Innovative Approaches to Researching Landscape and Health

Open Space: People Space 2

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ROUTLEDGE

Contents

Chapter 2

Using behaviour mapping to investigate healthy outdoor environments for children and families:

conceptual framework, procedures and applications

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This chapter focuses on a methodological approach to assess the health impacts of the places where children spend most of their time when not at home: childcare centres, schools, parks, residential neighbourhoods, and community institutions such as zoos, museums and botanical gardens – where families spend quality time away from the pressures of everyday life. These commonplace environments and mission-driven institutions are potential supporters of preventive health and disease prevention objectives to get children outdoors in contact with nature and engaged in physical activity. They fall within the scope of healthy community design, where this chapter is situated at the intersection with the built environment.

Environments and programmes used daily by children and families require innovative research and evaluation tools to assess their support for new health mandates. A body of knowledge is required to provide evidence-based guidance to help guarantee the success of design strategies and policy decisions.

To this end, this chapter presents three selected case examples (neighbourhood parks, a children's museum and childcare centres) to illustrate an approach based on behaviour mapping, which objectively measures the actual use of environments. The authors developed the methodology to investigate relationships between designed environments and intended behaviours, including those related to childhood public health and disease prevention.

Behaviour mapping is an unobtrusive, objective, observational method for measuring actual use of space. Compiled data disclose the pattern of behaviour in a given space, which may help design researchers and practitioners visualize children's physical activity in specific behaviour settings. The method is presented from a normative point of view, as part of a methodological approach aimed at improving the quality of relationships between people and the built environment.

Behaviour mapping can yield information about relationships between environment and behaviour and can answer questions such as, 'Which settings or components are most heavily used?' or 'Which physical components support significant amounts of physical activity, or social interaction, or interaction between children of different ethnic backgrounds?' The resulting graphical maps, accompanied by descriptive statistics, could add strength to the designer's decision-making process using an understandable visual language required for the design field. The method allows environmental components of interest to be linked with operationalized behavioural variables. For example, Moore and Cosco (2007) presented a behaviour mapping case study of community park design showing that, out of 12 identified behaviour settings, the five most heavily used (composite structures, swings, primary pathways, gathering settings, sand play settings) accounted for more than three-quarters (77 per cent) of the park use by children (p. 99). Settings such as swings within playgrounds and parks, within neighbourhoods, within cities, within climatic regions, within political jurisdictions, and so on, can be considered as nested ecosystems of the built environment, with each level structurally linked to the ones above and below. In an effort to bring the methodology to the attention of other professionals beyond landscape architects and designers, and before describing the case examples, a discussion about the broader context of application follows.

Measuring built environment variables relevant to design

According to US National Institute of Environmental Health Sciences (NIEHS):

> The built environment encompasses all buildings, spaces and products that are created, or modified, by people. It includes homes, schools, workplaces, parks/recreation areas, greenways, business areas and transportation

> systems. It extends overhead in the form of electric transmission lines, underground in the form of waste disposal sites and subway trains, and across the country in the form of highways. It includes land-use planning and policies that impact our communities in urban, rural and suburban areas.
>
> (NIEHS, 2009)[1]

Extending the NIEHS definition for the purposes of this chapter, the term 'built environment' is used to refer to all manufactured human artefacts and natural elements in children's everyday environments that might be present in streets, playgrounds, parks, greenways, nature preserves, childcare settings, schools, out-of-school programmes and community institutions. At the small scale at which children are physically engaged with the environment, this includes play equipment, trees and plants, topography, water, all other landscape features potentially influencing children's behaviours – and the pathways that connect them to children's homes (Moore and Cooper Marcus, 2008).

Health-related environmental issues have been researched and described in the field of environment and behaviour since the field emerged in the 1970s. Currently, the field needs to move beyond generalized environmental variables such as 'exposure to nature'/'not nature' to identify specific environmental components or characteristics more tightly related to health outcomes. An appropriate example is neighbourhood walkability, where sidewalk (pavement) connectivity is commonly used as a validated, reliable measure (Bull, Giles-Corti and Wood, Chapter 4, this volume). Relevance would be increased if detailed attributes that may differentiate sidewalk quality for users were included, such as the presence of shade trees and floral displays in neighbours' front gardens. Neighbourhood walkability measures for children would include detailed traffic counts and street engineering measures such as street width, intersection 'necking,' marked crossings and traffic lights, as well as the presence of adjacent parks and playgrounds. We assume that such detailed environmental design attributes and components may influence behaviour – especially of parents when deciding limits to their children's independent mobility and/or the voluntary, inner-directed decisions of the children themselves.

Built environment designers (architects, landscape architects, and urban designers) visualize environments that do not yet exist. As managers of environmental change, they (and the professional associations that accredit design education programmes) need to show how visions of new or retrofitted environments can be brought to fruition. Considered as a public health intervention, design innovation must be informed by evidence of success and developed into policy to have real impact. As partners in this task, design professionals need evidence to support development of built environment design policy to promote healthy human habitats, including places where children can engage with nature and enjoy active lifestyles as an integral part of daily life. This task requires new methodologies to investigate the design details of spaces scaled to the size and needs of children.

Healthy community design

The focal US Centers for Disease Control (CDC) policy area 'healthy community design' is based on the assumption that 'The way we design and build our communities can affect our physical and mental health' (CDC, National Center for Environmental Health, 2008). Healthy community design emphasizes two key factors at a higher level in the built environment ecosystem: density and mixed-use development. These factors are still relevant to design policy related to children and families. Increased density can decrease automobile dependence (reducing contributions to global warming) and make it easier for people, particularly children, to move around on foot and bicycle, which encourages residents to be more physically active (Frank, Engelke and Schmid, 2003).

We hypothesize that density may be associated with development of children's friendship networks, which can provide a protective social shield for groups of friends and siblings outdoors (Moore, 1986). Increased mixed use can encourage a more diverse mix of housing and related community and commercial facilities. In turn, this may increase community stability by making it easier for families to remain in higher-density environments to 'grow in place' (that is, not to move to the suburbs when children arrive) and 'age in place' (live on in the same community once children have left home).

Together, growing in place and ageing in place may support stability of extended families, which can provide a source of social and economic support, especially when times are hard. Combinations of higher-density and increased mixed-use development may augment social engagement and the growth of social capital (Frank, Engelke and Schmid, 2003), thus supporting improved physical, social, and mental health (CDC, National Center for Environmental Health, 2008). Hypothesized relationships such as these, between place, social life and healthy lifestyles, are under-researched, especially for children. And yet, according to the CDC website:

> Healthy community design can benefit children in many important ways. At a time when obesity and diabetes are rising among children, when asthma continues to be highly prevalent, and when conditions such as attention deficit disorder may be on the rise, it is crucial to seek, understand, and implement environmental design solutions that might help with these health challenges. Research increasingly suggests that children benefit from the opportunity to play outdoors, where they can explore and enjoy natural environments.
>
> (CDC, 2009)

A statement such as this, by an authoritative US government health agency, underscores the beneficial health implications of designing nature into spaces where children spend time in daily routines. Naturalizing such places, including childcare centres, schools, parks, and safe routes integrated with residential communities, can be seen as a potentially powerful community design strategy for the healthy nurturing of children. These ideas echo those of Frederick Law Olmsted, Jr. (1870–1957), 'arguably the intellectual leader of the American city planning movement in the early twentieth century' (Reps, undated). A century ago, about the same time the first commercial automobile appeared in the US, he proposed that:

> well-distributed public playgrounds and neighbourhood parks become one of the urgent needs if the health and vigour of the people are to be maintained. And the most important classes to provide for are the children and the women of wage-earning families. Most important because of their numbers, and of the direct influence of their health and vigour upon the efficiency of the coming generation; but most important also because they have less energy to seek out healthful recreation at a distance from their homes.
>
> (Olmsted, 1911)

The younger Olmsted's vision is supported by rapidly accumulating research, which suggests that nature can impact several health dimensions, including longevity (Mitchell and Popham, 2008). Diverse, stimulating environments offered by nature help children thrive (Maller et al., 2006); even so, today's children are growing up disconnected from nature's healthy offerings (Louv, 2005). This change coincides with, and is likely linked to, a decrease in children's physical activity (Roemmich et al., 2006). The most obvious and serious consequence is the rise in childhood levels of obesity (Andersen et al., 2006; Ogden, Carroll and Flegal, 2008). An association between children's time outdoors (where nature is) and physical activity has been established (Sallis et al., 1993), as well as the positive influence of nature on child development (Berto, 2005; Cornell et al., 2001; Wells and Evans, 2003), including key factors such as attention functioning (Faber Taylor and Kuo, 2008), healthy eyesight (Rose et al., 2008), and general health (Maller et al., 2006). The accumulated evidence suggests that childhood time outdoors may delay or prevent the onset of chronic diseases later in life.

To resolve healthy community issues related to children and families, environments need to be designed to support healthy behaviours. There is increasing recognition that shaping healthy behaviours, such as increased physical activity, will involve influencing social norms (Williams, 2007), like reintroducing the natural world as a backdrop to children's play (Staempfli, 2009) and encouraging individuals of all ages, friends, families, neighbourhoods and other identifiable social groups to be physically active (Watanabe et al., 2006).

The process, form and content of community design

Designing is 'to plan or produce with special intentional adaptation to a specific end, to devise or propose for a specific function' (Webster's Third International Dictionary, 1981: 611). Design professions are concerned with changing the conditions of community environments (buildings, open spaces and products), and their proposals for design interventions contain detailed descriptions of how environments should work, be laid out and managed (Moore and Cooper Marcus, 2008). Designers think about design problems through visual imagery, and express solutions as visual statements. Designing outdoor environments generally falls under the professional purview of landscape architecture, which, according to the American Society of Landscape Architects (ASLA), 'encompasses the analysis, planning, design, management, and stewardship of the natural and built environments' (ASLA, 2009).

Design is concerned with both built environment *form* (that is, the layout of space, its boundaries, pathway systems, and interrelationships between subspaces or behaviour settings) and built environment *content* (that is, the subspaces themselves, their physical components and supported behaviours).[2] Although these factors vary between one design and another, successful designs must knit them into compelling places, attracting users who perceive and use them as coherent wholes. To understand the success of design from this holistic point of view, methodologies are needed that link designed environments to behaviour and address both form and content. Research guided by this conceptual framework is more likely to create useful evidence required for design interventions for healthy child development. As Aboelata (2004: 1), asserts, 'The designated use, layout, and design of a community's physical structures including its housing, businesses, transportation systems, and recreational resources, affect patterns of living (behaviours) that, in turn, influence health.'

The promise of a transdisciplinary field

The American Academy of Pediatrics (2009) has recently added its considerable voice to the expanding chorus of concern about preventable childhood lifestyle diseases, for which modifications to the built environment are part of the solution. Bringing together different fields of expertise in a truly transdisciplinary[3] field to focus on built environment change holds promise for innovation and the required massive changes in both form and content. Interdisciplinary progress has been made for several years but the transdisciplinary goal of creating a new, integrated field has yet to be reached. It is no small task to create a field where differing research and practice traditions can develop a shared problem-solving strategy and language. One reason is that design still has much research ground to cover before achieving full respect and attention from potentially allied, research-driven disciplines such as public health. Equally, the potential allies of design do not yet understand the workings of the complex production processes of the built environment in a way that will inform the challenging task of changing those processes to support healthy built environment design.

