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Play-and-learn spaces: Leveraging library spaces to promote caregiver and child interaction

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A B S T R A C T

Modern libraries are reimagining their spaces as more than repositories for books. The Play-and-Learn Spaces project married developmental science with the changing nature of 21st century libraries. The study asked if it is possible to augment learning in informal spaces using the built environment to encourage discourse and interaction. For this project, the library space was reconstructed such that a corner became a climbing wall on which children could create words by following varied paths up the wall's letter-filled surface. Seating was transformed into large movable "Tangram"-type pieces and a stage, complete with magnetic words, invited children to create stories on the wall and complete story-related activities through socio-dramatic play. Using naturalistic observation, results demonstrated that the use of the Play-and-Learn spaces was associated with increases in the kinds of caregiver and child conversation and interaction known to support language, literacy and STEM skills. These results suggest that libraries can become part of a new learning culture that impacts city residents at the places they naturally go.

1. Introduction

For decades, researchers have focused on children's experiences within school settings to address educational inequities. On the one hand, this focus on the school achievement gap is logical as children's performance in kindergarten predicts their later achievement (Rabiner, Godwin, & Dodge, 2016). However, given that children from families experiencing poverty regularly enter formal schooling *already* lagging behind their peers in language development, reading readiness, and spatial skills (Duncan, Kalil, & Ziol-Guest, 2017), school-based efforts are not enough to narrow the achievement gap. In fact, approximately 80% of children's time is spent outside of school (Meltzoff, Kuhl, Movellan, & Sejnowski, 2009) at home and in community settings. Thus, to address these gaps in a meaningful way, it is important to offer a variety of opportunities for children to develop their academic and social competencies both in and out of school.

One way to do so includes leveraging the typical daily experiences of caregivers and children by transforming everyday activities, such as a trip to the supermarket or laundromat (Bustamante, Hassinger-Das, Hirsh-Pasek, & Golinkoff, 2019; Hassinger-Das, Bustamante, Hirsh-Pasek, Golinkoff, Magsamen, et al., 2018; Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018) into fun learning and engagement opportunities. Since research suggests that conversations targeting literacy or mathematics topics facilitate children's cognitive development (Gunderson & Levine, 2011; Pruden, Levine, & Huttenlocher, 2011; Sheridan, Knoche, Kupzyk, Edwards, & Marvin, 2011), a promising method is to support high-quality language-based interactions. Not surprisingly though, everyday spaces for families are designed to address their primary purpose (e.g., selling groceries or washing clothes) and do not scaffold or support caregiver-child, or child-child interactions. Yet early work suggests that targeted interventions in these spaces hold promise for increasing the kinds of interactions associated with positive language, literacy, and STEM outcomes (Bustamante et al., 2019; Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018; Hassinger-Das, Bustamante, Hirsh-Pasek, Golinkoff, Magsamen, et al., 2018; Hassinger-Das, Palti, Golinkoff, & Hirsh-Pasek, 2019).

Libraries are one "everyday space" involved in transforming families' everyday experiences into high quality learning and engagement opportunities. Indeed, libraries represent a type of space that is uniquely positioned to support this type of development. Many libraries

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are reimagining their spaces as more than just repositories for books (Clark, 2017; Culture and Citizens Services, 2011; Niegaard, 2011), morphing into community and activity centers. For example, recent literature has discussed the implementation and evaluation of library makerspaces, collaborative workspaces that feature high tech to no tech equipment, as a way that libraries can encourage learning and creativity (Abram & Dysart, 2014; Cun, Abramovich, & Smith, 2019). Public health researchers have also noted the potential of libraries for reducing health disparities as a community-level resource (Philbin, Parker, Hirsch, & Flaherty, 2019). Further, 94% caregivers surveyed by the Pew Research Center in 2012 believed that libraries are vital for their children. Of that 94%, 79% expressed that libraries are important because they provide safe spaces, meaning free from violence and other dangers, for children, and 81% said libraries offer children resources that they do not have at home (Pew Research Center, 2012). These statistics suggest the need for data from evidence-based interventions to describe the effects of libraries reconsidering their role in society.

Critically, caregivers experiencing poverty are more likely than caregivers from higher income backgrounds to view library services as important, particularly in offering services that are non-traditional, like digital media labs (Pew Research Center, 2012). This suggests that library spaces could be uniquely positioned to help boost potential for the children and families who need the most support. The Play-and-Learn Spaces project married developmental science with the repositioning of 21st century libraries. Situated in three urban neighborhoods, the Play-and-Learn Spaces project was created by a collaborative process of design including architects, librarians, and scientists spearheading an initiative to infuse powerful high-quality caregiver-child interactions into everyday spaces (Bustamante et al., 2019; Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018; Hassinger-Das, Bustamante, Hirsh-Pasek, Golinkoff, Magsamen, et al., 2018) with the input of the people already using those spaces.

2. Problem statement

As technology advances and patterns of library usage change, libraries also need to change to adapt to the times. Educational inequity exists and is not something that can be solved by waiting for formal education because a) children from families experiencing poverty are often already behind their more advantaged peers when they get to kindergarten and b) children spend 80% of their time outside of formal school contexts. This research asked whether libraries, institutions already undergoing a transformation as technology advances and places where lower-income families already go, could serve as a space to support playful learning and interaction to help address the achievement gap.

