use of external literacy models, the team restructured the goals and objectives of the cognitive environment around the toys to focus on socializing the child participants to the use of external literacy models. It became clear that the children needed an intermediate step to introduce them to the tools necessary to create operable constructions—i.e., written instructions and pictorial depictions of construction structures on the box covers.

Overall, we found that the learning environment we designed around the Rokenbok Toy promoted cognitive skills and literacy practices that are beneficial for English language learners' school-readiness skills. The toy and its model-based instructions not only required step-by-step temporal ordering of construction that allowed children to operate at the level of concreteness and non-verbal cognition, but also it promoted their engagement in sequential and linear thinking; skills privileged in the school environment. Thus, children were encouraged to combine the cognitive skills of sequential and linear type of learning with non-verbal forms of thinking such as visual reasoning and physical manipulation, typical of formal instruction. In sum, the deliberately designed learning environment we created around the toys endorsed two types of learning modalities: *auditory-sequential* and *visual-spatial* learning (Silverman, 2002). Adult mentors, however, were a prominent part of the learning environment we designed. Their theoretically inspired goal was to "scaffold" the children's development of cognitive skills (Vásquez, 2003). Essentially, their goal was to work towards socializing children into a set of practices that would help them build a perceptual world that attended to the important visual foci required for building according to the represented constructions in the pictures.

The Present Study: Developing Readiness for Science-related Skills and Dispositions

Using a modified set of Rokenbok construction toys, called ROK Blocks, the present study drew on the theoretical and organizing principles developed in the pilot study to design of curricular materials and activities that targeted the social and cognitive development of preschool-age children. The Rokenbok Company designed the new toy to provide a "low floor" entry into the construction activity, and thus meet the needs of the youngest early childhood builders.

The study was guided by the following key research questions:

RQ 1: What are the characteristics of a strategically designed curricular activity based on the ROK Blocks construction toy that enhances the cognitive, socio-emotional, and school-readiness skills of preschool age children from underserved language minority communities?

RQ 2: What kind of expert-peer guidance ensures optimal learning development?

RQ 3: What are the properties of the curricular activities and materials that effectively organize and support a culture of optimal learning without expert-peer guidance?

Theoretical framework of the study

The objective to unleash the inherent learning potential of the ROK Blocks toys is founded on a socio-historical approach to learning and development that emphasizes the role of culture and social interaction in the development of cognitive abilities (Vygotsky, 1978). We built on Vygotsky's idea that the child's mind internalizes culturally constituted forms of thought embedded in the social and material world, and thus, organized the symbolic and material world of pre-school children twice a week as we studied the cognitive, socio-emotional, and school-readiness skills that this new environment produced. Following Cole and Engeström's (2006) idea that these socio-historically informed interventions "create new kinds of activities that promote the desired form of development and are suitable for a given social group at a particular time and place" (p. 495), we developed materials through an iterative process of "progressive refinement" (Collins et al., 2004), tweaking them to optimally provoke participating children to experience themselves as active learners and thinkers. These theoretical perspectives emphasize the dialectic that ensues as the environment shapes the individual's cognitive processes and the individual shapes the environment. In other words, these processes happen within a functional cognitive system. Changes in children's development is not so much in the amplification of one particular mental function (for example, memory) as in the character of those functions in which remembering takes place. In this spirit, the process of "progressive refinement" of designed curricular materials and activities aimed at promoting changes in the inter-functional relations that a specific cognitive skill with other cognitive and socio-behavioral functions. The goal was to guide children through a self-directed engagement framework in which the activities of the ROK Block cognitive ecology offered possibilities for the expansion of their overall cognitive and behavioral functional system, called executive function skills (see the section on EF below). We did not aim to create an activity that would specifically target the development of an isolated cognitive skill but, rather, attempted to create a culture of optimal learning that restructures the organization of children's cognition and socio-emotional development in terms of a holistic qualitative change.

Two other theoretical concepts informed the goals we set for ourselves to create an optimal learning environment: 1) the situated "extended mind" cognition framework of Clark & Chalmers (1998), Goodwin (2010), Malafouris (2004) and Sutton (2008) and 2) the "embodied cognition" framework proposed by a growing body of research in the fields of cognitive science and neuroscience (Churchland et al., 1994; Maravita & Iriki, 2004; Nunez, 2006). Clark & Chalmers (1998) argue that "extended cognition is a core cognitive process, not an add-on extra" (p. 15), that is, the incorporation of bodily action and features of the environment are crucial to scientific understanding of cognition and its development. Churchland et al. (1994) highlight the coordination of perception and situated action as active constituents of the cognitive processes. Following this line of thinking, we aimed to observe the development of children's cognition as part of mediated social activity within a cognitively rich external socio-cultural space composed of deliberate talk, gestures, embodiment, and the manipulation of material objects.

Methodology of the study

Setting

The study was a 3-way comparison study involving three Head Start Programs with similar ethno-linguistic and socioeconomic profile and programmatic offerings situated in North San Diego County. The Chicano Federation of San Diego, Head Start's grantee agency, allowed researchers to conduct the study during the program's Creative Curriculum hour. The ROK Blocks table was one of multiple activity systems children could select from and stay as long as they wanted. The study involved two intervention sites and a control site where researchers participated twice a week for two hours. All sites were given access to researchers and the same number of ROK Block toys (4-5 boxes). The especially designed curricular materials were introduced only at the two intervention sites. One of the intervention sites included child participants attending the *Mi Clase Mágica* (MCM) program, a pre-school adaptation of *La Clase Mágica,* a research cum social action initiative that aims to provide child participants with a cognitively and dialogically rich environment steeped in intellectual resources derived from multiple cultural sources [lcm.ucsd.edu]. This site was used to compare the possible impact that MCM had on targeted skills, which will be completed at a later time.

The third component of this research study was a control site, a third Head Start preschool program situated in North San Diego County, only a few miles from the two intervention sites. An adult member of the team attended the Creative Curriculum session of the site once a week and assisted children who voluntarily engaged in the ROK Block building activity. While the site did not receive the designed curricular materials, the children did have access to the aspiration objects the adult mentor constructed for the children. The children displayed a familiar building trajectory to that of the intervention site children, however, there were several differences that set them apart.

Similarities included a strong initial interest to build trucks, cars, walls, towers; constructions that utilized large sized blocks in a stacking fashion. Wheels were the preferred manipulative throughout the course of the study. A significant influence in children's building was the response to modeling by the expert-peer. Children were regularly inspired to build the aspirational objects that these peers constructed.

Social interaction also appears to be more prevalent and necessary at the control site throughout the course of the study, a point we observed in the free unstructured period at the intervention sites. Children's building significantly depended on prompting and direct instruction from the adult mentor who provided support as requested by the children. A regular occurrence of crosstalk between all of the children and expert-peers was observed throughout the entire time— i.e. children commenting on what their peers and the adult were building. Instances of children's interest to engage with these blocks typically focused on acquiring physical support from the expert-peer who was asked to hold and handle the blocks, as well as guide them in their use. Unlike the intervention sites, where children became more engrossed at engaging the materials, the children at the control site depended more on the adult guidance.

Another important distinction is the use of the snap-fit blocks for decoration than for construction purposes. For example, they used these pieces to add ears, eyes, and tails etc. to their creations but not much else. At the end of the study, the children were still building towers and experiencing difficulties with the sturdiness of their constructions, unlike the children at the intervention sites who used the instructional materials to create more complex creations.

Participants

The sample comprised of children from low-income backgrounds, 3-5 years old who were predominantly Latino English language learners (ELLs). Approximately 140 children across 7 classrooms self-selected to participate in the study— i.e., they chose to play at the ROK Block table.