Development of a shared methodology can be seen as a crucial strategy that could yield early results focusing attention on design of the built environment. As Jackson and Kochtitzky urge:

> We must integrate our concepts of 'public health issues' with 'urban planning issues.' Urban planners, engineers, and architects must begin to see that they have a critical role in public health. Similarly, public health professionals need to appreciate that the built environment influences public health as much as vaccines or water quality.
>
> (Jackson and Kochtitzky, 2001: 15)

Because it is adaptable to many types of environments, different scales and varied settings, behaviour mapping is the type of methodology that may add impetus to a strategic push towards a common ground where a wide range of disciplines can contribute.

Creating evidence-based community design policy

To be effective, community design interventions need to be evaluated to demonstrate whether the desired improvement has resulted. In this policy arena, there is a growing desire in the scientific and design practitioner communities for increased rigour, validity and reliability in measuring the impact of the built environment on human behaviour (Frank, Engelke and Schmid, 2003).

Interest is particularly strong in the burgeoning interdisciplinary field of active living research, driven by recognition that built environment factors may help to explain the variability of active lifestyles across different populations and urban contexts (Frumkin, Frank and Jackson, 2004). In order to evaluate, adjust and, if necessary, create new policy to support active living and liveability in general, reliable, empirical evidence is needed, matching the level of regulatory detail appropriate to different sectors of urban development, including building envelope and setback regulations; street engineering; zoning and building density; location of parks, playgrounds and greenways; storm water management; and design of civic spaces. Many of these regulations apply at the 'site design' level. Those responsible for designing, managing and regulating built environments need access to precise site-design-level data that relates to specific designed elements in those environments in order to make informed decisions.

In addition, built environment moderators (and potential mediators) such as zoning regulations, parking requirements and building codes need to be researched and understood if policy is to be developed to encourage built environment design in a healthy direction. Behaviour mapping can provide a research tool to measure the behavioural effects of these secondary policy variables related to the physical settings and elements of children's environments.

Environment and behaviour (E&B) research has a 40-year track record and a developed repertoire of methodologies to study healthy lifestyle issues and help build the evidence base necessary to develop design and management solutions. Kevin Lynch, a design researcher and practitioner, who conceived the city as a human artefact designed to serve human needs, was one of the first to recognize the practical utility of an environment-behaviour approach in his concept of 'fit' (Lynch, 1981: ch. 9).

Lynch also instigated the first international study of children's urban environments (*Growing Up in Cities*, Lynch, 1977), which was replicated in expanded form in the 1990s (Chawla, 2002). The research subfield of children and family settings has developed a substantial conceptual framework and effective methodology, which Lynch helped to shape by establishing a multimethod direction that has evolved over many years. Direct observation of behaviour, objective measurement of physical activity, combined with qualitative, child-friendly methods (for example, drawings, child-taken photographs with or without audio-tagging, journals, semi-structured interviews and child-led safaris, Driskell, 2002) offer data-gathering tools to measure children's behaviour and perceptions useful to inform design. These complementary methods used to explore and identify environmental discriminatory items produce data that can be linked to behaviour mapping data, thus improving interpretation of results produced by both qualitative and quantitative research designs.

Theoretical framework

The theoretical basis of the authors' ecological approach to design research and the methodology presented here (behaviour mapping) are the key concepts of *affordance* (E. Gibson and Pick, 2000; J. Gibson, 1979) and *behaviour setting* (Barker, 1976; Heft, 2001 fully described in the previous volume in this series (Moore and Cosco, 2007; Cosco, 2007) as well as by Heft in this volume. Together, affordance and behaviour setting offer a common framework for researchers and designers to both analyse the quality of environments and use findings to improve designs.

Behaviour setting

Behaviour setting has been employed as a concept by environmental design researchers in a variety of areas with variable degrees of complexity (Lynch, 1981). The present authors have applied the concept as a unit of analysis in environment–behaviour research studies over several decades, which has resulted in the development of a stable set of behaviour setting types used in the ongoing design assistance and research programs of the Natural Learning Initiative at North Carolina State University, USA. Each application provides an opportunity to re-test the validity of individual types or the whole set of types.

Behaviour setting provides an evidence-based method of subdividing an environment or area behaviourally so that environment and behaviour can be linked directly, which is essential for understanding the impact of design on children's behaviour and for guiding design interventions. As a unit of analysis, behaviour setting it provides a common language for linking design to research by disaggregating designed outdoor environments or areas into their functional parts as a designer would (that is, pathway, climbing area, sand pit, water play setting, gathering place, tricycle path, vegetable garden and so on).

Behaviour setting has the potential for linking research findings to design policy to provide an analytical tool for managers of built environments in a way that can inform decision making and policy development in the professions responsible for public and institutional environments. Measurable user response could provide crucial data to inform investment or management decisions and increase confidence that specific designs would support desired behaviours.

Affordance

Affordance also has practical applications. Applied to environmental management and design, the concept of affordance can be used to identify and analyse similarities and differences among behaviour settings such as manufactured play equipment, sand play areas, pathways and vegetated settings. It can explain how design details afford variations in activity across behaviour settings of the same type. For example, why one sand play setting is more popular than another for caregivers with young children could be explained by the elevated sand enclosure that affords a sitting wall for the adult. Museum curators can use affordance concepts to understand how different exhibits' physical components or attributes may affect desired learning behaviour responses. Characteristics of plants such as fragrance or fruiting habit may influence their 'smellability' or 'pickability'. Identified affordances can provide valuable information for managers by focusing attention on detailed design of components that affect costs balanced with benefits for users.

Behaviour mapping

Behaviour mapping can be applied in a variety of built environment contexts, particularly as they relate to the behaviour of children and families, where environment–behaviour interaction is qualitatively different from interaction where only adults are engaged. Application of the method began in the 1970s with indoor environments (Ittleson, Rivlin and Proshansky, 1976). However, several early applications focused on children's outdoor behaviour, mainly settings at the level of residential neighbourhood (Björklid, 1982; van Andel, 1984–85), park and playground, and renovated schoolyards (Moore, 1974; Moore and Wong, 1997). These early examples used pencil and paper techniques to gather data, and hand graphics to spatially represent results. An exception was van Andel (1984–5), the first investigator to create a digital program to code both behaviour and attributes of the built environment linked through a relational database. The development of geographical information systems (GIS) now makes this task easier since GIS software programs in general allow the recording of not only events and activities on the ground but also their location (Longley et al., 2005). This and the availability of hand-held digital coding devices provide researchers with a choice of methods for gathering, processing, analysing and representing data.

Behaviour mapping procedures

A key criterion of behaviour mapping, as discussed here, is that the behaviour map is compiled from direct field observations of individuals in situ, where both environment variables and behaviour variables are observed simultaneously and coded at precisely the same site location (Figure 2.1). To develop a behaviour mapping protocol, several typical dimensions are addressed: *study*

Figure 2.1
Field researcher gathering behaviour mapping data in a childcare centre preschool outdoor play and learning space. The paper base plan scaled drawing is fixed to large clipboard. Location of observed individuals are being marked with red ink fine point "Pilot" pen on the base plan. Behavioural and environmental data are being entered in the PDA, using the stylus taped (for convenience) to the other end of the ink pen.

site boundaries, behaviour setting boundaries, observation sessions (or data-gathering site visits) and *session scheduling,* and the *number and duration of rounds of data gathering* to be conducted during each session.

Study site boundaries

It is not necessary for the whole site to be observed, only those areas accessible to users that can be used by them. The Bay Area Discovery Museum (BADM) outdoor exhibit areas studied by Moore et al. (2008) contained large, steep, landscaped slopes that were not used by even the most intrepid young visitors and so were excluded from the 'effective net study site'. The site boundary for Moore and Cosco's (2007) park study was clearly marked by a chain-link fence. Lacking such conditions, effective site boundaries must be defined post hoc as a result of the behaviour mapping. For large and/or heavily used sites, where observation times may be curtailed, the space can be subdivided to create a manageable protocol. For the Environmental Yard (an urban schoolgrounds renovation project) behaviour mapping study, the site was divided into two subareas observed by two observers during the 30-minute lunchtime recess (Moore and Wong, 1997: 239).

Behaviour setting boundaries

Behaviour setting boundaries (the subareas of a site) can often be defined by the 'lines on the ground' of physical components such as pathways or a meeting space such as a gazebo. Frequently, however, children's actual behaviour attached to settings spills over beyond boundary lines on the ground. Boundaries must then be defined post hoc by the clusters of actual behaviour.

In a study of Minnesota suburban school playgrounds conducted by the authors, play equipment was installed in subareas defined by use zone safety surface boundaries, which attracted the bulk of play activity. However, a proportion of behaviour spilled onto adjacent areas of mown grass and asphalt, extending the behaviour setting boundaries. In other cases, the behaviour defined separate behaviour settings (around a grove of trees and a free-standing cluster of rough-and-tumble play). Such settings were also mapped to show both the amount and type of behaviour compared with behaviour associated with manufactured equipment.

To study new or unfamiliar types of site design, two waves of data may need to be gathered; first, to define behaviour setting boundaries; and second, to code behaviour and physical attributes of each defined setting. To investigate early science learning and its relationship with the environment (a topic lacking research literature) in the Bay Area Discovery Museum (BADM) outdoor exhibit space, Moore et al. (2008) conducted a pilot project, including gathering sufficient data to define behaviour setting boundaries for later application.

Observation sessions – scheduling

To investigate moderators such as seasonal change, observations should ideally be conducted over a twelve-month period. Typically, this scope of observation is impractical because of the time commitment and cost involved. However, if suspected underuse or nonuse of the space is an issue, the only way to provide convincing evidence is to devote long hours observing what might turn out to be an unused space. The I-PARK (Investigating Parks for Active Recreation of Kids) team observed twenty inner-city parks in 2007 during eight summer weeks (the assumed high-use season). Preliminary results show that the majority of parks were relatively underused in contrast with a small minority of recently retrofitted parks that were heavily used. The finding rather convincingly illustrates the positive effect of park renovation. However, interpretation of the issue of underuse or nonuse was limited by the lack of interview data in the sparsely used parks. For instance, were potential users frightened by the lack of upkeep, or was the old, worn-out equipment unattractive, or was the weather too hot? We don't know.

If a research objective is to measure the relative use or 'loading' across behaviour settings, observation sessions should be conducted during assumed high-use periods (which could be established through a pilot study), to yield as much data as possible. Cosco (2006) observed preschool playground use during outdoor playtimes programmed by individual childcare centres. Cooper Marcus (in Moore and Young, 1978: 117) observed behaviour in the St Francis Square residential development during a multi-session 'composite day' covering the period 8:00 am to 8:00 pm. Moore and Cosco (2007) gathered multiple rounds of park use data on all days of the week and weekends to ensure that data reflected weekly park use.

Observation rounds per session – number, interval and duration

Resources available to support observation time, including the number of observers available and the number of sites to be observed, often dictate decisions about the number of rounds per session. Climate, seasonal effects on activity, special events, often associated with public holidays, and cultural celebrations may affect the choice of both number and duration of rounds per observation session. Such external influences are also important control variables, which the researcher(s) should attempt to either exclude or hold constant during the observation period.