This study asked about the efficacy of installing play and learning-focused architectural designs in a public library to encourage the kinds of conversations and interactions that have been shown to be beneficial for children's learning. The project solicited, valued, and incorporated community input into the design and implementation processes. Hypotheses predicted that the Play-and-Learn Spaces would support higher **quality** caregiver-child (and child-child) interaction and decrease technology use as well as increase participation (**quantity** of visits) in children's programming at the libraries. This project is part of a larger initiative seeking to design new public spaces that embed scientific knowledge into the architecture. Evidence suggests (e.g., Chi, 2009; Hirsh-Pasek et al., 2015) that when caregivers purposefully create fun learning spaces that utilize playful learning methods, they maximize learning across domains such as literacy, mathematics, and socio-emotional development (see Bustamante et al., 2019, Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018, Hassinger-Das, Bustamante, Hirsh-Pasek, Golinkoff, Magsamen, et al., 2018, for reviews). Libraries too, can be transformed to promote more active learning and the type of caregiver-child engagement that drives conversations known to support learning. Libraries can become part of a new learning culture that impacts people in the places they naturally go. Indeed, libraries are leading the way in implementing this type of innovative reimagining. The goal of this study is to scientifically evaluate the efficacy of one project in this vein.

3. Literature review

3.1. Libraries as community and play spaces

Since their creation, public libraries have fostered community development, knowledge transfer, and learning (Aabø & Audunson, 2012). Libraries are tasked with helping caregivers meet children's literacy needs (Clark, 2017) and fostering children's development of creativity and flexible thinking (Culture and Citizens Services, 2011). In light of societal and technological changes that have taken place in the past several decades, many libraries are converting into what Niegaard (2011) calls “experimentariums.” This term highlights the transformation from spaces for storing and lending print books to the inclusion of new media types (e.g., e-books), as well as including areas for play, the arts, and digital information. Since many books and other traditional print resources (e.g., newspapers, archival documents, etc.) are now being digitized, libraries are looking for new ways to use their physical space to serve the needs of the public (Niegaard, 2011).

One way to promote additional in-person visits to the library is by developing spaces targeted for various populations. For many libraries, children and families are a large focus of programming as well as the targeted users of the children's section of the library. One effective method to engage children and their caregivers is through play activities. Most researchers conceptualize play as fun, voluntary, and flexible, with active engagement, no extrinsic goal, and oftentimes make-believe (e.g., Lillard et al., 2013; Rogoff, 2003; Zosh et al., 2018). In fact, play in the library is not a novel idea, as far back as the 1850s, games are mentioned as a part of library activities (Nicholson, 2013). However, play has not been a core priority of libraries (Culture and Citizens Services, 2011). Including play requires libraries to signal that play is appropriate in library spaces (Culture and Citizens Services, 2011) since many in the public think of libraries as quiet, inactive spaces.

As an example, the Vejgaard Library in Aalborg, Denmark, installed a Pirate Universe activity center in their children's library. This area featured a temporary pirate ship structure with a treasure chest, pirate-themed costumes, and a touchscreen wall with pirate-related images (Culture and Citizens Services, 2011). The ship even had a tower from which children could shoot toy cannonballs. The front of the space was dedicated to caregivers, featuring a hammock and tables and chairs. The goal of this space was to encourage children and families to physically engage and to make connections with pirate-themed literature and other media.

In another instance, researchers from the University of Southern Denmark, ISIS Katrinebjerg as well as several companies and libraries joined together to create the Children's Interactive Library Project. The team was looking for ways that today's children can shape their own experiences within the Aarhus Public Libraries. The reimagined children's library includes play activities like Story Surfer. In this installation, children can touch and stand on a large featuring a projection of a page from a book. Story Surfer allows them to select how they interact and advance through the book. In this way, the Aarhus Public Libraries provides a space for children to physically engage with library content and even create their own new ways of looking at that content. Similar “maker and hacker” spaces are becoming more common every year.

Through their work in libraries in Tianjin, China, Wang, Xu, and Wu (2019) proposed five principles for designing library activities for preschool children: familiarity, newness, ease, social interaction, and joy. The authors argue that children enjoy activities that are familiar and that they feel comfortable with, but there also needs to be an element of newness that entices them to participate (Wang et al., 2019).

Activities should be within a child's learning zone of proximal development (ZPD) (Vygotsky, 1978) so that they are able to complete it with some caregiver support, but not so easy that it fails to pose some challenge. Finally, activities should promote social interaction between children (and caregivers) and spark joy. While these principles were developed with a preschool population, it is likely that they also apply more broadly, since they reflect a great deal of research in the science of learning regarding how humans learn best (Chi, 2009; Hirsh-Pasek et al., 2015).

3.2. Why increase conversations through play?

Play can help connect individuals with public spaces around them (Oosterman, 1992). In particular, playful learning, a broad pedagogical approach featuring child-directed play methods including free play, guided play, and games (Hassinger-Das et al., 2017), offers one way to infuse learning within the built environment. In free play, children choose how to play by deciding the rules, situation, and roles (Hassinger-Das et al., 2017). Unlike free play, guided play is caregiver-initiated yet child-directed. That is, a caregiver scaffolds the play experience and infuses it with learning opportunities, children take the lead to move the play forward (Weisberg, Hirsh-Pasek, Golinkoff, Kittredge, & Klahr, 2016). In this manner, guided play combines the exploratory nature of free play with developmentally-appropriate scaffolding in support of a learning goal (Weisberg et al., 2016). Games combine fun and enjoyable elements with educational content to build on children's experience of optimal learning (Habgood & Ainsworth, 2011; Hassinger-Das et al., 2017). Incorporating evidence from the science of learning into public spaces like libraries might promote curiosity and a desire to learn as well as a *mise en place,* or mindset that is receptive to learning opportunities (Weisberg, Hirsh-Pasek, Golinkoff, & McCandliss, 2014).

Research suggests that playful learning offers opportunities for increased conversation and communication (Toub et al., 2018; Weisberg et al., 2016). By encouraging conversation between child peers and between children and caregivers, playful learning activities foster the building of the communication foundation that is critical for children's later academic success (Adamson, Bakemen, Deckner, & Nelson, 2014; Romeo et al., 2018; Sperry, Sperry, & Miller, 2018). This research hypothesizes that by mindfully creating spaces for children that allow them to explore, initiate, and direct playful experiences with high-quality materials, can promote the kinds of targeted interactions between caregivers and children that have been shown to relate to stronger academic and social outcomes.