The research team was led by 3 seasoned researchers; Principle Investigator, Olga Vásquez, graduate research assistant, Ivana Guarrasi, and staff research assistant, Robert Carr. A curriculum developer, Sarah Aglietti, also served as a consultant in the development and introduction of the materials. The research was supported by an additional group of 12 undergraduate research assistants who participated as paid assistants or for academic credit. All of these assistants participated as adult mentors or expert peers in implementing curricular activities and supporting children's development at the intervention sites. An additional assistant engaged with children and ROK Blocks at the control site.

Data was collected at the two original intervention sites during 22 sessions that spanned over 5 months and an abbreviated phase of 6 sessions at the fourth site. No data was collected on the use of the toys at the control site other than the personal information on the child participants for comparison of the STAR tests taken in the second grade—two to 3 years from the end of the study. All sessions were 30-50 minutes. The control site was offered the same number of toys and a research member to play with the children; however, the designed curriculum materials and activities as well as the scaffolding techniques used at the other two sites were withheld. All ROK Block sessions were offered as a supplemental activity across the four sites during the daily "creative curriculum" hour. The researchers' intervention table of ROK Block construction toys and designed curricular activities constituted one station of the "creative curriculum" hour among numerous activity stations that included scientific experiments, computer, painting, reading, dress-up and so on. The children self-selected the ROK Block table although on occasion, teachers urged specific children to attend. Children could join and leave the table at any point of time based on their preference, but they typically stayed the entire session (40-45 minutes); otherwise stayed approximately 15-20 minutes. All sessions were observed and documented using written observations in full-length ethnographic field notes taken by 2-3 research assistants, video cameras used to record interactions across the entire session, parent take-home questionnaires, and unstructured and open-ended interviews with the teachers. Video recordings were made of the children during each session in order to further expand the opportunities for observation and analysis.

Data collection consisted of three phases at the two main intervention sites and a final abbreviated sequence at a third intervention site. The study began with a pre-intervention stage in which children at the intervention sites were encouraged to explore and manipulate the toys with only a minimal amount of guidance. The children were introduced to building toys without guidelines other than, “here are some toys for you to play with.” The objective was to simply observe them “playing to learn” in self-directed play, without seeming too directive or authoritative. Two to four session into the study, a “landscape mat” was placed on top of the play table without explicit verbal cues. The mat’s function was to call attention to the possible constructions the toy offered and encourage children to incorporate in their play, the road, parking area, lake, construction site, park and several model constructions The mat’s function was to call attention to the possible constructions the toy offered and encourage children to incorporate in their play the road, parking area, lake, construction site, park and several model constructions depicted in the graphic landscape.

Thus, the intervention began in earnest with the introduction of external literacy models in the form of a landscape-style mat. This phase applied an iterative process in which curricular artifacts were designed, implemented, studied and evaluated within the context of playful activities, and then redesigned after the research team examined the functionality of the materials in action. This process yielded three “landscape-style” mats, one set of instructional place mats, and two sets of instructional flip-books. Each artifact designed gave way to the next, once its optimal version was thought to have been achieved—i.e., the artifact sufficiently indicated the prompting of socio-cognitive development; children were actively engaged and innovatively building.

The final abbreviated phase of six sessions took place at a third intervention site that had not participated in the first two phases. The site was selected because of its ethnic and socio-economic similarities to the study’s 3 other sites and to test the sequencing of the materials that had been developed. The stated goal was to test the functionality of the latest and most optimal version of each artifact and to examine whether there was an ideal order that would set in motion a “flowering” of the developmental processes and whether we could document in a time-lapse photography fashion. We lined up the artifacts to build on each consecutive developmental stage, we theoretically assumed the previous artifact had achieved. That is, researchers reorganized the order of the implementation of curricular materials to evaluate the most appropriate sequence for children’s development and test the effectiveness of the designed materials in a new context.

Throughout the study, one to four adult mentors from the research team participated at the two ROK Block tables set up each session. Without explicitly dictating a specific set of rules and a course of action children had to follow, the adults guided children at the intervention tables through the construction process and use of graphic instructions—i.e. the placemats, books, and landscape mats—facilitating the children’s “play” with the ROK Block construction toys. As such, they provided a structure intended to transcend the children’s unstructured exploration and creativity with the goal of socializing them into a variety of cognitive and scientific competencies that once acquired could be re-utilized for novel and imaginative projects. Once curricular materials were introduced to children, the adult mentors guided children through a step-by-step processes of the construction in a coordinated manner using the visual and oral instructions. Children were not expected to follow the adult direction if they did not feel like doing so, but they were given enough room to respond to the adult’s prompts—e.g. “Build,” “Can you find this piece in the bin?” “What piece is missing?” “What’s next?” etc.—based on their personal preferences and inclinations. In other words, all participation on the part of children was voluntary; they could enter into, leave and direct the course of their participation in the activities at any point of time. Each session involved at least one or more adult-mentors who were bilingual English-Spanish speakers so that children could choose the language in which they preferred to interact.

Findings

The study examined the impact of several types of curricular materials on the development of cognitive and school-readiness skills of preschool children. In this section, we discuss the iterative process of design, implementation, and evaluation of different curricular materials in the order in which they were introduced to children. The main objective was to design a curricular artifact, introduce it into playful activities, study it and then modify it to restructure the most effective learning environment in which children could achieve their optimal cognitive and socio-cultural development. In what follows, we give a general overview of children’s engagement with the ROK Block unstructured play activity, and then we discuss the intervention process separately for each designed curricular material.

The development of children’s construction skills

An important observation that was garnered from the data was the similar developmental trajectory in construction skills and types of creations displayed by the children across all intervention sites. At first, children stacked blocks one on top of another, building “towers” of various heights. The “car” was also a common construction during the initial phase. These cars consisted of one or two blocks with a number of wheels (not necessarily four) attached. These types of constructions were so pervasive that they could be identified as specific periods in children’s construction trajectory such as the “tower period” and “car period.” Over time, the cars became more elaborate and bigger (sometimes turning into “trains”), and the towers slowly transformed into “houses” and “walls” as the children began to attach blocks sideways rather than solely on top of each other. The “wall period” was unique in that children added wheels to their “walls,” thus bridging their competence with building towers and cars. The shift from “towers” to “houses” seemed to mark children’s discovery and understanding that ROK Blocks could be used to build upwards, but also in three dimensions.

Building cars, towers, and houses was a recurrent choice for children throughout the study. Some of the children continued building these types of creations even after the introduction of placemats and books. The functionality of cars became really important; the children were concerned with how their cars rolled on the floor and often tried to readjust the wheels if they did not work. Another pervasive type of construction children created during the free play period and after the car phase were curves and circles made out of the curvilinear red blocks. At first children started building semi-circles representing “boats”, “bridges”, “rainbows,” and later attempted to make a sinusoid-like “snake”, or even a full circle, thus creating a “hamster wheel” or a “doughnut.” Often, children’s building choices were initially inspired by the adult mentors who would build the first “bridges” and “snakes”.

During the initial phases, the children primarily used the big blocks with the “friction-fit.” They commonly included a few “snap-fit” blocks when making their creations only after several sessions of building with the bigger blocks. They often made a house or a wall out of the big blocks and then “decorated” it with the small snap-fit blocks and wheels. Connecting these blocks together generally required much more persistence and patience by the children. During the free play phase children used these types of blocks only sparingly and often gave up connecting these pieces together if they did not succeed on the first or second attempt. The introduction of the instructional materials significantly increased time and effort children put into connecting them. As children became aware of the sequence of steps to complete the particular construction, they tended to stay on task longer in comparison to free play period, during which children frequently adapted their constructions in order to minimize their manual struggle with the blocks.