Because data gathering is expensive (see below), a typical objective is to gather as much data as possible in a short period of time. Pairs of observers are most commonly employed observing simultaneously, thus yielding twice the number of rounds and double the data possible with a single observer. Pairs of observers also allow for reliability testing to be conducted as part of the protocol. For efficiency of observer deployment, rounds should be conducted sequentially, with a predetermined round interval and duration. Round interval defines the predetermined time between the start of each round. Round duration defines the time taken to conduct a round, which will vary slightly depending on the number of observations coded. To ensure that round interval remains constant, allowance should be made in the schedule for slack time between rounds, typically five to ten minutes.

Round interval and duration is typically determined by the size of the site and density of users to be observed. Larger sites usually require longer round interval and duration. The more dense behaviour is, the slower the round navigation will be because of the time required to record behaviour. Round intervals of less than ten minutes are rare, first, because most moderately sized sites such as urban parks with moderate use levels, for example, require at least ten minutes to conduct a single round, and second, because round intervals of less than ten minutes indicate low-use conditions, suggesting consideration of a different session schedule. In any case, short round intervals result in higher levels of double counting, which may threaten study validity.

Large sites may require much longer round intervals. The behaviour mapping study of downtown Davis, California, conducted by Francis (1984), employed a single daily round covering twenty-two subareas with three observers, totalling thirty-three rounds in total, conducted over a period of four weeks (total number of individual observations not noted). Francis replicated the study in 2008 and observed 2,743 individuals (personal correspondence).

Control issues

To protect a behaviour study from external threats such as the climatic cycle, local variation in weather conditions, periodic changes in school schedules, public holidays and community-wide cultural events, the observation schedule should be framed as tightly as possible. For example, Moore et al. (2008) gathered BADM data during one springtime week including the weekend (when visitor population was known to be high and as a strategy to include more fathers in the sample).

Using behaviour mapping to investigate healthy outdoor environments for children and families

Three recent behaviour mapping studies illustrate the versatility of behaviour mapping applications in three different types of outdoor environments:

- *Neighbourhood parks*: key components of healthy neighbourhood design. Investigation of neighbourhood park behaviour by children and families can inform policy development to counteract sedentary lifestyles at neighbourhood level. The illustration used here is *Investigating Parks for Active Recreation of Kids (I-PARK)*, a study of park use by children and families, conducted in Durham, North Carolina.[4]
- *Children's museums*: community destinations offering active outdoor environments that afford children's play as a vehicle for informal learning. Investigation of children's play and learning in outdoor exhibit areas can improve understanding of how behaviour setting (exhibit) design can afford desired behaviours. The illustration used here is *My Place by the Bay: Prepared Environments for Early Science Learning*, a study of early science learning conducted in the outdoor exhibits at the BADM.[5]
- *Childcare centres*: community institutions where the majority of children under five in the United States spend most of their waking hours while parents work. Centre outdoor environments are particularly important because they can afford higher levels of physical activity. Investigation of relationships between setting physical attributes and preschool physical activity can influence policy developed by regulatory bodies. The illustration used here is *Measuring Physical Activity Affordances in Preschool Outdoor Environments*, a study of outdoor preschool areas in 30 childcare centres located in the Research Triangle urban region of North Carolina.[6]

Healthy neighbourhood parks

Neighbourhood parks provide a potentially important neighbourhood destination for regular healthy outdoor activity for children and families. They have therefore become an important research topic in the field of active living. The most commonly used research tools to measure physical activity behaviour include those developed by McKenzie and colleagues, beginning in 2002 with SOFIT (System for Observing Fitness Instruction Time), followed by SOPLAY (System for Observing Play and Leisure in Youth), and SOPARC (System for Observing Play and Recreation in Communities, McKenzie and Cohen, 2006; McKenzie et al., 2006).

The initial focus of McKenzie's work was physical education, using SOFIT to investigate the physical education behaviour of elementary and middle-school students in the standardized physical environment of gymnasia.

Using SOPLAY, McKenzie moved investigations outdoors to schoolyard environments, the large majority of which contain standardized, manufactured play equipment, surrounded by open areas of asphalt and mown grass, and used primarily during school recess. Most recently, using SOPARC, McKenzie and other investigators have begun to study community spaces such as parks and playgrounds where, unconstrained by schoolday schedules, populations are more varied and exhibit more diverse behaviours in both space and time. Each of McKenzie's instruments uses similar time sampling observational protocols and codes for physical activity level, activity type, and ratings for a limited number of environmental variables, such as 'accessible' and 'usable'. The SOPARC protocol subdivides the park into observational 'target areas', predefined by activity function (organized sports fields, playgrounds, social areas, and mobile activity such as walking and biking) (McKenzie and Cohen, 2006). SOPARC cannot be defined as a behaviour mapping tool as discussed here because it does not plot precise locations of observed individuals, and uses predefined, roughly sketched observation 'target zones' instead of more precisely delineated behaviour settings. However, as a reliable, validated tool most often cited in the literature, it was applied in the main I-PARK study. Also, SOPARC was assumed to be a more time-efficient method than behaviour mapping for gathering park use data in large community park sites.

To capture a broader range of environmental variables, investigators have used Environmental Assessment of Public Recreation Spaces (EAPRS), developed by Saelens and colleagues (fifth edition), to code physical settings and attributes of public parks and playgrounds (Saelens et al., 2006).[7] This eighty-three-page 'environmental audit' instrument codes a vast range and number of park environment attributes (646 items in sixteen domains and six subscales). However, corresponding behavioural data must be gathered by some other means, and SOPARC is most commonly used by active living park researchers for this purpose. As behaviour and environment are coded separately using different instruments, complex statistical modelling must be used to search for possible relationships between a relatively small number of behavioural variables and a vast number of environmental attributes. Interpretation of results that may apply to design policy is potentially challenging.

These validated, reliable methods have been rapidly adopted in the active living research field; however, they lack coding protocols that link behaviour to environmental attributes at a level of physical precision necessary to produce outcomes that can be applied to built environment design policy and practice related to children. The SOPARC roughly sketched 'target areas', more than likely delineated in a mere outline sketch of the park area (accurate site base plans are often not available and must be generated by overlaying available GIS real property data with aerial photography), serve as systematic targets for observation. However, they cannot be considered as precisely defined behaviour setting boundaries corresponding to the items of direct relevance to users' behaviour and to design professionals.

Behaviour mapping has the potential to overcome this limitation by defining empirically established behaviour setting boundaries, and by coding behaviour and environmental attributes simultaneously at the same spatial location so that environment and behaviour are directly linked to the same data point. By linking location and behaviour, detailed analyses can be conducted that include policy-sensitive outcome measures. Use/space ratio, for example, provides a direct measure of the efficiency of different behaviour settings in terms of amount of use relative to footprint size and construction cost – useful metrics for guiding park management decisions (Moore and Cosco, 2007).

SOPARC offers possible advantages in contexts where park sites are relatively large and density of activity is low. In the I-PARK study, SOPARC was used to gather data across twenty study sites, where the majority of 'target zones' were large compared with typical behaviour settings. Results (after eight weeks of observation) indicated low to very low levels of use of many parks (essentially nonuse in most: see Figure 2.2). In a small minority of sites where

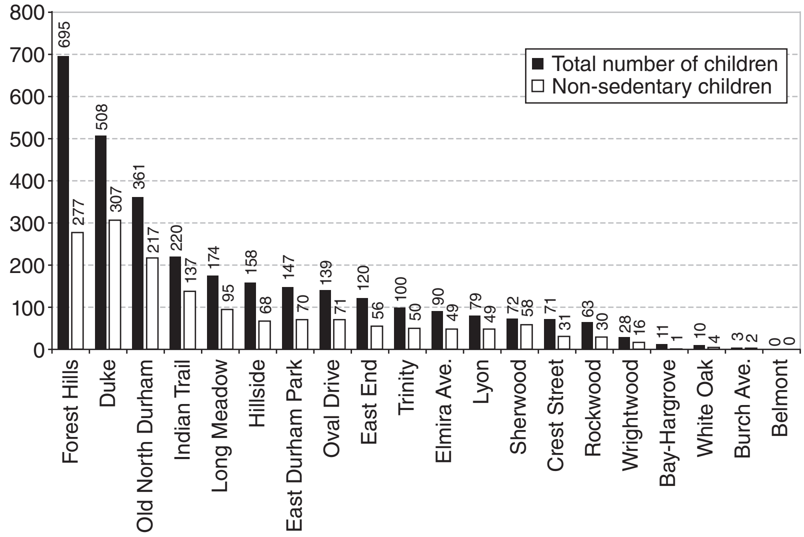

Figure 2.2

Children observed (N=3049) by park across 20 urban parks in Durham, North Carolina, USA. Physical activity data was gathered using the SOPARC three-point scale during eight weeks, summer 2007. Level of use was highly variable with the majority of parks underused. The proportion of children exhibiting non-sedentary physical activity varied between 81% and 40% (ignoring one outlier of 9%) with a mean of 54%. Just three parks accounted for 51% of total use by children across all 20 sites. In two of these parks, the playground had recently been replaced. The third site was adjacent to a school where summer programs used the park. Variability of total use and proportion of non-sedentary physical activity across the 20 parks may be due to neighbourhood physical factors (traffic levels, accessibility, etc.), neighbourhood perception of danger (crime, for example), or could be due to physical characteristics of the parks themselves (choice of facilities and activities, amount of shade, for example), or negative park perception (crime, rundown, unkempt landscape, for example). Interpretation presents a challenging task that may be assisted by results of in-park interviews (currently being analyzed) and/or by using statistical modelling.

recent physical improvements had been made, use levels were far higher. Three of these 'high-use' park sites were studied further using behaviour mapping (one of which, Forest Hills, is presented here, Figures 2.3–2.9). Behaviour mapping, together with a measure of physical activity (SOPARC) and user interviews, were used to assist understanding why these parks were more heavily used, thereby helping to interpret the results of the larger study.

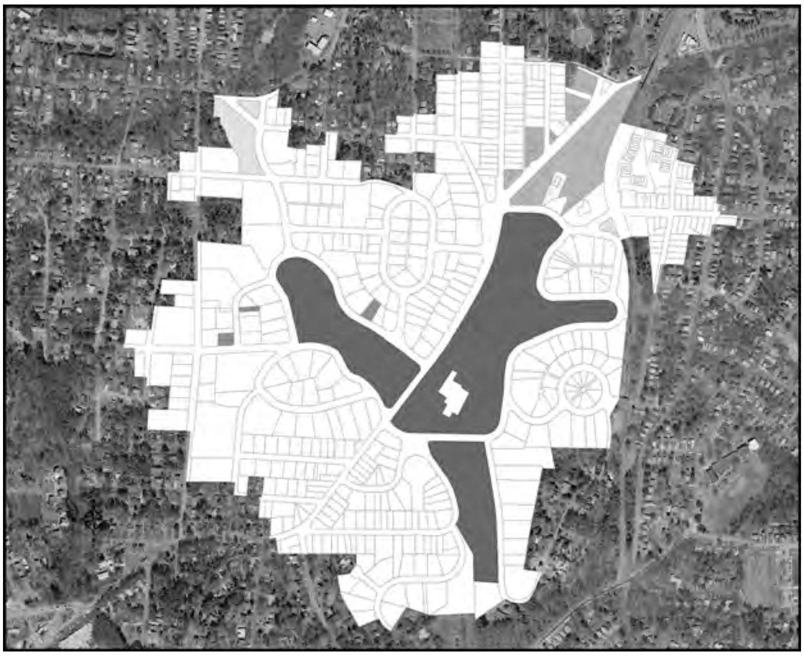

Figure 2.3
Forest Hills, Durham, North Carolina: One of the larger (45.86 acres) I-PARK sites shown in context of its surrounding older residential neighbourhood with ¼-mile network buffer (used in neighbourhood analysis of "getting to the park"). The recently renovated playground case study site (white shape), accounted for only 2% of the total park area but Y% of observed children (using SOPARC), which makes Forest Hills Park appear to be the most heavily used park of the 20 in the I-PARK study.