Previous projects have demonstrated the effectiveness of this approach. For example, the Playful Learning Landscapes initiative (Bustamante et al., 2019; Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018; Hassinger-Das, Bustamante, Hirsh-Pasek, Golinkoff, Magsamen, et al., 2018) is designed to provide opportunities for conversation and learning outside of schools for families from underserved communities. Projects in this initiative have boosted caregiver-child communication about language, literacy, and STEM as well as interaction through signage installed in supermarkets (Ridge, Weisberg, llgaz, Hirsh-Pasek, & Golinkoff, 2015) and through the installation of playful learning architectural designs at a bus stop (Hassinger-Das et al., 2019). A related project by the Laundry Literacy Coalition (2019) created Laundry & Literacy Kits featuring signage, puppets, books, an alphabet rug, and other elements, which were distributed in laundromats in New York City. An evaluation found that children engaged in 30 times more literacy activities in the retrofitted laundromats than in those without the added literacy activities (Laundry Literacy Coalition, 2019). These projects demonstrate the ability to transform everyday spaces into places that support communication related to language, literacy, and STEM. The present study asks if a library transformation driven by community feedback will generate similar outcomes.

4. Method

4.1. Conditions

Two conditions were created for this study: Play-and-Learn and Non-Play-and-Learn. The Non-Play-and-Learn condition consisted of data collected at the control site library during the pre- and post-installation time periods as well as data collected at the play-and-learn library sites prior to the play-and-learn installations being constructed. The Play-and-Learn condition consisted of the data collected at the play-and-learn library sites after the play-and-learn installations were constructed. Observations took place in December 2017 through August 2018 for both the Non-Play-and-Learn condition and the Play-and-Learn condition.

Due to the nature of real-world data collection in community settings, it was not possible to establish paired observations at pre- and posttest, leading to data analytic challenges. Therefore, the analytic decision to present Play-and-Learn vs. Non-Play-and-Learn conditions was made for several reasons. First, there was no way of ensuring that the same caregiver/child groups or groups of children visited the libraries before and after the installation of the Play-and-Learn Spaces. Second, preliminary analyses revealed no differences between Play-and-Learn sites prior to the installations of the Play-and-Learn Spaces (pretest) and the control site library at posttest, both conditions represented “business-as-usual” for the libraries involved.

4.2. Participants

Table 1 reports the number of children and caregivers by condition, gender, and race/ethnicity. Children aged approximately 1–10 were included in the study. Older siblings (10–15) were included in the conversational turns but were not counted as the caregiver in the caregiver-child interaction. Older teenage siblings (approximately 16 years or older) were included as the caregiver in the caregiver-child interaction. Other siblings or caregivers could be included when

Table 1
Demographic characteristics of sample, number of groups observed, and time at location.

	Play-and-Learn		Non-Play-and-Learn	
Number of groups observed	72		83	
	Caregiver	Child	Caregiver	Child
Total number of individuals	91	142	66	195
Mean number of individuals per group	2	2	2	4
Mean approximate age in years	31	6	27	5
Gender				
Female	74	63[1]	51	104[1]
Male	17	67[1]	15	49[1]
Relationship to child				
Mother	38	–	22	–
Father	4	–	7	–
Other relative	8	–	5	–
Teacher	4	–	22	–
Unknown/friend	33	–	4	–
Race/ethnicity[2]				
White	11	13	16	23
Black	30	20	17	39
Latinx	26	22	15	66
Asian	7	7	6	12
Other/Multiple races	4	9	2	7

Note: There are more individuals than the total number of groups because some of the groups had multiple children or caregivers.

[1] Numbers do not total the total number of children because gender could not be captured reliably for all children.

[2] Race/ethnicity information could not be captured reliably for all participants.

Table 2
Types of groups by condition.

	Non-Play-and-Learn condition	Play-and-Learn condition
One caregiver, one child	23	28
More than one caregiver or more than one child	29	44
Only children	31	0
Total:	83	72

counting conversational turns. Table 2 describes the types of groups by condition. "Groups" could contain one or more caregivers and one or more children as long as they arrived together. A group might also be comprised of unaccompanied children who came together. Notably, there were no groups comprised only of children who visited the Play-and-Learn condition. The caregiver-child groups did not necessarily include a parent; that is, it may have included a library staff member or caregiver (relationship data was not gathered from the participants). Given the unobtrusive nature of this observational study, it was not required by the university Institutional Review Boards to collect informed consent nor to debrief participants upon the conclusion of the study.

4.3. Library selection and conditions

4.3.1. Library selection

All libraries were located in Philadelphia, Pennsylvania. The Free Library of Philadelphia commissioned the project in response to the evolving needs of children and families using their library branches. They selected the four libraries, three Play-and-Learn libraries and one control library. Two library branches were characterized by high levels of PreK-aged children's library program attendance (Libraries A and C) and two libraries were characterized by stagnant PreK-aged children's library program attendance (Library B and control library). This enabled the researchers to see how the new Play-and-Learn Spaces would affect children's program attendance in addition to caregiver-child interaction.

4.3.2. Control library

No changes were made to this library. The control site library was located next to a recreation center in an area of the city with a median household income of $33,608,considerably below the city average of $41,449, and where approximately 83% of the population identifies as Black, 10% identify as white, 3% as Latinx, 2% as Asian, and 2% as other races (City Data, 2016). Originally, this library was to be a fourth Play-and-Learn space site, but due to funding concerns, this library was designated as a control site.