After the introduction of the instructional materials most of the children attempted to follow the pictorial instructions. Only a very few children were able to build independently following the placemats and books; they generally needed to be guided—i.e. socialized—into the activity in order to accomplish it successfully. Thus, the definition of “success” changed considerably. Children’s actions became more purposeful and goal-oriented. The instructional materials served as inspiration for them to build a variety of objects they knew from their everyday experience such as a “camera”, “kitty”, “butterfly”, “cell-phone”, or other more imaginative things such as a “flying car”, “piglet on wheels”, and “robot”. Children typically began with the intention of faithfully reproducing the pictures. However, during the first few sessions with the curricular materials, they needed (and sought) adult guidance, prompting, and encouragement in order for them to follow the sequential order. If children required assistance they asked for help from the adult mentor or quietly observed another child building the same construction. However, they tended not to openly ask other children for help nor sought to work collaboratively with others on the same construction.

Once they had been initiated into the activity and developed the necessary skills to accomplish their objectives, children became much more independent during the building process and required less help from adults. By replicating the construction they saw in the sequence of pictures, they experienced the benefits of exerting great effort, focus and time in following the instructional materials step by step. Subsequently their motivation to follow other pictorial guides became significantly stronger. When children experienced a moment of success, they tended to draw the attention of an expert-peer—i.e., member of the research team—saying “Look, I did it!,” “I made a robot!”.

Consider the example of Noah’s creative attempts to build a bridge that was much more elaborate than the example shown in the book. Noah had observed his friend Jose building but initially displayed difficulty completing a bridge without following the instructions in the book. When an adult mentor prompted him to use the instruction book he was able to quickly built the basic bridge and further expand it with other blocks. The bridge became longer and much more intricate than the original one in the book. In the last session, Noah, was observed actively trying to figure out the instructions to build the helicopter, one of the most challenging constructions in the set of materials that were created.

Overall, during the last several sessions, children exhibited goal-oriented behavior with a high level of persistence in problem solving and motivation to succeed, a dramatic change from their first exposure to the blocks in free play. We believe that this change in behavior was a result of being socialized to the use of external literacy models that provide a step-by-step progression. When children experienced success by building according to the designed external models, they seemed to develop the confidence and trust that the instructions provide a reliable guidance to complete their construction, although following instructions was challenging at times. Only after they had managed to complete their constructions using the pictorials in the placemats and books did some of the children begin to enhance their creations in imaginative ways. For example, after they completed a “kitty” pictured in the placemat, they added “wings” and ended up playing with a “flying kitty.” In other cases, they simply expanded the creation they built by making it larger, more elaborate, or substituted some of its parts with different pieces.

There is a comparable quality we observed between the exploratory imaginative building before the intervention and the creative building that took place during the last few sessions of the study. In both cases, the children’s creative action tended to happen ad hoc without much prior contemplation in the moment of building. However, we believe that a qualitative change occurred in the children’s vision of what they wanted to build and what steps they took to pursue that goal. After the introduction of the instructional materials, children’s actions became structured, however, they were also increasingly open to exploratory variations in new and creative ways in terms of how the initial goal was accomplished. In other words, children exhibited less creative variation in their building before they were given a structure to follow and expand upon. In fact, before the intervention, children tended to copy each other or continuously build the same type of construction over the period of several sessions (i.e., children kept building towers and houses or cars and trucks, etc,). The data analysis suggests that even though children’s creativity and imagination was inherently present in their play from the beginning, it came to the forefront in a more articulated way once they acquired a basic set of “tools” they could employ and a primary pattern of operation which they could alter, reinvent, and experiment with.

The development of perceptual vision and engagement with different materials

Pre-intervention phase

During the pre-intervention phase, the research team was careful not to impose its expectations on what the children “should or should not do” or what they “wanted” to see the children do. The initial goal was to simply observe their engagement with ROK Blocks, in self-directed play, without coming across as directive or authoritative. To do this, the children were offered as little guidance as possible. However, even this initial phase always included an average of one to three adult mentors who were well equipped to provide children with the material and intellectual resources as well as stimulation to explore ROK Blocks without dictating any specific set of rules to follow. Although, this phase was designed to observe children play with the toys unencumbered by adult intervention, the adults were ready to moblize their expertise to “scaffold children’s progress through their zone of proximal development” (Vygotsky, 1978). However, their observation was also focused on how these toys functioned in a typical undirected environment.

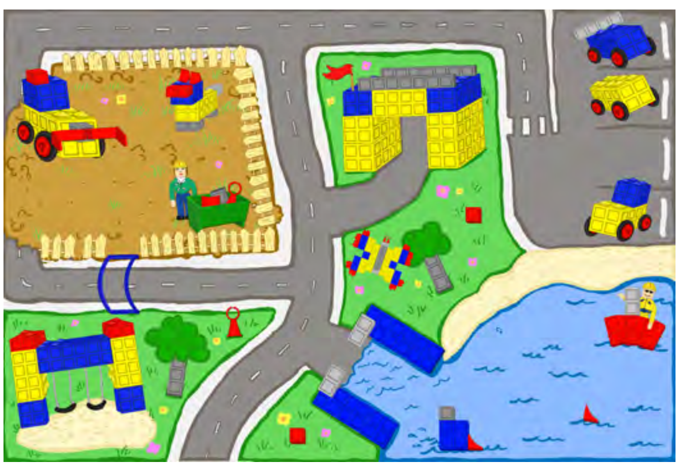
First intervention phase – non-instructional materials

The introduction of curricular materials during the pre-intervention phase of the study was designed to provide an additional point of entry into the construction activity besides the blocks and to examine if children’s exploration and play with the blocks altered. The pre-intervention materials were designed to create an environment of playful engagement with the blocks apart from building. More importantly, they were designed to initiate the process of socializing the children into the literacy practice of “looking” at pictorial representations of the block constructions that would potentially inspire them to build the assembled constructions displayed on the mats.

Landscape Mats.

* Original Design

The landscape mat was designed to provide a setting for children to play with their toys (i.e., driving the cars on the roads, placing the boats into the water area) at the same time that it inspired them to build particular creations that fit into the environment on the mat—see original design. Initially, some children came to the ROK Block table but did not engage in the building process, however, these children actually incorporated the mat into their play more than those who had were absorbed in building. It appeared that the mat functioned as a way for these children to engage in the activity without the need to directly engage in the building process. These children participated by playing with either the figurines or with a small number of blocks, utilizing the pictures on the mat as a backdrop for play.

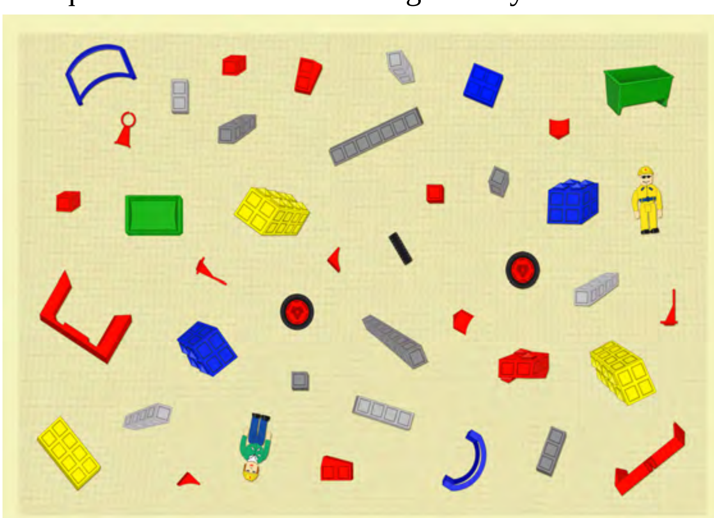


* Revised Design

Within a very short time, the research team realized that the images of inspirational constructions depicted on the mat were too small and abstract for the children to “see” or use as models. A new mat was created with landscape that magnified these inspirational constructions, making them more prominent and simple to follow—see revised design. The background on this mat was designed as an open space—representing by a grassy lawn—and the model constructions were prominently displayed. Four different creations were displayed on the mat, each one embodied a different level of difficulty including three small blockhouses, a truck, a seesaw rocker, and a bridge. Interestingly, the children acknowledged the depictions, but did not imitate them spontaneously in their creations. We observed only a few children trying to construct blocks based on the images (one boy even counted the number of blocks to make sure he built it in the exact same way). However, once children were individually encouraged by the adult mentors to build similar construction, they were more likely to collaborate with the adult to build the same constructions.