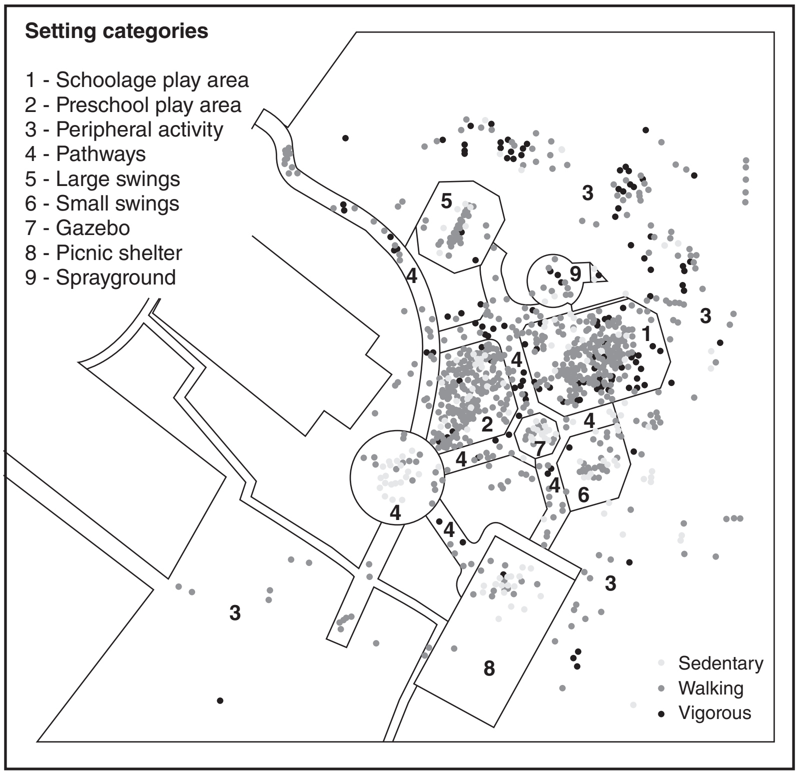

Figure 2.4
Forest Hills Park playground behaviour map: Physical activity level coded using SOPARC codes (pale grey – sedentary activity, mid grey – walking, dark grey – vigorous physical activity). The majority of activity can be observed in two main clusters of children using the school age manufactured play equipment area (right) and the preschool play area containing three small playhouses and sand and water play settings (see Figures 6 and 7).

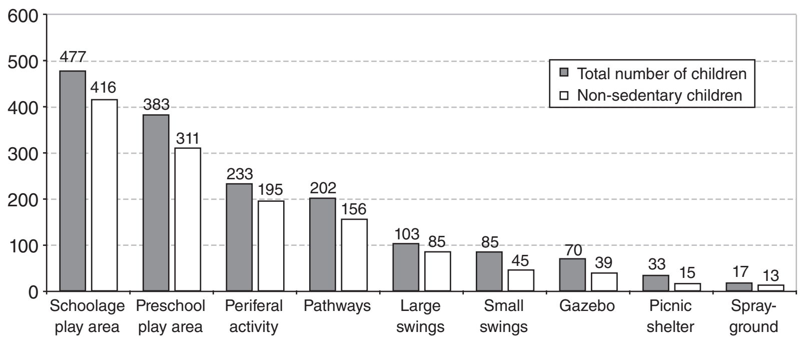

Figure 2.5
Forest Hills Park playground: Distribution of total and non-sedentary child activity across settings. In six of the total of nine behaviour settings, the proportion of non-sedentary behaviour was greater than three-quarters of all behaviour in the setting and in the school age and preschool play areas, the proportions were 87% and 81%, respectively. Across all settings (including those affording more sedentary social behaviour – gazebo and picnic shelter), non-sedentary behaviour was still high (72%). This easily accessible, well-used, recently renovated playground, offering a variety of play settings and comfortable, shady social settings, afforded a high proportion of non-sedentary activity, rising to a high of 87% in the school age play equipment setting. (Note: the low activity level in the spray ground was because data were gathered in the autumn season. In midsummer, this setting would have attracted more activity.

Figure 2.6
Forest Hills Park playground: Overall view of playground.

Figure 2.7
Forest Hills Park playground: School age manufactured play equipment, and social/sitting affordances.

Figure 2.8
Forest Hills Park playground: Preschool sand and water play settings (the area also included three small playhouses).

Figure 2.9
Forest Hills Park playground: Shady, central favourite gathering place for families with young children.

Main conclusion based on behaviour mapping

Children and their caregivers are more likely to be attracted to neighbourhood parks if they have up-to-date, well-maintained playground equipment. Particularly attractive playground settings include composite climbing structures, swings, water play and sand play. Comfortable, shady seating will attract caregivers and provide a viable social setting for adults, which may prolong the duration of park visits. These findings partly replicate those of the earlier study by Moore and Cosco (2007). Policies proposing neighbourhood parks as important active recreation destinations should recognize the need to provide a diverse choice of play and social settings, and also emphasize the critical management role of regular maintenance and periodic retrofitting to upgrade equipment.

Healthy outdoor settings for children's museums

Children's museums are 'places where children and adults can engage in interactive exploration, adventure, and learning together' (Frost, Wortham and Reifel, 2005: 83). They offer active community destinations that are particularly attractive to children and families, especially museums with outdoor environments. In the United States, more than 340 children's museums are members of the worldwide Association of Children's Museums (ACM). However, only eighty-three (24 per cent) extend their programmes into designed outdoor settings (Rajakaruna, 2006). To change this situation, the ACM has stressed the importance of designed outdoor settings in its member institutions (ACM, 2008).

At community level, museums and similar nonformal education institutions such as zoos and botanical gardens are potentially important family destinations for healthy outdoor activity. Design can make a difference in attractiveness and therefore increase the likelihood of repeat visits, which are good for the sustainability of the museum as well as the health of visitors of all ages.

As the US National Science Foundation (NSF) funded construction of the BADM outdoor areas (accommodating young children, three to eight years old), research focused on 'early science learning'. However, results show that children's play is the primary vehicle for science learning – indeed, BADM could be called a successful play museum in relation to its outdoor environment. As healthy child development through play is cloaked in the language of science learning, research findings offer a new message, 'come and learn science through healthy outdoor play'. The study of the museum's outdoor exhibits identifies environmental attributes more likely to support such a message. As this type of design-based research is sparse, the results will provide valuable guidance to children's museums and other nonformal education institutions interested in designing successful outdoor early childhood spaces.

The lack of research literature helps explain the undeveloped state of the art in design of early childhood outdoor spaces in community institutions (besides childcare centres, discussed later). Empirical findings are still lacking. For example, in the well-documented national report on early childhood pedagogy by Bowman, Donovan and Burns (2000), the outdoors is not mentioned even though science-related learning was a central topic.

However, we know from play environment research that diverse outdoor environments motivate spontaneous interaction by children and freely accommodate a broad range of individual differences (Moore and Wong, 1997). Such environments motivate exploration, assembly and reassembly of parts, and in the process provide a multitude of cues or affordances that encourage active play (Cosco, 2007). We know that diverse outdoor environments can be designed to motivate learning through play. In this regard, the BADM behaviour mapping study was an attempt to link physical attributes of settings to particular types of play behaviour.

Part of BADM, Lookout Cove occupies a dramatic location on the shoreline of San Francisco Bay in sight of the famed Golden Gate Bridge (Figure 2.10). The layout of Lookout Cove contains a variety of exhibits (settings), each one of which is intended to convey a science-related aspect of the Bay Area region to young visitors and accompanying adults (Figure 2.11). Children using the area had a median age of five years (according to an online survey of museum members conducted as part of the overall study).

Figure 2.10
Bay Area Discovery Museum, Lookout Cove: Gravel Pit (far left), Shipwreck, 'Sunken Digs' (mid-foreground), the real Golden Gate Bridge (far distance, against sky), Fishing Boat (below Golden Gate Bridge), Tide Pools and Sea Cave (far right), Golden Gate Bridge manipulable play and learning setting (foreground left).

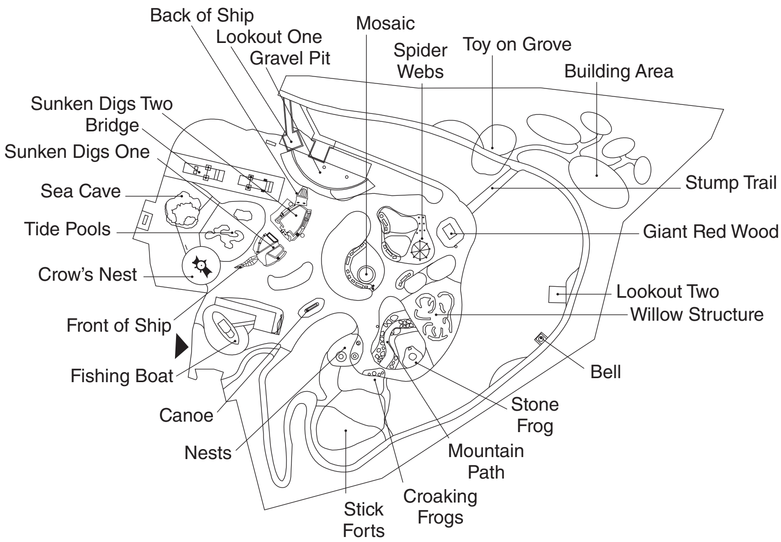

Figure 2.11
Lookout Cove: Exhibit (setting) layout.

Two linked behaviour mapping studies were conducted. First, data were gathered on a paper base map (to record spatial location) in multiple rounds of observation, timed at equal intervals of twenty minutes. Results were used to define behaviour settings and their boundaries, which defined target areas for coding the second study of play and learning behaviours using codes developed through a pilot project conducted by the authors at the North Carolina Botanical Garden, Chapel Hill, North Carolina.[8] Appendix A presents the full coding scheme demonstrating the possibility of creating an extensive database of independent and moderator variables to study hypothesized relationships with a dependent variable (in this case, early science learning).

For the second study, two observers moved in timed circuits in opposite directions (clockwise and anticlockwise) around Lookout Cove and coded the behaviour of each individual occupying the setting sequentially using PDAs with customized pull-down menus. By systematically scanning each setting and capturing snapshots of each child's behaviour, this method made it possible to gather multiple-coded data more easily and reliably than paper and pencil methods. Codes included early science learning activity (playing, observing, exploring, experimenting, and cause and effect), related environmental and social contextual codes, and interaction with accompanying adults.