4.3.3. Play-and-Learn libraries

The children's sections of three library branches were redesigned to create Play-and-Learn Spaces. Libraries A and B had a median household income significantly below the city average with Library A at $23,905, and Library B at $25,471 (City Data, 2016). Library A was located along a major thoroughfare in an area of the city in which approximately 80% of the population identified as Black, 13% as white, 4% as other races, and 3% as Latinx (City Data, 2016). Library B's community contained approximately 49% of the population who identified as Black, 28% as Latinx, 13% as Asian, 8% as white, and 2% as other races (City Data, 2016). Lastly, Library C served an area with a median household income of $56,425,higher than the city average, in which approximately 62% of the population identified as white, 17% identified as Asian, 11% as Latinx, 8% as Black, and 2% as other races (City Data, 2016).

4.4. Community engagement and design

The project design team members included Studio Ludo, a non-profit organization whose mission is building better play through research, design, and advocacy,and Smith Memorial Playground & Playhouse (Smith), a non-profit organization that stewards, consults about, and advocates for play. The design team collaborated on running community engagement sessions with Libraries A, B, and C. The goals of each session were to: 1) observe library staff reactions to users engaging with a variety of non-traditional materials in the library; 2) help library patrons of all ages envision and articulate the kind of space in which they would like to play and learn; and 3) synthesize feedback and observations into a menu of design features or schemes.

Sessions were advertised via flyers in and outside the libraries, as well as on various social media channels through the library and by Studio Ludo and Smith to maximize attendance. Session times were chosen based on library staff feedback to get a broad scope of users and to observe the variety in energy and activity levels. For example, the after-school rush at Library B and a weekend morning at Library A were selected to observe a large number of families. To capture feedback from individuals who could not attend community engagement sessions, Studio Ludo created extra copies of the library design activity sheets for librarians to complete with patrons outside of session hours. Sessions were facilitated by both Studio Ludo and Smith and lasted between 2 and 4 h. During these sessions, participants were asked to design the kinds of spaces they would like to have in their libraries, either through drawing, building, or sharing stories through the following activity options: 1) drawing their design on a library design activity sheet; 2) large-scale tempera painting on a wall or stretch of shelving in the library, that was covered with plastic; and 3) building with loose parts, such as foam and plastic blocks, cardboard, paper tubes, fabric, rubber bands, and egg cartons. Additionally, a Verb/Adjective Vision Board prompted and inspired patrons to identify or explore their preferences by viewing precedent images from innovative libraries, meeting spaces, or other creative arts spaces. During activities, facilitators took note of the librarian's reactions to things that may have seemed rowdy, messy, or otherwise difficult to manage.

Each session generated a collection of drawings, images, and informal interviews and observations with librarians and patrons about the kind of play space they would like to see in their library. The three general themes of the community input were: 1) more child-friendly physical spaces since children spend a lot of time after school at the library doing homework; 2) utilizing the library as a safe space to wait for caregiver pickup; and 3) more interactive activities for families with young children who often spend time at the libraries during the morning.

Then, DIGSAU, the project architecture and design firm, created scale models of each branch and representations of different play elements also based on patron responses from engagement sessions. For example, they created a small box to represent a theater space, a cone shape to represent a climbing tower in Library C, and small bookshelves with holes to show placement of the shelves in the new layout. In another round of design sessions, branch staff and the design team (including DIGSAU, Studio Ludo, Erector Sets, the project fabricator, and Smith) played around with the model pieces to test-out various scenarios. By including all parties, from users to builders to the research team, in the design process, issues such as feasibility and specific concerns, such as sight-lines, were addressed immediately.

4.4.1. Play-and-Learn space designs

DIGSAU, with support from Studio Ludo, then took the community input and designed a set of installations for the Play-and-Learn Spaces. They designed a climbing wall on which children could create words by climbing to different letters up the wall's surface. The climbing wall was a response to the community members' calls for more opportunities for physical activity and learning opportunities in the library. Seating was

Fig. 1. Library play-and-learn spaces.

transformed into large movable blocks that fit like puzzle pieces into reading nooks in existing bookshelves. A stage, complete with magnetic play surfaces and letters, invited children to create stories on the wall and complete story-related activities through sociodramatic play. The stage was designed to encourage physical activity as well as engaging learning opportunities for both older and younger children. A perching tower also offered space to climb, play, and hide away to quietly read a book (Fig. 1). Each library received some combination of these elements; Library A featured a climbing wall, stage, magnetic play surfaces, and blocks and nooks, while Library B featured a stage, magnetic play surface, and blocks and nooks. Library C's play-and-learn space included a perching tower, magnetic play surfaces, and blocks and nooks.

4.5. Data collection

This research aimed to capture data about both quantity (attendance at library children's programming) and quality of interaction (e.g., adult-child interactions) in both study conditions.

4.5.1. Children's programming attendance

Library staff members continued to collect counts of the number of participants in children's programs at their branches, as they have done in the past. These programs did not necessarily include the installations in the Play-and-Learn Spaces, but they did take place in the children's library section. The goal was to see if the installation of the spaces related to increased use of other children's library programs and potential "flooding" effects of interest in the rest of the library.

4.5.2. Observation protocol

The observation manual and protocol were adapted from Ridge et al. (2015) and Hassinger-Das et al. (2019), which all included observation procedures that are highly relevant to the present study motivation and constructs. A detailed description of the data collected follows.

4.5.2.1. Time spent in space. Trained observers recorded the time (in minutes) that all caregiver/child groups and groups comprised entirely of children spent in the space.

4.5.2.2. Observing interactions. Table 3 summarizes the aspects of caregiver and child interactions that were observed and recorded by the trained observers. Using these data, an interaction score was computed for caregivers in each group (13 possible behaviors), children in each group (14 possible behaviors), and each caregiver-child group (27 possible behaviors; computed by combining the caregiver total interaction score + the child total interaction score).