In our view, the landscape mats began to familiarize children with the practice of focused observation — i.e. "looking" and understanding the relations between the physical blocks and their visual representations. The mats also provided children with the flexibility to follow the instructional materials at their own timing while entering into the building activity. The pictures in the landscape mats created new possibilities for children to participate in the ROK Block activity even without being directly engaged in building process itself. By spending time at the table, exploring the pictures, and playing with the figurines and blocks without building, children who initially did not engage in the process of construction had opportunities to watch others do it, which became a motivating force for them to pursue their own building activities. Through the introduction of landscape mats, the ROK Block activity maintained their attention and opened up new options for children to continue participating after they had constructed their creations. Slowly, however, they began to build smaller constructions on their own.

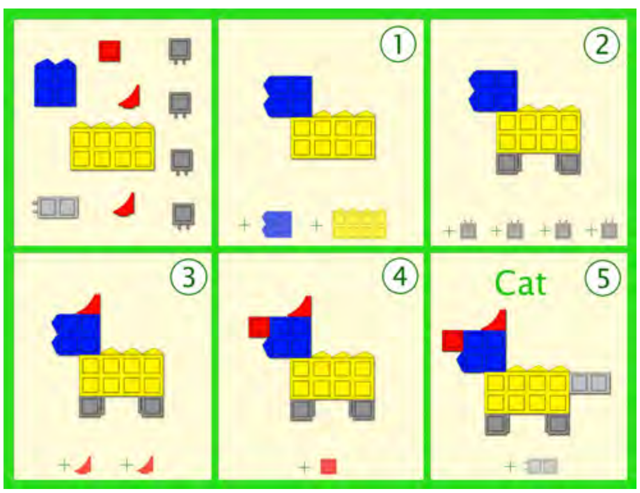
Analytic mat. In between the two mats, the research team considered the possibility that the children required a more formal introduction to each of the individual blocks and their various dimensions, and thus designed "the analytic mat." The purpose of this new artifact was to create a stepping-stone towards visual literacy that would socialize children's perceptual vision into the practice of looking at instructions. It depicted all of the blocks from the ROK Block box in the exact size as their respective physical size. Each of the blocks was displayed at several different angles. The desired objective was for children to learn to relate the images of the blocks with the physical blocks—i.e. symbol-object relation—in a very specific and focused way. During the engagement with this mat, children were encouraged to "see" that the blocks can be depicted at different angles, and not only from the frontal perspective. The "analytic mat", in comparison to "landscape mats" was predominately used as a quick 5-10 minute matching activity before the actual building started since it took children approximately 5 minutes to match all the depicted blocks with the real ones. In the matching game activity, expert peers asked children (as teams or individuals) to take turns at matching the block with its respective image on the mat. The matching game worked towards the development of children's executive function skills (see the section on EF skills below). However, we found that after two rounds of the matching game it was too difficult for children to retain focus as they became easily distracted.



Depicting the different angles of the blocks seemed to be a revelation for many children. Images of the blocks with the least obvious angles usually took children the longest time to match. At the same time, most children who participated in the game demonstrated competency at identifying and matching most of the blocks. One of the main drawbacks of this mat was its failure to keep children's attention for more than a few minutes. However, even those brief encounters with the mat seemed to effectively prompt children to develop perceptual vision and prepare them for the subsequent introduction of multiple-step instructional materials.

Second intervention phase – instructional materials

The second intervention phase focused on the development and iterative implementation of instructional materials that children could follow independently. They were designed to restructure the cognitive ecology of the ROK Block activity in order to target the playful development of children's cognitive and school-readiness skills, augment the complexity of their constructions, and promote motivation to engage in a playful science and engineering related activity from the earliest age. The research team also designed the instructional materials for preschool children to afford them a springboard for later engagement with a more advanced set of Rokenbok manipulatives. The two types of intervention materials, placemats and books, aimed to give a direct exposure to the visual literacy practice in the context of preschool construction play. Working with visual data is a skill that constitutes the core of much scientific practice. Driven by the need to look for a piece of visual information, the instructional materials were designed to incite the development of socio-emotional and school-readiness skills such as the practice of visual perception of patterns, maintaining attention while making connections across symbols and objects necessary for building competencies. Incorporation of the instructional materials into the ROK Block activity structured children's free building in specific ways. Both placemats and books were labeled bilingually, in English and Spanish, to make socio-cognitive connection to the children's background experiences.



Placemats. In order to re-orient children from their usual free building time and capture their full attention, the adult mentors introduced the placemats at the beginning of the first intervention session by showcasing each placemat individually. Each placemat represented a progression of step-by-step pictorial instructions on how to build a specific construction such as a "kitty", "truck", "butterfly", and "cell-phone." The first step represented all the blocks necessary to build the construction and the last step represented a fully built construction. The pictorial progression displayed the building of the construction by adding a new set of blocks during each step or page. The new additional blocks in each particular step were showcased below the respective step. Adult mentors talked to children about all the creations they could possibly build following these placemats and engaged in short conversations with the children about their ideas and preferences with respect to their building goals.

The placemats also created opportunities for children to develop their executive function skills (see the section on EF below). The first step depicted an assortment of blocks needed for building. The adult mentors encouraged the children to identify and look for all the blocks before they started building. Moreover, they guided children through the process of going through the sequence one step at a time, emphasizing the importance of not skipping steps. However, many children did not follow the sequence and tended to go immediately to the last step with the fully completed creation, trying to approximate their construction to that image.

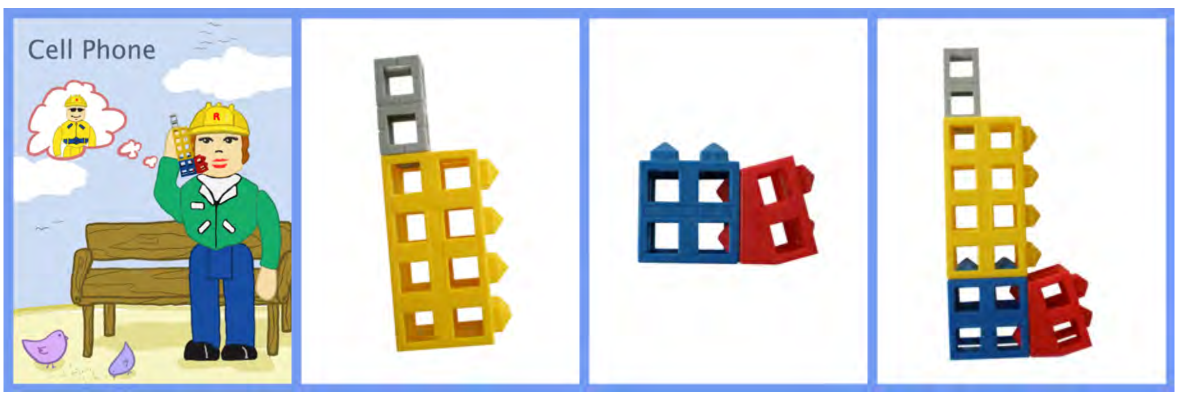
Most of the children engaged with the placemats yet required very structured adult guidance. Those children who preferred to build in a completely unstructured way continued doing that unless prompted by the adult. Moreover, only a few children were able to immediately follow the sequential order of the placemats without adult guidance. The independent engagement with the placemats inherently represented a new type of literacy skill and all of the children in our sample needed some form of adult direction in order to acquaint themselves with the placemats. They first had to be "socialized" to understand the value of using this instructional material to aid in building. The progression of steps was not obvious to them despite the numbers indicating a successive order. Children at this age typically have not yet mastered visual recognition of basic numbers and because the steps were arranged in two rows, one on top of the other, many children did not initially grasp the left to right or top to bottom progression of the steps. They did not understand that they had to first follow the sequential order of the top row and then transition to the bottom row following the same pattern. Many preschool age children have not yet mastered the movement from left to right, a skill necessary for the development of traditional print literacy. Many of the children did not ask direct questions to clarify the points of their confusion, instead they often communicated their concerns nonverbally through gaze, pointing, and manipulation of the blocks. The opportunity to interact with the adult mentors during hands-on manipulation of the materials seemed to make for an effective form of interaction that children sought throughout the building process.