The composite behaviour map shows a concentration of activity in behaviour settings close to the entrance area, on the left side of the drawing (Figure 2.12). Distribution of use across behaviour settings is highly varied (Figure 2.13). Almost three-quarters of use by children (74 per cent) is accounted for by

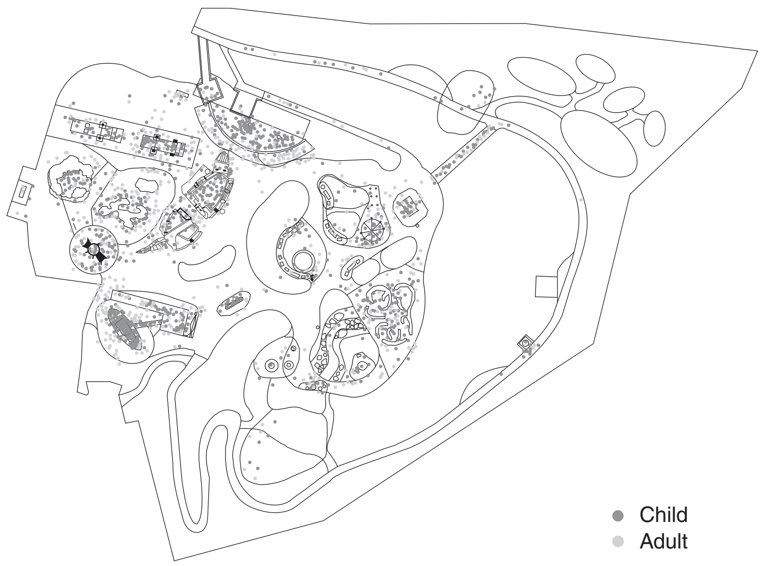

Figure 2.12
Lookout Cove: Composite behaviour map (children, dark dots; adults, pale dots). In several behaviour settings (Gravel Pit, Sunken Digs, Tide Pools, Fishing Boat) there is a clear pattern of children clustered within the setting with caregivers distributed closely around the setting – possibly because the settings were physically uncomfortable for adults to be in. In other settings (Bridge, Willow Structure) children and caregivers were more intermingled – possibly because the settings were comfortable for caregivers to get inside to participate in the activity with their children (building a bridge with loose parts, playing hide-and-go-seek in and around the structure).

just six of the twenty-one settings (fishing boat, gravel pit, shipwreck, bridge, willow structure and tide pools). Figure 2.14, which shows behaviour mapping data converted to density of use (average per round of observation), underscores the effectiveness of the two most densely used settings: the gravel pit and fishing boat. That is, they occupy a relatively small amount of space compared to the amount of use they afford or attract.

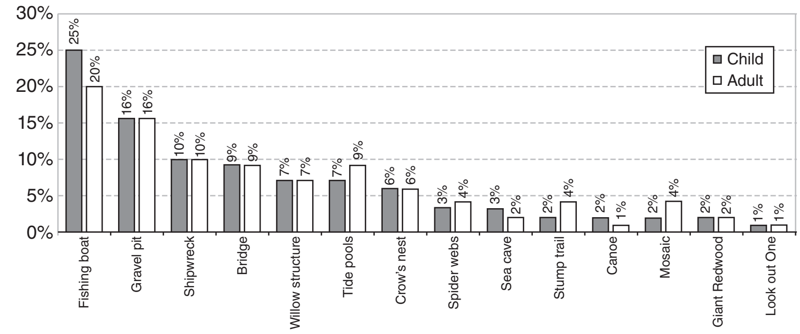

Figure 2.13
Lookout Cove: Distribution of child and adult users by setting. In the majority of settings, child and adult use was roughly equal. As informally observed in verbal interactions between adults and children, this may reflect the interest of educated middle class caregivers in engaging with their children in enjoyable activities with perceived educational benefits. Caregivers were also observed chatting with each other while their children played. This observation underscores the importance of designing outdoor play and learning settings to afford comfortable social gathering and interaction among adults.

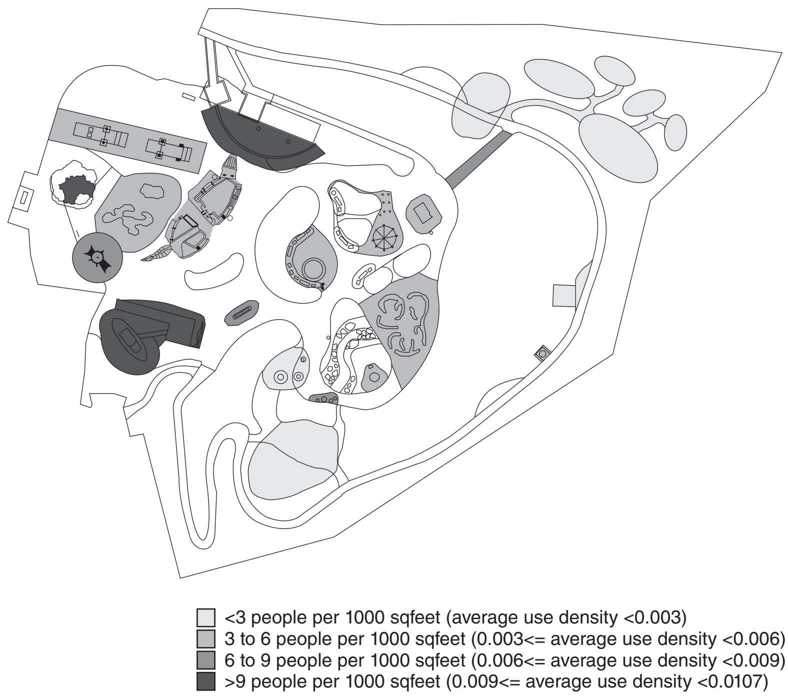

Figure 2.14
Lookout Cove: Average use density of settings (average per round of observation). Density measures such as this could provide a useful objective parameter for managing visitor perception of crowding.

The success of the gravel pit may be explained by the affordance of its pile of gravel and large toy trucks which were especially attractive to preschoolers. The low wall containing the gravel afforded caregivers a convenient, comfortable place to sit near their children so they did not get bored and uncomfortable, and ready to move on after a few minutes.

The attraction of the fishing boat may be explained by the large amount of dramatic play it stimulated. Larger proportions of observing, exploring, and cause and effect activity relative to other settings were afforded by its physical features. It was a 'real' boat and still retained accoutrements such as a wheel, various knobs and levers, a bell and a cooking galley, which afforded manipulation during fantasy play, helping children to pretend to go on voyages, battle storms at sea, navigate dangerous waters, and so on. The fishing boat was located with the Golden Gate Bridge in the background, which may have added to the dramatic play value of the setting.

With the exception of the willow structure, the other five high-use settings could be manipulated by children and/or contained loose parts. The willow structure, which in fact was a work of art constructed from 'living willow', attracted use because of the hide-and-seek and chase games afforded by its complex, exploratory, three-dimensional sculptural spaces. None of the remaining settings with relatively low proportions of use afforded manipulability or loose-parts play.

Main conclusion based on behaviour mapping

Nonformal education destinations with outdoor exhibit areas serving young children will be more attractive if they include settings with manipulable components and or loose parts. These attributes are more likely to increase both dramatic and active play and will provide a broader range of learning activity, particularly related to early science learning behaviour. Policies proposing nonformal education institutions as active recreation community destinations should recognise the need to provide a diversity of outdoor settings designed to stimulate dramatic and imaginative play and managed to offer manipulative, loose parts play.

Childcare outdoor environments: Investigating setting attributes and preschool physical activity

Current US policies for providing healthy children's environments are based on childcare quality assessment scales used for licensing (Harms, Cryer and Clifford, 1990). Increased knowledge of play environment characteristics is needed to inform childcare licensing policy and accreditation regulations, and encourage the development of best practices to support physical activity. Researchers are making efforts to rectify the knowledge gap by identifying environmental characteristics that might be associated with children's health such as physical activity (Dowda et al., 2004, 2009).

The behaviour mapping study presented here is part of a study of thirty preschool play areas, the aim of which is to link behaviour setting attributes with early childhood activity affordances and to identify environmental features that might encourage different ranges of preschool physical activity. Resulting behaviour mapping illustrates how play settings may produce different physical activity outcomes.

Using the behaviour mapping methodology described above, outdoor behaviour settings were systematically and consecutively scanned using a paper map to locate subjects in the space, and a handheld computer (PDA Dell Axim Pocket PC, Austin, Texas) to record gender, setting type, physical attributes where the target subject was observed, and physical activity level using the Children's Activity Rating Scale (CARS) (Puhl et al., 1990; DuRant et al., 1993). The scale allows trained observers to record children's activity on a scale 1–5 representing different levels of energy expenditure (1 = motionless; 5 = vigorous).

Eight behaviour maps were collected per play area (four from each observer) and processed using GIS software (Longley et al., 2005). The total number of children in the play area and the weather conditions were noted at the time of observation. The data were used to create the attribute tables in GIS to conduct analyses. Additional environmental variables that might contribute or hinder preschool activity were added to the GIS attribute table (setting square feet, ground surface material and amount of shade).

Study overview

To illustrate the method, behaviour maps of two childcare centres (Centre A, Figure 2.15; and Centre B, Figure 2.17) located in the Research Triangle Area, N.C., are presented here. Both centres were high-quality early childhood institutions and held a North Carolina licence that requires the highest performance in teacher training, environmental quality, safety and educational standards.

The outdoor areas were comparable in several key dimensions. They had a similar number of behaviour settings, similar square footage, and a comparable number of behaviour mapping observations in relation to the number of children (thirty and twenty-one, respectively). Children were observed during outdoor play in each centre. The composite behaviour maps are shown in Figures 2.16 and 2.18. However, the layout of the sites and the mix of settings were different (Figure 2.19). Settings in Centre A included four dramatic play areas, one gathering area, eight open areas, a multiple loop pathway, one planted area, one composite play structure, a porch/transition area, and a sand play area. Settings in

Figure 2.15
Centre A: The upper end of the site is a large open area shaded by several trees and surfaced with woodchips to protect against erosion. This area is gently sloping down away from the camera. A sand play setting is visible to the right. A concrete paved pathway is just visible looping around a central, custom-made timber play structure. The pathway was highly attractive to children using wheeled toys. The roof of the centre building can be seen rising in the background.

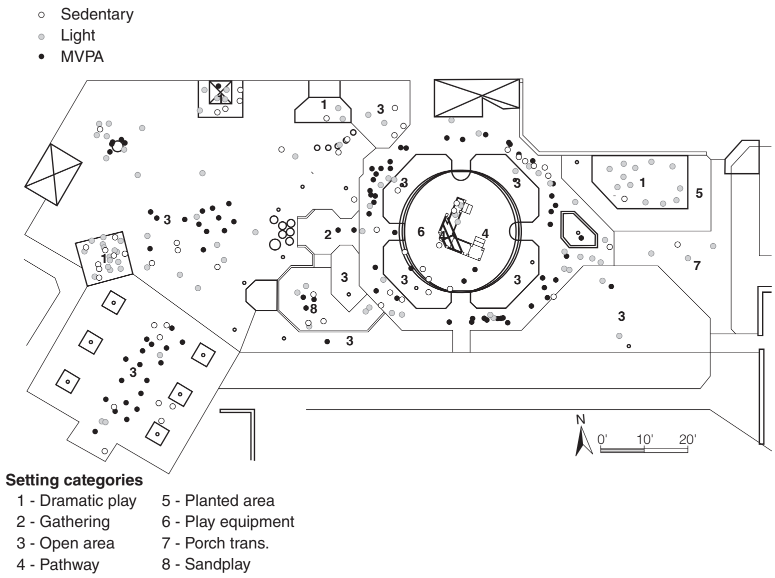

Figure 2.16
Centre A: behaviour map of physical activity. The moderate and vigorous physical activity "affordance" of the circular pathway for wheeled toys is indicated by the higher density of observations, which may also be influenced by the synergetic effect of the number and diversity of settings adjacent to the circular pathway.