4.5.2.3. Valence scores. The overall affective tone of each observation in its entirety (positive, negative, or neutral) was recorded by trained observers. Positive affect is reflected in smiling, laughter, positive tone of voice, affection, and responsive interaction. Negative affect involves in frowning, harsh tone of voice, closed-off body language, disengagement, scolding a child, and frustrated or anxious interaction. Neutral interactions are neither positive nor negative, represented by verbal discussions without much emotion.

4.5.3. Observation training

Four trained research assistants collected the observation data. These data collectors were blind to study hypotheses to ensure that the evaluation remained independent. Data collectors were trained via four 2-hour training meetings, during which the lead investigator met with observers to code example videos of caregiver/child interactions using the protocol, as well as researcher-led role-play interactions. Since the observations at the libraries were not video-recorded, observers were allowed to watch the videos one time through, and then discussed

Table 3
Behaviors recorded as part of caregiver interaction, child interaction scores, and caregiver/child interaction scores.

	Behavior	Coding
Caregiver Interaction Score	Stop in the play space	Yes = 1 point
	Point to the play space	Yes = 1 point
	Ask about the play space	Yes = 1 point
	Provide information about the play space	Yes = 1 point
	Use number-related languages	Yes = 1 point
	Use spatial-related language	Yes = 1 point
	Talk about colors	Yes = 1 point
	Talk about letters and sounds	Yes = 1 point
	Laugh	Yes = 1 point
	Physically interact with the space	Yes = 1 point
	Engage in physical activity	Somewhat active = 0 points
		Moderately active = 1 point
		Very active = 2 points
	Follow the child's focus	0 times = 0 points
		1–3 times = 1 point
		4–6 times = 2 points
		7+ times = 3 points
	Use technology	Yes = −1 point
Child Interaction Score	Ask to stop in the play space	Yes = 1 point
	Point to the play space	Yes = 1 point
	Ask about the play space	Yes = 1 point
	Provide information about the play space	Yes = 1 point
	Respond to the caregiver	Yes = 1 point
	Use number-related language	Yes = 1 point
	Use spatial-related language	Yes = 1 point
	Talk about colors	Yes = 1 point
	Talk about letters and sounds	Yes = 1 point
	Laugh	Yes = 1 point
	Physically interact with the space	Yes = 1 point
	Engage in physical activity	Somewhat active = 0 points
		Moderately active = 1 point
		Very active = 2 points
	Follow the caregiver's focus	0 times = 0 points
		1–3 times = 1 point
		4–6 times = 2 points
		7+ times = 3 points
	Use technology	Yes = −1 point
Caregiver/Child Group Interaction Score	Caregiver total interaction score + Child total interaction score	

agreement and challenges. After each training meeting, observers were asked to independently code videos. These videos were then reviewed as a group during the next training session.

4.5.3.1. Inter-rater reliability. To determine inter-rater reliability, research assistants were paired up to complete observations of five caregiver-child groups in a library that was not among those included in this study. Then, their ratings were compared to determine the level of agreement. For example, if both coders agreed on every item when observing the same caregiver/child group interaction, they would achieve 100% agreement. The research assistants had to achieve 85% agreement on the total interaction score to be considered reliable. All research assistant pairs achieved this level of reliability.

5. Results

5.1. Quantity of interaction

5.1.1. Children's programming attendance

Based on librarians' participant counts, the installation of the Play-and-Learn Spaces was associated with significant increases in children's programming attendance at all three library branches (Fig. 2). Library A saw a 190% increase, when comparing the nine months prior to the Play-and-Learn space installation versus the three months immediately after installation. Library B experienced a 158% increase, while Library C demonstrated a 201% increase in participation. Across all three Play-and-Learn libraries, this results in an average increase of 189%. In contrast, the control library saw a 304% decrease in program attendance during the same period. These findings suggest that the Play-and-Learn Spaces were attracting greater numbers of children (and families) to the libraries for children's programming as compared to before the installations opened.

5.1.2. Time spent in space

Analyses first compared the two conditions (Play-and-Learn vs. Non-Play-and-Learn) on the amount of time groups spent in the space. Data were analyzed using an independent samples *t*-test. Results show a statistically significant difference for time spent in the space, with participants in the Play-and-Learn condition staying in the space significantly longer (M = 27.79 [SD 3.32] minutes) than participants in the Non-Play-and-Learn condition (M = 9.28 [SD 12.81] minutes) ($t = -2.070$, df[93.419], $p = .041$).

5.2. Quality of interactions

5.2.1. Overall interaction scores

Next, analyses looked at overall interaction score to investigate whether the two conditions produced significant differences in the nature of the interactions that took place among participants. Data were analyzed using independent samples *t*-tests. Table 4 presents the means and standard deviations for the dependent variables for each of the two conditions (Play-and-Learn = 72 groups; Non-Play-and-Learn = 83 groups). Results show no statistically significant difference for caregiver interaction scores, with caregivers in the Play-and-Learn condition obtaining similar interaction scores to caregivers in the Non-Play-and-Learn condition ($t = -1.794$, df[117], $p = .075$). Results show a statistically significant difference for child interaction scores, with children in the Play-and-Learn condition obtaining higher child interaction

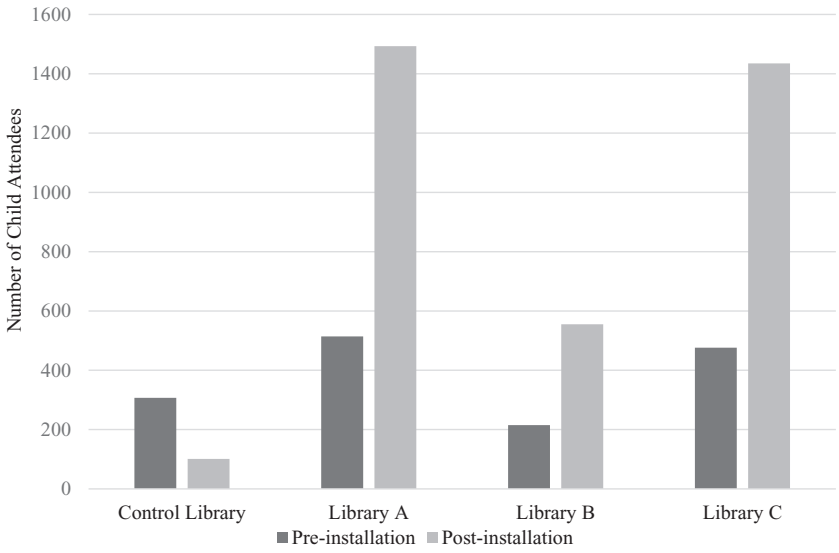

Fig. 2. Children's library program attendance by library and timepoint.