The placemats considerably transformed the ROK Block activity. They helped children better articulate their building goals and a direction on how to attain them. Even though the placemats structured their activity in a particular way, they also left enough room for experimentation and imaginative building. Once the children completed their creation they often "improved" it by using their own imagination. In this way they were able to put a unique touch to their constructions (see more in the section on the trajectory of children's building above). In addition, we observed that children were able to complete the constructions they set out to build. The completion of individual steps during the process of following the instructional placemats seemed to heighten their sense of accomplishment and give them confidence in their abilities to "follow" the instructional materials. It provided motivation for future building.

Overall, after building one or two creations with the adult guidance, most of the children quickly grasped the basics of following these instructional materials and then were capable of following the mats more independently. After one or two sessions the children began to seek the help of adult mentors only when they needed a particular block and they could not find it on the table or when they had trouble manually attaching two blocks. However, children demonstrated increased competence in identifying and communicating their needs and seeking help to move forward in their building process. While working on their own and collaboratively with the adults, the children demonstrated a growing ability to utilize graphic instructions.

While these materials did prompt children to pay close attention to instructions, the visual data on the placemat was too overpowering for a relatively small sheet of paper. This caused some children to become sidetracked while trying view the different little graphics on the placemat. It became obvious that a visually "cleaner" and enlarged depiction of the blocks helped children to read the patterns of visual data on the mat. We resolved to address this issue by creating books as a new means of introducing sequential instructions.

Books. The research team designed the next set of visual building instructions in a format that was ubiquitous in children's everyday life. Books are a common literacy practice and thus a logical form for designing instructional materials. Books and book reading activities are a fairly common practice in preschool. We observed preschool teachers read to children almost every day we were present. According to the parent interviews, reading is also a common practice at home. The goal was to use this format to socialize children to a new form of visual literacy that used pictorials and minimal language. Our observations had made clear that preschool children were better at perceiving and discerning the information from the visual material if pictorials were presented in elementary forms, uncluttered by large amounts of distracting visual data. Therefore, we retraced our steps to display only one image per page for each step of the building process showing blocks on a scale that corresponded to the size of the physical blocks.

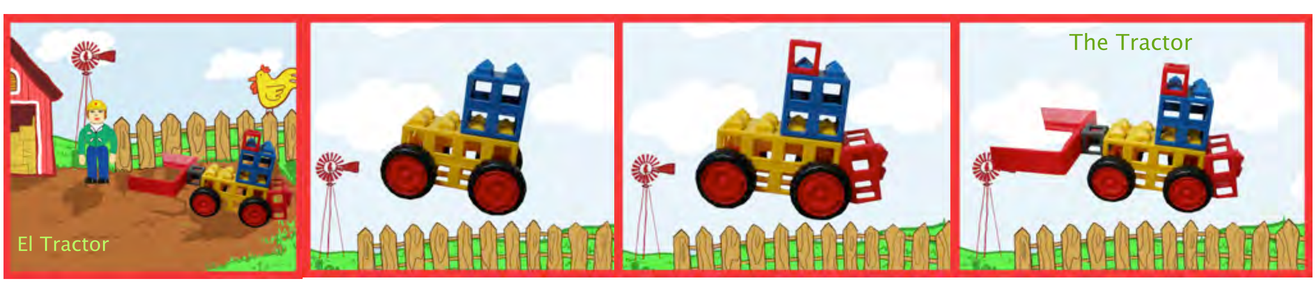


While we do not know the prior affect of the placemats on preparing children for this form of literacy, the visual appeal of the books, nevertheless seemed to positively affect their motivation to engage in the building process. More children showed initial enthusiasm to engage with the books than the placemats. The books emphasized an artistically stimulating background in addition to the basic series of steps. However, children appeared to experience a greater challenge in using the books than they did with the placemats. Most of them focused primarily on the visually appealing cover of the book that displayed the finished constructions in an artistically designed environment, but spent only seconds opening the book to random pages. Paradoxically, the visual attractiveness of the book covers overrode the actual steps inside of book.

One of the greatest benefits of the books was that the size of the depicted blocks corresponded to the size of the actual blocks. We observed many children (especially during the first few sessions) placing the actual blocks on their respective images and then connecting them together. Even though each page represented only one step in the construction series, children seemed to have trouble "seeing" the individual steps as part of a whole. On the page they saw only one individual part in isolation and they did not understand how it related to the other steps in the series nor what part it represented in the finished creation. The individual steps often seemed to be too abstract for children and the concept of the sub-assembly as part of the building progression was confusing and foreign to them. We found the sub-assembly to be a cognitively more difficult operation for children because their working memory (see section on EF skills below) did not seem to be developed enough at this age. They either could not remember the assembled parts they saw on the cover as they engaged in building the individual sub-parts or they lost sight of what they originally set out to build. For example, they would complete one step, flip the page to the next step and because they saw the picture of a completely different set of blocks together, they became confused and thus disassembled blocks they had put together in the first step and began to construct the second step anew. We observed one child become so frustrated with the steps that he flipped back to the front cover saying that he could "see it better" that way.

In general, the children demonstrated a strong preference for adding new steps onto already completed part of the construction — each step representing a new addition to the old structure. They were generally able to build more independently when they could "see" and identify for themselves what part of the original construction they were working on such as "the body of the robot", then adding on "the head", "hands", 'legs", "shoes", and so on.

Once we observed these challenges during the first session, we revised the books and eliminated the discontinuity between the individual steps (see below revised book). In other words, each page (step) depicted a newly added set of blocks to the construction that was depicted in the previous step. In this way we eliminated all depictions of sub-assembly from the instructions and assisted children's memory. This revision seemed to lessen the confusion children experienced with the original books (even for those children who did not participate in the first session and were exposed to the books for the first time). Similarly to the engagement with placemats, once children acquired the basic skills to follow the books, they required progressively less expert-peer guidance and some of them began proceeding through the books independently after only two sessions. However, the goal of decreasing the amount of adult mentor guidance and involvement during the initial exposure to the instructional material was not accomplished. The adult mentor's assistance was especially prominent during the first session when the books were introduced, but progressively decreased with each session. Some children were able to follow the books on their own during the second session and required the adult help only sporadically when they encountered an obstacle they could not problem-solve on their own.



Development of problem solving skills

The ROK Block activities were packed with problem solving opportunities during all phases of children's engagement. However, in order to engage in problem solving children needed to define something as a problem. They first had to recognize that there was a discrepancy between their desired goal and the actual state of their construction and then reason that they needed to correct the incongruity. Hence, in the data analysis we looked for moments in which a problem was identified, analyzed, and a solution was sought. In addition, we looked for similar instances that illustrated a child's ability to draw conclusions, extract a rule from successful solutions and finally incorporate new information into subsequent building processes. The most frequent problem we observed was children's difficulty in connecting particular blocks in a desired way. Several of the smaller snap-fit blocks required a significant amount of strength and precision of alignment in order to attach them. This was not readily apparent at the beginning during the free play period when children needed little adult assistance. At this stage, they tended to substitute the snap fit blocks with the ones that what easier to attach rather than ask for assistance. They also spent more time exploring how they could connect individual pieces in building constructions that were stable and would not fall apart. As children began to build bigger and more elaborate constructions, the big friction-fit blocks were generally picked up first and the children were left with the small snap-fit blocks if they wanted to continue building. However, as time went on, children began to choose smaller and more challenging blocks from the many different types of blocks in the ROK Block box.