Figure 2.17
Centre B: One side of the site included a steep hill with, at the midpoint, a slide descending into a large area surfaced with woodchips. Two additional manufactured play equipment behaviour settings are visible as well as a narrow wheeled toy path in the lower right corner of the photograph.

Figure 2.18
Centre B: behaviour map of physical activity. Activity is spread evenly across the behaviour settings, all of which appear attractive. The central area contains several manufactured equipment settings, including swings. A large sand play area is located at the bottom right corner, which affords more sedentary activity than other settings.

	Play area sqft	Number of settings	Observations
Center A	9,414.58	17	256
Center B	8,265.72	18	207

Figure 2.19
Centre A physical activity related to ground surface material. The high level of MVPA on concrete reflects the wheeled toy affordance on the circular pathway. The higher MVPA on the woodchip surface reflects the 'runnable' affordance of the open areas, which were surfaced with a thin layer of woodchips for anti-erosion control in the shady zone under a large oak tree (as compared to a thick layer of woodchips used as a safety surface, which typically is less 'runnable').

Centre B included three dramatic play areas, six open areas, a looped pathway, four pieces of play equipment including a slide on a slope, and a large sand play area.

Results of behaviour mapping

The large majority of observations of activity occurred in three types of behaviour settings in Centre A: pathway, open areas and dramatic play. Most activity was also observed in the same type of settings in Centre B, with the addition of play equipment (Figure 2.20). However, the distribution of activity in the same type of setting was different in each centre (Figure 2.20). In Centre A, 87 per cent of children's activity was observed in the three behaviour settings mentioned above: open areas (35 per cent), pathway (33 per cent) and dramatic play settings (19 per cent). Two of these settings (open areas and multiple loop pathway) accounted for 92 per cent of the moderate to vigorous activity (MVPA). In Centre B, most children were observed in the play equipment area (38 per cent), open areas (26 per cent), dramatic play areas (18 per cent) and the looped pathway (13 per cent). The open area and play equipment accounted in this case for 72 per cent of MVPA.

Figure 2.20
Centre B physical activity related to ground surface material. The wheeled toy path, which lacked the exploratory affordance of the larger pathway of Centre A, afforded less MVPA. On the other hand, the woodchip surface afforded a similar amount of MVPA as the woodchip surface of Centre A. Even though the woodchip setting was a thick safety surface and possibly less 'runnable', its central location adjacent to several other settings may have created a synergetic effect of children running between settings, which may explain the larger amount of MVPA.

Discussion

As in the previous examples, behaviour mapping can be used to identify *specific environmental features*, in this case associated with higher levels of physical activity, where behaviour setting is the unit of analysis. Results from these types of analyses may provide appropriate guidance to designers and policy makers to help them create healthier, active preschool playgrounds through environmental interventions. The illustrations presented here support the assumption that the different characteristics of play areas might influence children's behaviour and their level of physical activity related to *setting category, setting form,* and *ground surface*.

Centre	Dramatic play	Gathering	Open areas	Pathway
Centre A	4	1	8	1 (multiple loop)
Centre B	3	0	6	1 (loop)

Centre	Planted area	Play equipment	Porch / transition	Sand play
Centre A	1	1	1	1
Centre B	0	4	2	1

Setting category

In these examples, children preferred specific behaviour settings (open areas, pathways, play-equipment and sand play settings).

Setting form

Children are attracted by specific behaviour setting forms, pathways being a clear example (Cosco, 2006). The behaviour maps presented here show levels of play that appear to be influenced by the particular forms of pathway (Figure 2.21). In Centre A, the multiple looped pathway setting was used by children to run or ride around and to access the diverse settings connected to it. We could speculate that children 'read' the pathway affordance (circulation route and connector to other play nooks) and use it freely. Designers could apply this knowledge for creating active play settings.

In Centre B, we speculate that the narrow pathway had less influence on children's activity for several reasons: although looped, this pathway was unattractive because it was narrow, and was undifferentiated spatially, therefore

Centre A	**Sedentary**	**Light**	**MVPA**	**Total**
Dramatic play	22%	35%	1%	19%
Gathering area	2%	0%	1%	1%
Open area	36%	29%	41%	35%
Pathway	19%	25%	51%	33%
Play equip	16%	3%	3%	6%
Porch trans	2%	3%	0%	2%
Sandplay	5%	5%	3%	4%
Subtotal	25%	38%	37%	100%

Centre B	**Sedentary**	**Light**	**MVPA**	**Total**
Dramatic play	38%	17%	5%	18%
Gathering area	0%	0%	0%	0%
Open area	6%	13%	47%	26%
Pathway	11%	10%	15%	13%
Play equip	44%	56%	25%	38%
Porch trans	2%	0%	0%	.5%
Sandplay	%	4%	7%	4%
Subtotal	32%	24%	45%	100%

Figure 2.21
Centres A and B physical activity distribution by behaviour setting as recorded using 5-point CARS scale. Physical activity "sedentary" represents levels 1 and 2; "light" level 3; and "MVPA" (moderate to vigorous activity) levels 4 and 5. The types of setting were similar in Centres A and B; however, the distribution of total activity and MVPA was variable across setting types. This may be interpreted in terms of affordance factors (layout, objects, and events). For example, the more engaging, exploratory layout of the pathway in Centre A could explain the larger amount of active use, particularly for wheeled toys, compared to Centre B. Conversely, the greater number and relative attraction of the Centre B play equipment could explain its higher level of active use compared to the Centre A play equipment.

lacking in exploratory appeal. It supported a limited number of play behaviours (a line of 'drivers' riding in one direction). The low number of adjacencies compared with Centre A may have reduced the potential synergetic effect of the pathway (as discussed below).

Ground surface

It was assumed that different ground surface materials would afford different levels of physical activity given the variability of responsive qualities to movement. In both centres, moderate to vigorous physical activity was found in settings with medium to hard ground surfaces such as concrete, decking, soil and woodchip (Figure 2.22 and Figure 2.23). Hard pathway surfaces such as the Centre A concrete pathway appear to support more moderate to vigorous activity, especially when wheeled toys are available, because they are easier to use on smooth surfaces. These findings have clear implications for design, since ground surface selection is considered a critical decision by designers, until now driven by safety criteria rather than by physical activity objectives. Harder ground surfaces have been identified as a predictor of higher levels of activity in preschool boys, suggesting ground surfaces could be a modifiable environmental factor to promote physical activity (Cardon et al., 2008).

In contrast, moderate to vigorous activity is negligibly supported by sand. It is very difficult to run through sand and yet it has been used frequently as a ground surface, sometimes covering the entire playground as a safety feature. This suggests that the prevailing practice of meeting safety standards using sand as a safety surface may inhibit higher levels of activity. Such knowledge may help designers and policy makers understand the need for tighter fall zones and diversified ground surfaces around play equipment. Ground surface treatments may support higher moderate to vigorous activity and encourage the use of wheeled toys, balls, and similar loose or moveable equipment.

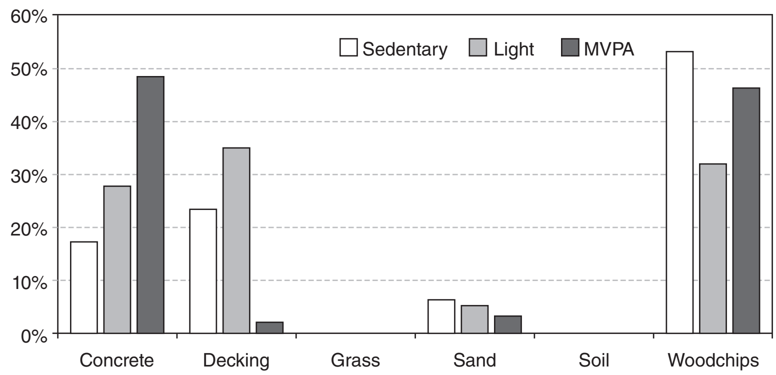

Figure 2.22
Centre A physical activity related to ground surface material. The high level of MVPA on concrete reflects the wheeled toy affordance on the circular pathway. The higher MVPA on the woodchip surface reflects the "runnable" affordance of the open areas, which were surfaced with a thin layer of woodchips for anti-erosion control in the shady zone under a large oak tree (as compared to a thick layer of woodchips used as a safety surface, which typically is less "runnable").

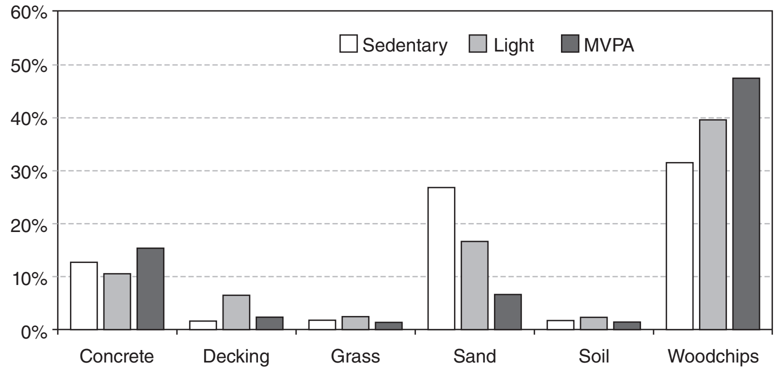

Figure 2.23
Centre B physical activity related to ground surface material. The wheeled toy path, which lacked the exploratory affordance of the larger pathway of Centre A, afforded less MVPA. On the other hand, the woodchip surface afforded a similar amount of MVPA as the woodchip surface of Centre A. Even though the woodchip setting was a thick safety surface and possibly less "runnable," its central location adjacent to several other settings may have created a synergetic effect of children running between settings, which may explain the larger amount of MVPA.

Synergetic effect

Children's play behaviour can be highly dynamic in space and time, changing from one moment to the next, from vigorous to sedentary and vice versa. An important aim of health-promoting design is to create environments that support *sustained* moderate to vigorous activity. To achieve this policy objective, increased understanding is required about how behaviour settings may be linked to one another to produce a synergetic effect that supports children's higher levels of activity (Cosco, 2006). This approach assumes that setting diversity, materials, and spatial arrangement or *layout* (a key attribute of affordance) may be combined (by design) to increase attraction for children, hold their day-to-day interest, and thereby encourage moderate to vigorous activity as they develop varied motor skills and capabilities.

For example, children were observed using a combination of play equipment, wheeled toy path, and vegetation that enticed them to collect leaves and twigs in carts, pull them around the path, move the cart's load onto the play equipment platform and make it fall down the slide only to collect it and start the cycle again. Behaviour mapping is able to capture such temporal sequences by coding both fixed features (platform and slide) and loose parts (leaves and twigs), which in combination can animate children's ranging behaviour across several settings.

Analysis of the childcare data currently underway indicates a significant relationship between behaviour setting adjacency (the number of settings touching the target setting) and level of physical activity. This further reinforces the relevance of the potential synergetic effect in children's environments, and suggests that compact layouts affording more choice of activity at any given moment are likely to produce higher levels of physical activity than dispersed layouts. This is not to say that the layout of children's environments should always be compact. Domains of child development other than physical activity may be afforded by less compact settings that offer children more breathing space (for sociodramatic play, for example). Behaviour mapping is available to continue to explore such hypotheses.