Table 4
Means and standard deviation of interaction scores by condition.

	Non-Play-and-Learn condition			Play-and-Learn condition		
	n	*M*	*SD*	*n*	*M*	*SD*
Caregiver Interaction Score[1]	47	7.21	2.79	72	8.18	2.93
Child Interaction Score	83	7.99	2.84	72	10.83	2.46
Caregiver/Child Group Interaction Score[2]	47	15.45	4.61	72	19.01	5.62

[1] Caregiver Interaction scores were not computed for groups that did not contain caregivers.
[2] Caregiver/Child Group Interaction Scores were not computed for groups that did not contain caregivers.

scores than children in the Non-Play-and-Learn condition ($t = -6.626$, df[154], $p = .001$). Finally, results show a statistically significant difference for caregiver/child interaction scores, with participants in the Play-and-Learn condition obtaining higher caregiver interaction scores than participants in the Non-Play-and-Learn condition ($t = -4.118$, df [117], $p = .001$).

Though these aggregate interaction variables lend support to the researchers' hypothesis that the Play-and-Learn condition promotes more interaction, a more nuanced look at individual aspects of the interactions shows further differences between the Non-Play-and-Learn and Play-and-Learn conditions. Thus, analyses examined technology use, language use, laughter, and physical interaction with the space by both caregivers and children.

5.2.2. Technology use

Next, technology, meaning smartphone and tablet use as a distraction from interaction, data were analyzed using Pearson Chi-Square tests. While results show no relationship between caregiver technology use and condition, with caregivers in the Play-and-Learn condition (21 groups) using technology almost the same amount as caregivers in the Non-Play-and-Learn condition (20 groups; $\chi^2 = 1.552$, $df = 1$, $p = .213$), there was a statistically significant relationship for children: Those in the Play-and-Learn condition (3 groups) used technology significantly less frequently than children in the Non-Play-and-Learn condition (26 groups; $\chi^2 = 18.380$, $df = 1$, $p = .001$).

5.2.3. Language use

As noted in Table 3, language use was accounted for in the interaction scores by noting the presence of number, spatial, color, and letter/sound language. Numerical language related to numbers, counting, numerical order, or sorting. Spatial language referred to the four spatial talk categories identified by Cannon, Levine, and Huttenlocher (2007): size (e.g., big, small, tall, short), features (e.g., heavy and light, bent, curvy), directions (e.g., above, under, over, through), or shapes (e.g., triangle, hexagon). Letter/sound language addressed colors, letters, or literacy skills, such as, “Bear starts with ‘b’.” It was of interest to look at these types of language individually to investigate whether the presence of the Play-and-Learn-Condition facilitated their appearance in caregiver and child talk.

Table 5 describes the percent of caregivers that used each of these types of language by condition, while Table 6 shows the percent of children that used each of these types of language by condition. Results show no relationship between caregiver number-related language use and condition ($\chi^2 = 1.279$, $df = 1$, $p = .258$) or between caregiver color-related language use and condition ($\chi^2 = 0.593$, $df = 1$,

Table 5
Frequencies and number and percent of caregivers[1] that used number, spatial, color, and letter/sound language in play-and-learn and non-play-and-learn conditions.

		Non-Play-and-Learn condition	Play-and-Learn condition
Caregiver used number-related language	Frequency	27	30
	Total number of groups	52	72
	%	51.9	41.7
Caregiver used spatial-related language	Frequency	33	63
	Total number of groups	52	72
	%	63.5	87.5
Caregiver used color-related language	Frequency	8	15
	Total number of groups	52	72
	%	15.4	20.8
Caregiver used letter/sound-related language	Frequency	6	21
	Total number of groups	52	72
	%	11.5	29.2

[1] Child-only groups could not be included in this analysis of caregiver behavior.

Table 6
Frequencies and number and percent of children that used number, spatial, color, and letter/sound language in play-and-learn and non-play-and-learn conditions.

		Non-Play-and-Learn Condition	Play-and-Learn Condition
Child used number-related language	Frequency	42	35
	Total number of groups	84	72
	%	50.0	48.6
Child used spatial-related language	Frequency	52	62
	Total number of groups	84	72
	%	61.9	86.1
Child used color-related language	Frequency	26	24
	Total number of groups	84	72
	%	31.0	33.3
Child used letter/sound-related language	Frequency	11	23
	Total number of groups	84	72
	%	13.1	31.9

p = .441). However, results demonstrate a statistically significant relationship between caregiver spatial-related language use and condition as well as between caregiver letter/sound-related language use and condition. That is, caregivers in the Play-and-Learn condition used spatial-related language and letter/sound related language more frequently than caregivers in the Non-Play-and-Learn condition (χ^2 = 9.980, df = 1, p = .002, and χ^2 = 5.509, df = 1, p = .019, respectively). A similar pattern was found when looking at the child language scores. Though there was no relationship between child number-related language use and condition or child color-related language use and condition, there was a statistically significant relationship between child spatial-related language use and condition (χ^2 = 11.546, df = 1, p = .001) as well as between child letter/sound-related language use and condition (χ^2 = 8.081, df = 1, p = .004); again showing advantages in Play-and-Learn Spaces relative to Non-Play-and-Learn locations. These results demonstrate that several of the targeted language types were increased with the installation of the Play-and-Learn Spaces, suggesting that caregivers and children were using their conversations to focus on the content embedded into the spaces.