After the introduction of the instructional materials, children's problem solving opportunities expanded. Not only were they compelled to persist more often in working out how one block connected to another in a specific way (as shown in the instructions), they also identified a different type of problem—*how to put their creations together to match the pictures.* Using placemats and books that consisted of a series of steps, with each step being an extension of the previous step, children began to recognize that in order to move to the next step they needed to complete the current step first. Such understanding stimulated a dramatic change in children's determination to finish each individual step before moving on to the next one, notwithstanding how difficult it might be. Up to the time we introduced placemats and books into the ROK Block activity children's awareness of how to put the blocks together had been limited to those options that required the least struggle.

Once the children developed more complex visual literacy skills in terms of how to follow the particular set of instructions in the designed materials and became socialized into "seeing" the connections between the pictures and blocks, their theoretical understanding of the building process clearly developed beyond that of their manual skills and strength to attach the pieces together. We observed many instances when children exhibited a clear understanding of following the instructions, but kept failing at connecting the snap-fit blocks together. In these moments, the "manual" assistance of the adult mentors was crucial so that children could move on to the next step and did not abandon the activity just because their motor skills and strength were not yet developed enough to complete the constructions on their own.

After the introduction of the placemats and books one of the most common problems the children encountered was understanding how to position the block at the correct angle so other blocks could be attached as depicted in the picture. Even if children were skilled in connecting the appropriate blocks according to what they saw in the pictorial instructions, they often overlooked the correct positioning of blocks with respect to their openings and pointed cones. This made the connection between blocks in later steps unworkable even if their constructions appeared to look exactly like the one in the picture. We observed, however, that children's ability to solve such problems improved over time. The deciphering process took several attempts, a close study of the pictorial instructions, a significant amount of perseverance, and the inability to attract the adult mentor's attention. Once they resolved this problem children paid close attention to the blocks' positioning with respect to its openings and cones and never again struggled with the same problem to such an extent again.

Children commonly employed another type of creative solution to deal with the discrepancy between a goal they committed themselves to accomplish, for example, constructing a butterfly, and the realization that completing such project was too challenging for them at the moment. After children came to the conclusion that the particular task they set out to do required more of them than what they were capable of, they abandoned the instructional material, but not the project itself. In other words, when they could not attain their goal, they changed it. The goal was no longer to build the butterfly depicted in the placemat, but alternatively to build a butterfly of one's own imagination. Overall, once the children started to articulate their goals and express plans for building (the competence that had been heavily encouraged and scaffold by the adult mentors during the entire period of data collection), they became quite committed to the idea of a new goal and its attainment.

The development of children's "vision" and planning

Children's planning skills and vision of what they were going to build became significantly more pronounced after the ROK Block activity became more structured through the use of placemats and books. From the beginning adult mentors asked children about their thoughts and building plans with questions such as "What would you like to build today?," "What are you making?," and "What is this?" At first, children were generally quite hesitant to engage in conversations about their building process and the constructions they were making, especially during the free play. They often responded by saying "I don't know." However, they seemed to have some idea about their creations even during the free play despite their reluctance to explicitly talk about them. This was quite visible in their approach to sharing of blocks. Most of the time children were willing to share (sometimes after extended prompting from an adult), but many were adamant about keeping at least 4 wheels for themselves. In this way, children demonstrated their planning skills even without explicitly articulating them. A similar situation occurred with the "little figurines;" children insisted on keeping at least one of them so they could play with it once their creation was finished.

We observed that children's simple constructions did not necessarily point to their lack of enthusiasm for the ROK Block activity. On the contrary, it suggested that children have a clear idea about what they want to do. Jessica, for example, regularly came to the table to build "puppies" out of two yellow blocks connected together so that one represented a head and other a dog's body. Once she built two or three puppies, she played with them around the table. After several sessions one of the adult mentors suggested the possibility of adding ears on her puppies and without waiting for Jessica's response she added two red blocks on top of one dog's head. Jessica immediately disapproved, took the red blocks off her puppy and continued happily playing with the "dogs." It appeared that Jessica had a clear mental image of how she imagined her puppies to look like, although a quite minimalist aesthetic preference, indeed. As Vygotsky points out (1978), children do not always require elaborate and visually appealing toys to play with, their vivid imagination suffices. This and similar examples of children not building complex constructions did not mean that they lacked the skills or excitement to engage in a ROK Block activity, but rather that they found what they had constructed significantly appealing at the time.

During the free play children often became inspired to build a specific construction from the creations of other children and adult mentors. Children aspired to build the exact same creation, but often could not imitate it in exact detail. This seems to be one of the reasons we observed many children simultaneously building the same creations and thus organically forming a "car period," or a "house period" in their building trajectory.

After the team designed a more structured activity for children and introduced placemats and books, children's vision and planning became more overtly expressed through language and non-verbal behavior. Many children voiced their preferences verbally but even those children who tended to be quiet or were bilingual ELLs demonstrated their preference by pointing and grabbing the specific instructional material they chose to follow. During the intervention children asked for more attention, help and feedback on their building progress from the adults. These instances showed that the children had a clear vision of the goal ahead of them. The opportunity to experience the sense of accomplishment and ultimate reward after reaching the desired goal seemed to override the fact that following instructions was not an easy task.

Development of executive function (EF) skills

According to the previous research on early childhood development (Garon et al., 2008), children ages 3 to 5 years go through an important period in the development of regulatory executive function (EF) skills. EF is described as "adaptive, goal-oriented behaviors that enable individuals to override more automatic or established thoughts and responses" (p. 31). Three main measures of EF skills development in the preschool include: *working memory*, *inhibitory control* (response inhibition), and *attention shifting* (flexibility to shift attention). Attention, however, is important to all three abilities. Cognitive and motor inhibitory control represents distinct but related processes that help children to prioritize, regulate, and orchestrate their thoughts and behaviors. EF skills also serve as a measure for school readiness in terms of children's ability to be self-directive, such as starting a task, paying attention, persevering, and remembering.

In observing children engaged in the ROK Block activity, the research team focused on key EF skills related to school-readiness: forming ideas and planning to perform task such as articulating desires to build a particular construction, starting and maintaining an action until the planned step has been completed (and also knowing when a particular step is accomplished), knowing to stop the series of actions when the whole task is completed, and persistence in staying focused on individual actions to complete the task. The development of these skills facilitates critical thinking, self-regulation, goal setting, and problem solving necessary for children's success in school.

Initially, during the free unstructured play and exploratory engagement with ROK Blocks, children tended to manipulate the blocks in a random way. They showed limited planning and vision of what they were going to build. They often stacked the blocks one on top of another (as discussed in the "tower/car period" above) as had been found in the pilot study. This choice might have been a direct influence of the type of blocks available to the children in their background experience; with wheels being the only piece having any resemblance to a real-life object in their lives. The little figurines, green buckets, and wheels were the most identifiable items in the ROK Block box and proved to be the most valuable materials for the children.

After the introduction of the multiple-step instructional materials that included sequencing, children were more likely to work in a persistent and focused manner to connect the pieces as depicted in the pictorial instructions. Even when they struggled to connect the blocks and they were sometimes unable to do so without the adult's help, they demonstrated a heightened awareness and determination to complete the step. When the adult's help was not readily available to them, they persisted in asking for help or tried to accomplish the task at hand, and would typically not move to the next step. From all indications, the instructional materials, specifically, the "placemats" and "books," provided children with the opportunity to develop their EF skills, specifically, focused goal-oriented behavior and persistence.

Children's participation in a designed curricular activity

Children differed in the way they engaged with ROK Blocks based on their enthusiasm or reluctance to participate in the curricular activity that the research team had designed for them. Most of the children were quite actively engaged in the building activity, but varied in their interest to build using the instructional materials we provided for them. While some children consistently showed a strong inclination to use the instructional materials on their own initiative and kept building as many as three to four creations per session, others paid minimal attention to these materials.