Concluding discussion

Behaviour mapping is a relatively simple, versatile, objective research method processed with GIS that yields a relational database for performing statistical analyses and the ability to represent environment and behaviour data graphically. Designers may find spatial displays more meaningfully connected to their visual thinking styles than conventional data tables and charts, and therefore be motivated to apply environment–behaviour knowledge in evidence-based design.

The availability of small PDA devices and simple coding software with pull-down menus has opened up new possibilities for rapid data gathering using direct entry in the field. By using paperless digital ‘coding sheets’ for field data entry, data management can be more streamlined and less subject to error, therefore reducing the time devoted to data cleaning.

Behaviour mapping has been applied at many built environment scales ranging across early childhood spaces, school grounds, parks, neighbourhoods and urban downtown areas. The method is highly adaptable, allowing variables and codes to be tailored to different physical contexts, study objectives, research designs, and research investment including pilot studies, pre/post interventions, post-occupancy evaluations of individual sites (Cooper Marcus and Francis, 1998), and larger-scale, multi-site studies to identify significant variables (such as the study of preschool outdoor environments reported here).

In any particular study, variables of interest may be added to the database to shed light on specific topics or issues such as the optimal size of behaviour settings, significant environmental characteristics for higher levels of activity, improved understanding of types of social interaction and environmental characteristics, empirical testing of safety standards, and the cost-effectiveness of different types of design or programmatic interventions.

The implications of refining and continuing to apply behaviour mapping in healthy community design holds promise for guiding best practice in the creation of high-quality environments for children, their families, and indeed all types of users of outdoor space. New data will continue to emerge that identify behaviour settings, objects, layouts and events that afford higher levels of health-promoting behaviour in children and adults. Over the course of time, such findings will help form the basis of healthy community design policy at levels of detail relevant to built environment regulations through which policy is implemented. Our hope is that design professionals will see this method as an aid for developing evidence-based policies that frame design problems as health interventions and allow designers to apply their creative skills to search for solutions that maximize the public health value of design outcomes.

Acknowledgements

Assistance with data gathering – Robert Massengale, Shirley Varela, and the I-PARK student team; data gathering and analysis – Evrim Demir, Orçun Kepez, Gary Kueber, Zaki Islam. Data analysis – Tom Danninger.

Notes

1 The authoritative source of his broad definition is the US National Institute of Environmental Health Sciences (NIEHS), published it in 2004 in a request for proposals for a research programme on obesity and the built environment. http://grants.nih.gov/grants/guide/rfa-files/rfa-es-04-003.html
2 This approach to conceptualizing the built environment is based on a model developed by Kevin Lynch, with whom the first author studied. Lynch conceived the urban environment as *adapted space* and *flow system*. He was the first urban designer to make the important, yet simple, theoretical distinction between space and human use. For further information, see Banerjee and Southworth (1990: 355).
3 Here we refer to formulations and distinctions of multidisciplinary, interdisciplinary and transdisciplinary articulated by Jantsch (1975) and Nicolescu (2008).
4 The goal of Investigating Parks for Active Recreation of Kids (I-PARK) was to explore relationships between neighbourhood environment, park physical environment and levels of physical activity in discrete age categories of children and youth. The N.C. State University research team in addition to the authors, included Perver Baran, Ph.D.; Jason Bocarro, Ph.D.; Myron Floyd, Ph.D.; Orçun Kepez, Ph.D. and William Smith, Ph.D. To better understand active neighbourhood environments for children and families, potential links were investigated between walkable characteristics of neighbourhoods such as connectivity, park location and park use; and park settings such as trails, bike paths, athletic facilities and playgrounds. The study was supported by the Robert Wood Johnson Foundation through Active Living Research, San Diego State University.
5 The goal of My Place by the Bay: Prepared Environments for Early Science Learning, was to investigate relationships between the design attributes of early childhood museum outdoor settings and early science learning behaviours of young children. The field research was conducted at the Bay Area Discovery Museum (BADM), Sausalito, California, outdoor exhibit areas, which opened between 2003 and 2004. The study was sponsored by the US National Science Foundation as part of a construction and research project developed by Catherine Eberbach.
6 The goal of Measuring Physical Activity Affordances in Preschool Outdoor Environments was to identify discriminatory environmental items in preschool play areas to be included in a pilot tool to rate their potential to produce physical activity when three to five-year-old children are exposed to them. In addition to the authors, the research team included Howard Frumkin, Ph.D.; Orçun Kepez, Ph.D.; Karen Mumford, Ph.D.; Stewart Trost, Ph.D. and co-PI Dianne Ward, Ph.D. The study characterized behaviour settings, their components and attributes in terms of the physical activity patterns in preschool outdoor areas in childcare centres. The study was supported by the US National Institute of Environmental Health Sciences.
7 In an effort to both reduce the number variables and to define variables more closely tied to the needs of designers, co-author Moore and colleagues have developed a new park audit tool,

Children and Families Park Audit Tool (CAFPAT). Although published results are not yet available, preliminary analyses are promising.

8 A pilot project was conducted at the North Carolina Botanical Garden in July 2004. Four family groups were observed visiting the Herb Garden. This particular garden had been enhanced to accommodate child and family interests. Play components included fairy figures placed among planters, a fairy playhouse, fairy mailbox, digging pit, signs with activity prompts, and a blueberry house. During the pilot session, children exhibited curiosity and engagement although some parents appeared to rush them through the settings. Dramatic play was commonly observed. Even when children were asked to leave the setting, they continued to observe and make comments about aspects of the environment and to ask questions. From the open-ended observations, a list of behaviours of children and caregivers was compiled and used as a source for drafting the BADM observation protocol.

Appendix A: Early science learning codes

With the purpose of assessing the impact of the designed environment on science learning, a number of types of behaviours were defined to be observed and coded in My Place by the Bay Tot Spot and Lookout Cove (reported in this chapter). Children learn about the environment and its properties by interacting with it. They explore and manipulate materials and create assumptions about phenomena (National Research Council, 1996). Learning science implies also the ability to verbalize questions and to interact with others (children or adults) formalizing explanations or hypothesis. The possibility of being engaged allows children to learn from their own actions (Dyasi, 1999).

The following behaviours were selected to code for early science learning; engagement (Dyasi, 1999; Chermayeff, Blandford and Losos, 2001), child social interactions (Worth, 1999), interactions with the environment (Bowman et al., 2000; National Research Council, Science Education Standards, 1996), child expression of understanding/discovery (Bowman et al., 2000; National Research Council, 1996), and adult intervention (Bowman et al., 2000; Crowley et al., 2001).

The identified behaviours that support science learning follow a gradient of specificity from non-differentiated to intentional actions:

1 No science readiness behaviour.
2 Playing.
3 Observing.
4 Exploring.
5 Experimenting.
6 Cause and effect.

Although play is present in all of them (Wellington, 1990), for the purpose of the behaviour coding by setting, play was coded when more specific behaviours could not be identified. Code descriptors are listed below.

No science readiness behaviour

'No science readiness behaviour' was coded when the child was not engaged in any activity or type of play, For example, the child was sitting on the lap of the caregiver, sleeping or eating.

Playing

'Playing' was coded when the child was performing pretend play or engaged in an activity that could not be considered as any other science learning behaviour. For example, at the moment of the scan the child was engaged and carrying a pail but the intentions of their movements were not clear.

Observing

'Observing' was coded when the child was observing, examining closely but not engaged in in-depth inquiry. For example, the child was arriving at the setting but not yet performing a defined activity, or the child stopped their actions to observe other children.

Exploring

'Exploring' was coded when the child was making an explicit inquiry about something. For example, the child was minutely examining a play object or natural material (gravel, an insect or a leaf).

Experimenting

'Experimenting' was coded when the child was making an intentional inquiry, when it was clear that there was a plan being carried out. For example, the child manipulated and combined objects in a functional manner to create piles or series with loose materials.

Cause and effect

'Cause and effect' was coded when the child was making a deliberate action to produce a certain response: for example, hitting a bell or damming water.

Figure 2.24
My Place by the Bay (Bay Area Discovery Museum) code structure and descriptions.

Domain	No	Codes	Description of Codes
Science Learning Behaviour	1	Cause-effect	Making a deliberate action to produce a certain response to the action
	2	Experimenting	Making an intentional inquiry where there is a plan carried out
	3	Exploring	Making an explicit inquiry into something
	4	Observing	Watching closely
	5	Playing	Engaged in an activity that cannot be identified as any of the other science learning behaviours
	6	None	Not engaged in any activity or type of play
Engagement	1	Engaged	Sustained attention. Full concentration on the activity
	2	On looking	Moving between unrelated activities with scattered attention
	3	Disengaged	Not engaged with activity
	4	None	None of the three codes above describe the situation
Peer Interaction	1	Cooperative	Working together with other children during the activity
	2	Altercation	Signs of conflict, disagreement, or argument with peers
	3	None	None of the two codes above describe the situation
Environmental Interaction	1	Fixed manufactured	Manufactured (man-made) elements that are fixed and cannot change location (e.g. boat)
	2	Fixed natural	Natural elements that cannot be moved (e.g. tree)
	3	Loose manufactured	Manufactured (man-made) elements that are not fixed and can change location (e.g. toys)
	4	Loose natural	Natural elements that are not fixed and can change location (e.g. leaf, sand)
	5	None	Child is not in contact with any material or equipment
Child's Communication	1	No expression	When none of the conditions described below are present
	2	Converses	Any verbal communication by the child outside the activities that may initiate science learning behaviour
	3	Explains	Child's explanation of his/her activity to others
	4	Listens	Child pays attention to explanations, answers, and conversations
	5	Questions	Child's verbal inquiry
	6	Demonstrates	Child's demonstration of his/her discoveries
	7	Repeats	Child repeats words or phrases that are related to science learning experience
Adult Intervention	1	None	When none of the conditions described below are present
	2	Positive	Intervention that results in child's engagement in any of science learning behaviours
	3	Neutral	Intervention that is independent from initiating any science learning behaviour
	4	Observant	Keeping an eye on child's activities without interacting
	5	Negative	Intervention that stops any child behaviour

References

Aboelata, M. J., Mikkelsen, L., Cohen, L., Fernández, S., Silver, M., Fujie Parks, L. et al. (2004). *The Built Environment and Health: 11 Profiles of Neighborhood Transformation*. Oakland, Calif.: Prevention Institute.

American Academy of Pediatrics (Committee on Environmental Health) (2009) 'The built environment: designing communities to promote physical activity in children', *Pediatrics* 123 (6): 1591–8.

American Society of Landscape Architects (ASLA) (nd) General information, ASLA, Washington, D.C., available at: <www.asla.org> (accessed 1 December 2009].

Andersen, L., Harro, M., Sardinha, L., Froberg, K., Elelund, U., Brage, S. and Anderssen, S. (2006) 'Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study)', *The Lancet*, 368: 299–304.

Association of Children's Museums (2008) *Kids Dig Dirt!* Green Paper, Washington, D.C.: Association of Children's Museums.

Banerjee, T. and Southworth, M. (eds) (1990) *City Sense and City Design: The Writings and Projects of Kevin Lynch*, Cambridge, Mass.: MIT Press.

Barker, R. (1976) 'On the nature of the environment', in H. Proshansky, W. Ittelson, and L. Rivlin (eds), *Environmental Psychology: People and their Physical Settings*, New York: Holt, Rinehart & Winston.