5.2.4. Conversational turns

In both the Play-and-Learn and Non-Play-and-Learn conditions, roughly half of the group conversations lasted for 11+ turns, one quarter took 1–5 turns, and one-quarter took 6–10 turns (see Table 7). Interestingly, though the Play-and-Learn condition promotes higher interaction scores as well as more positive affect, it does not seem to increase the number of conversational turns; rather, it changes the quality and tone of the interactions.

5.2.5. Physical interaction with the space

There was no relationship between caregivers physically interacting with the space and condition, with caregivers in the Play-and-Learn condition physically interacting with the space at similar rates as caregivers in the Non-Play-and-Learn condition (χ^2 = 0.213, df = 1, p = .644). However, there was a statistically significant relationship between a child physically interacting with the space and condition. Children in the Play-and-Learn condition physically interacted with the space more frequently than did children in the Non-Play-and-Learn condition (χ^2 = 5.656, df = 1, p = .017).

Table 7
Number of turns in verbal interactions by condition.

	Non-Play-and-Learn condition		Play-and-Learn condition	
n	82		72	
	Frequency	%	Frequency	%
0 turns	3	3.6	1	1.4
1–5 turns	18	22.0	18	25.0
6–10 turns	20	24.4	17	23.7
11+ turns	41	50.0	36	50.0

Table 8
Frequencies of valence scores by condition.

	Negative	Neutral	Positive
Non-Play-and-Learn condition	4	46	32
Play-and-Learn condition	3	14	55

5.2.6. Valence scores

Table 8 presents the frequencies of interaction scores by condition. Data were analyzed using Fisher's Exact test due to small numbers that prohibited the use of Pearson chi squares. Results show a statistically significant relationship between valence scores and condition, with participants in the Play-and-Learn condition obtaining higher valence scores more frequently than participants in the Non-Play-and-Learn condition (p = .001). This suggests that groups demonstrated more positive affect while at the Play-and-Learn Spaces than in the control site library or at any library before the installation of a Play-and-Learn Space.

5.2.7. Laughter

Results show a statistically significant relationship between caregiver laughter and condition, with caregivers in the Play-and-Learn condition laughing more frequently than caregivers in the Non-Play-and-Learn condition (χ^2 = 6.986, df = 1, p = .008) and children in the Play-and-Learn condition laughing more frequently than children in the Non-Play-and-Learn condition (χ^2 = 4.209, df = 1, p = .040).

6. Discussion

Libraries are prime examples of community spaces where children spend their out-of-school time. This study asked if it was possible to refashion these spaces to support conversation, interaction, and potentially learning. The Play-and-Learn Spaces project maintained the essence of a library, as a space for information creation and sharing, while enhancing the interactive and engaged components of play. Other libraries, including the Vejgaard Library and the Aarhus Public Libraries, have undertaken similar redesigns to make libraries friendlier for children. This project extends this work to engage caregiver and child interactions through redesign of the built environment.

Overall, the results of the observations indicated the success of the Play-and-Learn project. Findings demonstrated that the installation of the Play-and-Learn Spaces was associated with increased interaction, in both quantity of attendance at library programs, and quality of caregiver and child interactions and discourse. First, greater numbers of children attended library programs after the installation of the Play-and-Learn Spaces than before. In contrast, at the control library, children's library program attendance actually decreased, suggesting that the increases at the Play-and-Learn libraries were not simply due to time of year or some other factor present in all of the library branches.

Additionally, people were spending more time in the libraries when there was a Play-and-Learn area available. Data collectors also recorded more interactions (for caregiver-child groups and children in general) at the Play-and-Learn sites. These data suggest that the Play-and-Learn Spaces encouraged caregivers and children to interact around the activities that were installed. There were statistically significant differences between caregiver and child behavior at Non-Play-and-Learn

versus Play-and-Learn Spaces in a variety of areas, including literacy-related talk, spatial talk, positive affect, more physical interaction with the space, more laughter, and less use of technology (such as smartphones and tablets).

It is particularly interesting that literacy-related and spatial talk increased in relation to exposure to the Play-and-Learn Spaces, while the amount of conversational turns was not. This suggests that caregivers and children changed the kinds of conversations they were having instead of increasing the amount of talk. Changing the content of the conversations happening in the children's libraries is encouraging, because it highlights the ability of the spaces to focus caregivers and children's conversations on the content highlighted within the Play-and-Learn designs. This finding is important because it reveals that if designs target particular kinds of interactions around reading or math, they can encourage interaction with that content.

Additionally, the increase in children's physical interaction with the library space is especially promising. Physical play helps reduce obesity and other health risks in children (Sattelmair & Ratey, 2009). Physically active play in childhood may also lead to the establishment of patterns of healthy behaviors that last into adulthood (Sattelmair & Ratey, 2009). By boosting children's levels of physical activity while in the library, the Play-and-Learn Spaces may help foster healthy behaviors for their child visitors. Overall, these spaces have driven increases in visitors and users and increased people's, especially caregivers of young children, comfort in visiting the library. The research team is encouraged that the Play-and-Learn Spaces demonstrably positive effects on the libraries involved.