Children tended to be surprisingly consistent in their preferences for one of three types of participation. Most of the children were "builders," who preferred the instructional materials and constructed at least one creation per session following either a placemat or a book. Other children favored "free building" and were not easily swayed by the adult's scaffolding to follow the pictorial steps. These children required constant adult involvement to continue the activity. Without the adult's attention they typically completed their creation according to their own creative beat. There were a few children who rarely built beyond putting a few blocks together, with or without instructional materials, yet regularly came to the ROK Block table for extended period of times. They were more likely to engage in building with the adult's guidance, but required a significant amount of scaffolding to focus on the building process.

Conclusions

(Key characteristics of a strategically designed curricular activity)

Data suggests that the curriculum that was developed can be useful in generating valuable educational experiences to develop children's school readiness and science-related skills. In addition, the results of this research helped identify those specific curricular activities and materials that require the least amount of adult guidance to support children's self-directed exploration and development, and at the same time be applied in preschool contexts that can not accommodate curricular activities that require continuous one-on-one engagement with a teacher or adult. Based on our observations of the children in our sample, we propose the following key characteristics of effective curricular activities for children's cognitive and socio-emotional development that relates to their school-readiness skills:

A. We suggest that ROK Blocks be used in conjunction with curricular material artifacts such as the ones we designed:

> ***The Revised Landscape Mat*** provides the background for a playful engagement with the blocks; motivates children to participate in the ROK Block activity in ways other than being directly engaged in the building process; socializes children's perception to the practices of "looking " and "seeing" that are vital for the development of their visual literacy skills; inspires them to reproduce the aspirational assemblages displayed in the landscape or use them as inspiration to create their own constructions; directs the children's attention to the creations they can build following the instructional materials and thus encourages their self-directed exploration.
>
> ***The Analytic Mat*** can be used as a matching game (played in teams or individually) for 5-10 minutes to introduce the blocks and their varied dimensions, however must be introduced as a special activity prior to play. The Analytic Mat directly scaffolds children's perceptual vision by socializing them to relate two-dimensional images displayed at different angles with the three-dimensional blocks they have at hand. In addition, it clearly exposes all of the blocks in the ROK Block set, brings them to children's attention, and thus prepares them for easy identification during their engagement with the instructional materials.
>
> ***The Kid Tips Sheet.*** We suggest a hybrid instructional material growing out of the analysis of the data on the Placemat and Book discussed above. The Kid Tips Leaflet was not implemented in the field, but was conceptualized after the data had been scrutinized during an in-dept analysis. The Kid Tips leaflet would aim at incorporating those characteristics of the designed instructional artifacts that proved to be the most productive for children's development, motivation, and their independent engagement with them. It could be designed as a size A3 paper (or bigger) format folded in a half, so it opens up like a book. The paper would be laminated and when open to resemble the Placemats that were used during the study. When the leaflet is closed, the first page would be designed as a book cover that depicts the completed assemblage using ROK Blocks, set in a colorful and aesthetically appealing background, originally designed for the book cover of the books we implemented during the study. This leaflet would preserve two features of the instructional materials we found to be the most successful—the visually appealing and highly motivational cover of the books and the layout of the series of steps that we found to be crucial for the development of preschool children's visual reasoning, displaying all the steps at once within the common view, so the child can be able to select, sort, review, and re-evaluate their decisions and reason at the comfort of their eye span. Children's ability to "look" independently for a relevant piece of visual material was significantly augmented by direct spatial adjacency of the entire series of steps.

Given the variability in children's socio-cognitive development and experiences with such materials, we do not recommend any particular order in children's engagement with these curricular material artifacts. The mental age of children in preschool children varies widely in many situations, as well as their socio-cultural backgrounds giving them a variety of experiences that may or may not include experiences with such materials as ROK Blocks or other construction toys. We also do not suggest that the materials need to be introduced all at once to children during a particular time (such as a period of free unstructured play, or requiring that one mat be introduced prior to/ immediately following another mat, and so on). The findings of this study show that it is highly desirable to provide different artifacts to children in order to amplify the affordances inherent in the ROK Blocks that create the conditions for optimal development. Due to the wide range of developmental readiness, learning curve and personality differences among children engaged in a playful activity, we suggest that children should have enough flexibility to explore a ROK Block activity on their own timing and intrinsic motivation. This is particularly true of Spanish/English bilingual children whose developmental trajectories and cultural backgrounds are so varied that they can make developmental leaps in a matter of a few months or even weeks. This does not mean that particular artifacts cannot be introduced to all children at one point in time, but children should always have a choice to play according to their own preference, current interests, and their mood on that particular day. In other words, it is ideal that all artifacts be available for them to choose from (or as many as logistically feasible during a particular session).

B. An important component for this age group was the role of the adult mentor in the social environment encouraged by the ROK Block activity. Our findings indicate that the role of the adult mentor is a critical component of this activity for preschool children, especially in the initial stages of play. Once children are socialized into the basic "ROK Block skills", they progressively need less guidance and help from the adult mentor and can rely on the graphic instructions instead. Such developmental trajectory can be as short as one or two playing sessions for some children but span over several weeks, even months for others. After children participate in the structured activity and acquire these basic skills, we highly recommend encouraging them to use these skills in divergent, creative, and independent forms of engagement with the ROK Blocks. The crucial cognitive, motor, and socio-emotional skills developed in a ROK Block playful activity are the following (for further discussion, see the findings section): children's physical ability to connect most of the "friction-fit" and at least several "snap-fit" blocks together so they are able to construct sturdy constructions, no matter how small they are; recognition of the basic properties of the blocks as containing sides with cones and holes and how they fit together; the perceptual skill of "seeing" the blocks and how they connect together when displayed in the image; a basic understanding of how and why to use the instructional materials, such as following a series of steps without skipping some of them and the ability to follow the order of steps as visually presented in the instructional material; ideally, identifying and overcoming at least a few "problems" they encounter in their building process with the adult guidance so they can build confidence in their own abilities to attain their goals; having a chance to observe the adult mentor demonstrating a particular problem solving for children (we found that children generally kept encountering similar types of problems and once they were walked through the process of solving them, they picked up the problem solving strategies quickly); enabling them to set goals or have a vision of what they want to build by following instructions and accomplishing the specific goal (this worked as a tremendous motivation and significantly increased children's trust in the instructional materials). See Appendix for more detailed recommendations for adult's engagement with the children.

C. Children should be provided with the opportunities to access the ROK Block activity from different entry points at all times (if possible). By different entry points we do not only mean "the low floor and high ceiling" for the building process, but also an integration of other activities, forms of interaction, and materials (such as the landscape mats, instructional materials, games with the analytic mat, telling stories about their creations, encouraging children to help their friends find the blocks they are looking for, conversations with the adults mentors, etc.)

D. It is desirable for the curriculum to always contain at least one, but preferably more, forms of "aspirational objects" available to children such as pictures of possible constructions, the pre-made constructions assembled out of the available blocks, the adult mentor modeling the building process of a particular construction for children – building *with* the children or asking for their help in assembling. This socializes children from the beginning to practice their executive function skills through goal-oriented behavior supported by a "vision" of their future objective.

E. We encourage socializing children into the habit of looking for a visual piece of patterned information using different visual materials throughout the activity. In this way they do not only work towards the development of their visual literacy, but also learn about the properties of different types of ROK Blocks and various possibilities of engaging with them. The visual materials, together with the adult mentor's guidance, provide opportunities for the scaffolding of children's cognitive and socio-emotional skills through the zone of proximal development.

F. Non-verbal communication that utilizes gestures and manipulation with the accessible materials in the environment provides great resources for interaction and development. Non-verbal communication together proved to be the main interaction channel for many children in communication with the adult mentors. We found that drawing heavily on both verbal and non-verbal modalities simultaneously was the most effective communication that facilitated children's optimal development.

G. The ROK Block activity should provide multiple ways to practice children's problem solving skills. The engagement with blocks in relation to other designed artifacts provides new types of "problems" that children need to resolve in order to accomplish their personal goals.

H. We recommend that new ROK Block manipulatives be designed to include blocks that represent life-like characteristics such as eyes, ears, feet and tails. These types of representations are familiar and popular with preschool children who would easily apply them to their creations, as was the case with the wheels.

Appendix A

Interaction recommendations for the adult mentor guidance of children's participation in the ROK Block activity

1. Ask a lot of questions. Questions provide more opportunity for the use of language for communication, strengthens adult-child connection, and allows insight into development/interests of the child, which can be useful in future interactions.

2. Group introduction. A group presentation in circle time may encourage more involvement with the mats. Here adult mentors could go over the process of how the children can interact with the mats, call attention to particular aspects of the material, engage children in using the materials for other creative acts such as story telling, labeling, planning, recalling, etc.

3. Build "aspirational objects." Imitation serves an important purpose in the life of a pre-school child. Children naturally want to imitate what they see or hear whether it is songs, stories, games or texts. Having aspirational objects displayed inspires creativity, generates interest, and an opportunity for adult-child interaction.

4. Integrate stories as much as possible. Children love storytelling and this can be a wonderful tool to impart instruction. In some interactions adults may tell stories during construction (using the blocks as characters/pieces in the stories) or in others, allowing children to reflect on their stories that have been completed. Writing children's stories about their creations is another way to help children develop their communication skills. By personalizing the constructed piece, the children are easily able to relate to the construction process and seem to also enjoy themselves more. Therefore, a problem of attaching blocks together could be transformed into "my dog needs a head" etc.

5. Employ demonstration. When children have difficulty with assembly, showing them to solve their problem using your own model is very effective. Resist the temptation to just snap it into place for them. This is especially true if the child has been working with you for a while and you are aware of their abilities. Challenge and difficulty offers growth. Demonstration of other children's work is often helpful.

6. Be specific with encouragements/compliments. Instead of saying that "I like what you built," say "I like how you put that extra wheel on your car." Not only can this open up a chance for more communication, it can also help to extend the child's vocabulary in relation to something of immediate interest.

7. Play games with the blocks whenever possible. The adult mentor can start to construct a piece, but rather than finishing the piece, he or she can enlists children's help and present the situation as a "problem," needing children's help to fix it. Try to encourage group games where the goal is collective instead of competitive.

8. Respect the different ways children learn. If a child doesn't understand one way of instructions, keep trying in different ways. A child may learn better by teaching others (interpersonal) or by using their bodies, hands, moving (bodily-kinesthetic) etc., visually through images/pictures (spatial), linguistic (through conversations, engaging in discussions), or self-directing (intrapersonal). Adult peers should challenge themselves to be creative in interactions and creative in how the blocks are put together.

9. Learn to listen. In adult-child interaction, adults can easily talk too much. Challenge yourself to be observant and extra conscious of your communication. With preschool children in particular, their verbal communications are often in a developing stage. Some children need to be slowly integrated into social circumstances and given space before communication is possible.

10. Avoid making assumptions about the children's creations. Rather than saying, "Is that a car" choose words that allow the child to describe their creation. Questions such as, "Tell me about what you made" respects their individual creativity and open up further dialogue (rather than receiving only a 'yes' or 'no'). After all, the object that looks like a car may in fact be a dinosaur.

11. Be flexible. This covers many circumstances. Learning is not always linear, with one foreseeable end. Having specific goals of instruction is important, but being too rigid removes the possibility for unexpected learning. Being flexible and open to new interpretations allows space for creativity and spontaneity to arise. For example, if the child attaches the wheels on the wrong side of his car, the adult mentor could respond with how "cool" it is and admires "how (the car) can go both ways". Children might notice their "mistakes" and make the correction independently of direct help from the adult.

References

Bourdieu, Pierre (1986), 'The Forms of Capital', in Richardson, John G., ed., *Handbook of Theory and Research for the Sociology of Education*, New York: Greenwood.

Child Development Division, California Department of Education (2008). California Preschool Learning Foundations. Sacramento: California Department of Education.

Churchlan, P.S., Ramachandran, V.S., & Sejnowski, T.J. (1994). A critique of pure vision. In C. Koch, C, & J. L. Davis (Eds.), *Large-Scale Neuronal Theories of the Brain*, 23 60. MIT Press, Cambridge, MA, USA.

Clark, A, & Chalmes, D.J. (1998). The Extended Mind. *Analysis, 58*, 10-23.

Cole, M. & Engestrom, Y. (2006). Cultural-historical approaches to designing for development. In J. Valsiner & A. Rosa (Eds.), *The Cambridge handbook of sociocultural psychology*, 484-507. New York: Cambridge University Press.

Fairlie, R. W. (2007). Explaining differences in access to home computers and the Internet: A comparison of Latino groups to other ethnic and racial groups. *Journal of Electronic Commerce Research*, 7, 265-291.

Fairlie, R. W., Beltran, D. O., & Das, K. K. (2010). Home Computers and Educational Outcomes: Evidence from the NLSY97 and CPS. *Economic Inquiry*, *48*(3), 771-792. doi: 10.1111/j.1465-7295.2009.00218.x.

Garon, N., Bryson, S.E., & Smith, I.M. (2008). Executive Function in Preschoolers: A review using an integrative framework. *Psychological Bulletin 134*(1), 31-66.

Goodwin, C. (2010). Things and their Embodied Environments. In L. Malafouris, & C. Renfrew (Eds.), *The Cognitive Life of Things*, 103-120.

Goodwin, C. (2007). Environmentally Coupled Gestures. In S. D. Duncan, J, Cassel, & E. Levy (Eds.), *Gesture and the Dynamic Dimension of Language*, 195-212.

Maravita, A., Iriki, A. (2004). Tools for the body (schema). *Trends Cogn. Sci. 8*, 79-89.

Makeing, S., Gramann, K., Jung, T., Sejnowski, T.J., & Poizner H.(2009). Linking Brain, Mind and Behavior. *Int J Psychophysiol*, *73*(2), 95-100.

Malafouris, L. (2004). The cognitive basis of material engagement: where brain, body and culture conflate. In E. DeMarrais, C. Gosden, & C. Renfrew (Eds.), *Rethinking the materiality. The Engagement of Mind with the Material World*, 53-62. Cambridge, UK: McDonald Institute for Archeological Research.

Moll, L. C., Amanti, C., Neff, D., & Gonzales, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory and Practice, 31*(2), 132-141.

Núnez, R.E. (2006). Do real numbers move? Language, thought, and gesture: The embodied foundations of mathematics. In Hersh, R. (Ed.), *Eighteen unconventional essays on the nature of mathematics.* New York: Springer, 160-181

Stanton-Salazar, R. D. (2001). *Manufacturing hope and despair: The school and kin support networks of U.S. Mexican youth*. New York: Teachers College Press.

Sutton, J. (2008). Material Agency, Skills and History: Distributed Cognition and the Archeology of Memory. In C. Knappett, & L. Malafouris (Eds.), *Material Agency*,7-55. Springer Science.

Valenzuela, Angela. 1999. *Subtractive schooling: U.S.-Mexican youth and the politics of caring.* New York: State University of New York Press.

Vasquez, O. A. (2003). *La Clase Mágica: Imagining optimal possibilities in a bilingual community of learners*. Mahwah, NJ: Erlbaum.

Vasquez, O. A., & Guarrasi, I. (2011). Building Minds: Identifying the Building Blocks of Imaginative Play. *Unpublished manuscript.*

Vygotsky, L. S. (1978). *Mind in Society. The development of higher psychological processes.* Cambridge, MA: Harvard University Press.