6.1. Play and learning in the library

The current study not only reflects the idea of transforming libraries into “experimentariums” focused on offering interactive experiences for patrons (Niegaard, 2011) but suggests that these kinds of changes can have transformative and supportive effects on social interactions in these spaces. By making the children's areas more fun and engaging, the library becomes more responsive to families' needs (Clark, 2017) while concurrently serving as potential supports for the academic and social competencies that are typically addressed in more formal school contexts. Indeed, work from the science of learning suggests that the fun and engagement that are inspired by the library are key characteristics that lead to learning (Hirsh-Pasek et al., 2015). Children get an opportunity to play with peers and with their caregivers (including library staff members). In 2013, then President of the American Library Association, Barbara Stripling highlighted the importance of “turning libraries into learning centers” (Mullaney, 2013).

By transforming these three library branches into centers for play and learning, caregivers and children interacted more and had more conversations when the Play-and-Learn Spaces were installed than they did when the libraries did not have these spaces. Results demonstrated that this type of intervention has the ability to inspire caregivers and children to transform their interactions in the library.

Caregivers and children also interacted more with the physical space in the Play-and-Learn Spaces after installation than when the children's library areas did not feature these installations. This suggests that groups found the installations to be engaging and enjoyable to use. Caregivers and children also relied less on technology, such as smartphones and tablets, while in the Play-and-Learn Spaces as compared to the Non-Play-and-Learn condition. This is encouraging, because caregivers and children often rely on these technologies instead of talking and engaging with one another (Radesky et al., 2014).

Finally, the increase in numerical, spatial, and letters/sounds talk suggests that groups were addressing the topics that were targeted through the Play-and-Learn Spaces. Thus, the introduction of the Play-and-Learn Spaces drove greater amounts of interaction between individuals and with the physical space and also to use the types of language that the designs targeted at greater rates than in the Non-Play-and-Learn condition.

6.2. Beyond libraries

By transforming a space that caregivers and children visit during the course of a regular day, the Play-and-Learn Spaces project is related to a broader initiative, Playful Learning Landscapes. Playful Learning Landscapes seeks to reimagine spaces to increase the kinds of caregiver-child conversations and interactions known to be related to child outcomes (Bustamante et al., 2019; Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018; Hassinger-Das, Bustamante, Hirsh-Pasek, Golinkoff, Magsamen, et al., 2018). The first Playful Learning Landscapes project was the Ultimate Block Party (UBP) (Grob, Schlesinger, Pace, Golinkoff, & Hirsh-Pasek, 2017). This event that attracted 50,000 people to participated in 28 playful learning activities in Central Park in 2010. The results from UBP showed that exposure to 3–4 of the activities led to increases in caregivers' beliefs about the links between play and learning (Grob et al., 2017).

However, the Ultimate Block Party required families to make the trip to Central Park to visit the activities. As a next step, Ridge et al. (2015) brought a similar concept to supermarkets, where families already go regularly. Researchers installed signs in the dairy and produce sections that gave questions that parents could ask their children while in the store. Research assistants unobtrusively observed shoppers to record the amount of interaction (e.g., number of turns in conversation, question asking) families used both before and after the installation of the intervention. In low-SES stores, adults and children interacted 33% more when the signs were posted, as compared to when the signs were not present (Ridge et al., 2015). No differences were observed in middle income environments. The project has been successfully replicated using mathematics-focused signage (Hanner, Braham, Elliott, & Libertus, 2019).

Another Playful Learning Landscapes project, Urban Thinkscape, asked whether it might be possible to reimagine a bus stop in an under-resourced community as a learning opportunity (Hassinger-Das et al., 2019). Urban Thinkscape combined the Conscious Cities movement in urban design with research from the science of learning. The Conscious Cities is particularly interested in determining how humans are influenced by the built environment (Brekke, 2016).

Urban Thinkscape was built with the local community. The research and design teams worked directly with community leaders and members tailor the space to their own specific needs and desires,from suggesting the location of the installation, giving feedback on design concepts, and even assisting in the building of the space. Designs installed included: Puzzle Bench (to encourage spatial skills (Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014), Jumping Feet (to spark executive functioning skills), Stories (to encourage narrative skills), and Hidden Figures (finding hidden shapes) (Hassinger-Das et al., 2019). Results demonstrated that Urban Thinkscape significantly impacted caregiver-child interaction of community members in ways targeted by the activities. Caregiver-child groups interacted more and had more conversations at the completed Urban Thinkscape site than they did before installation; they also almost equaled or outperformed caregiver-child groups at a control site playground in the same neighborhood.

6.3. Limitations

There are some limitations of this study that must be noted. It is unclear exactly which Play-and-Learn activities drove the increases in caregiver-child and child-child interaction since each Play-and-Learn space was examined as one unit. Next, it was not possible to determine the specific demographic information about participants since the study used naturalistic observation as the method of data collection. It was also not possible to know if children and caregivers visited the sites multiple times. This additional information would have further elucidated the effects of Play-and-Learn Spaces on conversations and

interactions.

In addition, research assistants clearly noticed the presence or absence of a Play-and-Learn space at an individual library. However, all research assistants were blind to the study hypotheses and demonstrated high levels of reliability in their data collection. Finally, these findings can merely suggest that there is a link between increased conversations and interactions and use of specific language types, such as spatial, numerical, and literacy-related, that might influence child academic outcomes, as suggested by previous research (Adamson et al., 2014; Gunderson & Levine, 2011; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010; Pruden et al., 2011). Future research in this area needs to determine how to more directly connect child academic outcomes with the types of conversations and interactions found at the Play-and-Learn Spaces.

7. Conclusion

The Play-and-Learn Spaces project demonstrated the ability of a play space installed within a children's library to foster conversations and interactions among children and caregivers. Previous projects in libraries across the globe have investigated the role of play in libraries, but this project is the first known to collect data regarding the effects of a play space on discourse and interaction in libraries. Building on the success of the Play-and-Learn Spaces project, the researchers hope to encourage libraries pursuing renovations and space planning to make opportunities for play. This work suggests that libraries represent a critical informal learning space that could play a role in helping to address the achievement gap between lower and higher income children.

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