Berto, R. (2005) 'Exposure to restorative environments helps restore attentional capacity', *Journal of Environmental Psychology*, 25: 249–59.

Björklid, P. (1982) 'Children's outdoor environment. A study of children's outdoor activities in two housing estates from the perspective of environmental and developmental psychology', *Studies in Education and Psychology,* 11 (Stockholm Institute of Education, Department of Educational Research).

Bowman, B., Donovan, M. and Burns, S. (eds) (2000) *Eager to Learn: Educating our Preschoolers*, Washington, D.C.: National Academy Press.

Cardon, G., Van Cauwenberghe, E., Labarque, V., Haerens, L. and De Bourdeaudhuij, I. (2008) The contribution of preschool playground factors in explaining children's physical activity during recess. *International Journal of Behavioral Nutrition and Physical Activity*; 26 February: 5–11.

Centers for Disease Control and Prevention, National Center for Environmental Health (2008) 'Healthy community design, fact sheet', available at: <http://www.cdc.gov/healthyplaces/docs/Healthy%20Community%20Design.pdf> (accessed 31 July 2009).

Centers for Disease Control and Prevention, National Center for Environmental Health (nd) 'Children's health and the built environment', available at: <http://www.cdc.gov/healthyplaces/healthtopics/children.htm> (accessed 31 July 2009).

Chawla, L. (ed.) (2002) *Growing Up in an Urbanising World*, London: Earthscan.

Chermayeff, J, Blandford, R. and Losos, C. (2001) 'Working at play: informal science education on museum playgrounds', *Curator*, 44 (1): 47–60.

Cooper Marcus, C. and Francis, C. (1998) *People Places: Design Guidelines for Urban Open Space*, 2nd edn, New York: Wiley ('Post-Occupancy Evaluation,' Chapter 8: 346–56).

Cornell, E. H., Hadley, D. C., Sterling, T. M., Chan, M. A. and Boechler, P. (2001) 'Adventure as a stimulus for cognitive development', *Journal of Environmental Psychology,* 21: 219–31.

Cosco, N. (2006) *Motivation to Move: Physical Activity Affordances in Preschool Play Areas*, unpublished doctoral dissertation, Edinburgh College of Art, Heriot-Watt University, Edinburgh.

Cosco, N. (2007) 'Developing evidence-based design: environmental interventions for healthy development of young children in the outdoors', in C. Ward Thompson and P. Travlou (eds), *Open Space People Space,* 125–35, London: Taylor & Francis.

Crowley, K., Callanan, M., Jipson, J., Galco, J., Topping, K. and Shrager, J. (2001) 'Shared scientific thinking in everyday parent–child activity', *Science Education*, 85(6): 712–32.

Dowda, M., Brown, W. H., McIver, K. L., Pfeiffer, K. A., O'Neill, J., Addy, C. L., et al. (2009) 'Policies and characteristics of the preschool environment and physical activity of young children', *Pediatrics*, 123: 261–6.

Dowda, M., Pate, R., Trost, S., Almeida, M. and Sirard, J. (2004) 'Influences of preschool policies and practices on children's physical activity', *Journal of Community Health*, 29 (3): 183–96.

Driskell, D. (2002) *Creating Better Cities with Children and Youth: A Manual for Participation*, London: Earthscan.

DuRant, R. H., Baranowski, T., Puhl, J., Rhodes, T., Davis, H., Greaves, K. A., and Thompson, W. O. (1993) 'Evaluation of the Children's Activity Rating Scale (CARS) in young children', *Medicine and Science in Sports and Exercise*, 25: 1415–21.

Dyasi, H. (1999) 'What children gain by learning through inquiry', *Foundations,* Arlington, Va.: National Science Foundation.

Faber Taylor, A. and Kuo, F. E. (2008) 'Children with attention deficits concentrate better after walk in the park', *Journal of Attention Disorders*, available at: <http://jad.sagepub.com/> (accessed 20 December 2008).

Frank, L., Engelke, P. and Schmid, T. (2003) *Health and Community Design: The Impact of the Built Environment on Physical Activity*, Washington, D.C.: Island Press.

Francis, M. (1984) 'Mapping downtown activity,' *Journal of Architecture and Planning Research*, 1 (1): 21–35.

Frost, J., Wortham S. and Reifel, S. (2005). *Play and Child Development*. Upper Saddle River, N.J.: Prentice Hall.

Frumkin, H., Frank, L. and Jackson, R. (2004) *Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities*, Washington, D.C.: Island Press.

Gibson, E. and Pick, A. (2000) *An Ecological Approach to Perceptual Learning and Development*, New York: Oxford University Press.

Gibson, J. (1979) *The Ecological Approach to Visual Perception*, Boston, Mass.: Houghton-Mifflin.

Harms, T., Cryer, D. and Clifford, R. (1990) *Infant/Toddler Environment Rating Scale*, New York: Teachers College Press.

Heft, H. (2001) *Ecological Psychology in Context: James Gibson, Roger Barker, and the legacy of William James's Radical Empiricism*, Mahwah, N.J.: Erlbaum.

Ittleson, W., Rivlin, L. and Proshansky, H. (1976) 'Use of behavior maps in environmental psychology', in H. Proshansky, W. Ittleson and L. Rivlin (eds), *Environmental Psychology: People and their Physical Settings*, 2nd edn, New York: Holt Rinehart & Winston.

Jackson, R. and Kochtitzky, C. (2001) 'Creating a healthy environment: the impact of the built environment on public health', Sprawl Watch Clearinghouse Monograph Series, available at: <http://www.sprawlwatch.org/health.pdf> (accessed 3 July 2009).

Jantsch, E. (1975) *Design for Evolution: Self-Organization and Planning in the Life of Human Systems*, New York: George Braziller.

Longley, P., Goodchild, M., Maguire, D. and Rhind, D. (2005) *Geographic Information Systems and Science*, London: Wiley.

Louv, R. (2005) *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder*, Chapel Hill, N.C.: Algonquin.

Lynch, K. (1977) *Growing Up in Cities*, Cambridge, Mass.: MIT Press.

Lynch, K. (1981) *Good City Form*, Cambridge, Mass.: MIT Press.

Maller, C., Townsend, M., Pryor, A., Brown, P. and St. Leger, L. (2006) 'Healthy nature healthy people: 'Contact with nature' as an upstream promotion intervention for populations', *Health Promotion International*, 21 (1): 45–54.

McKenzie, T. and Cohen, D. (2006) 'SOPARC (System for Observing Play and Recreation in Communities)' *Description and Procedures Manual*, Department of Exercise and Nutritional Sciences, San Diego State University, San Diego.

McKenzie, T. L., Cohen, D., Sehgal, A., Williamson, S. and Golinelli, D. (2006) 'System for Observing Play And Recreation in Communities – SOPARC. Reliability and feasibility measures', *Journal of Physical Activity and Health*, 1: 203–17.

Mitchell, R. and Popham, F. (2008) 'Effect of exposure to natural environment on health inequalities: an observational population study', *The Lancet,* 372(9650): 1655–60.

Moore, R. (1974) 'Patterns of activity in time and space: the ecology of a neighborhood playground', in D. Canter and L. Lee (eds), *Psychology and the Built Environment,* 118–31, London: Architectural Press.

Moore, R. (1986) *Childhood's Domain: Play and Place in Child Development*, London: Croom Helm.

Moore, R. and Cooper Marcus, C. (2008) 'Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood', in S. Kellert, J. Heerwagen and M. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, Hoboken, N.J.: Wiley.

Moore, R. and Cosco, N. (2007) 'What makes a park inclusive and universally designed? A multi-method approach', in C. Ward Thompson and P. Travlou (eds), *Open Space People Space,* 85–110, London: Taylor & Francis.

Moore, R., Cosco, N., Kepez, O. and Demir, E. (2008) *My Place by the Bay: Prepared Environments for Early Science Learning*, Bay Area Discovery Museum (BADM), Sausalito, California. Final report to the National Science Foundation, project #0125740.

Moore, R. and Wong, H. (1997) *Natural Learning: Creating Environments for Rediscovering Nature's Way of Teaching*. Berkeley, Calif.: MIG Communications.

Moore, R. and Young, D. (1978) 'Childhood outdoors: towards a social ecology of the landscape', in I. Altman and J. Wohlwill (eds), *Human Behavior and Environment, vol. 3: Children and the Environment,* 83–130, New York: Plenum Press.

National Institute of Environmental Health Sciences (NIEHS), http://grants.nih.gov/grants/guide/rfa-files/rfa-es-04-003.html (accessed 2 December 2009).

National Research Council (1996) 'National Science Education Standards', *National Research Council*, available at: <http://books.nap.edu/openbook.php?record_id=4962&page=R2> (accessed 4 May 2009).

Nicolescu, B. (ed.) (2008) *Transdisciplinarity – Theory and Practice*, Cresskill, N.J.: Hampton Press.

Olmsted, F. L., Jr. (1911) 'The city beautiful', *The Builder*, 101, July 7, 1911: 15–17, formatted as a web document by John W. Reps, available at: <http://www.library.cornell.edu/Reps/DOCS/olmst_11.htm> (accessed 31 May 2009).

Ogden, C., Carroll, M. and Flegal, K. (2008) 'High body mass index for age among US children and adolescents, 2003–2006' *Journal of the American Medical Association*, 299 (20): 2401–05.

Puhl, J., Greaves, K., Hoyt, M. and Baranowski, T. (1990) 'Children's Activity Rating Scale (CARS): description and calibration', *Research Quarterly for Exercise and Sport,* 61 (1): 26–36.

Rajakaruna, C. (ed.). (2006) *2006 Membership Directory*, Washington, D.C.: Association of Children's Museums.

Reps, J. (nd) 'Writing about Frederick Law Olmsted, Jr', available at: <http://www.library.cornell.edu/Reps/DOCS/olmst_11.htm> (accessed 31 May 2009).

Roemmich, J. N., Epstein, L. H., Raja, S., Yin, L., Robinson, J. and Winiewicz, D. (2006) 'Association of access to parks and recreational facilities with the physical activity of young children', *Preventive Medicine*, 43: 437-41.

Rose, K. A., Morgan, I. G., Ip, J., Kifley, A., Huynh, S. and Smith, W. (2008) 'Outdoor activity reduces the prevalence of myopia in children', *Ophthalmology*, 115 (8): 1279–85.

Saelens, B. E., Frank, L. D., Auffrey, C., Whitaker, R. C., Burdette, H. L. and Colabianchi, N. (2006) 'Measuring physical environments of parks and playgrounds: EAPRS instrument development and inter-rater reliability', *Journal of Physical Activity and Health*, 3 (1): 190–207.

Sallis, J., Nader, P. R., Broyles, S. L., Berry, C. C., Elder, J. P., McKenzie, T. L. and Nelson, J. A. (1993) 'Correlates of physical activity at home in Mexican–American and Anglo-American preschool children', *Health Psychology*, 12 (5): 390-98.

Staempfli, M. B. (2009) 'Reintroducing adventure into children's outdoor play environments', *Environment and Behavior,* 41 (2): 268–80.

Van Andel, J. (1984-1985) 'Effects on children's behavior of physical changes in a Leiden neighborhood', *Children's Environments Quarterly,* 1 (4): 46–54.

Watanabe, M., Nakamura, K., Fukuda, Y. and Takano, T. (2006) 'Association of parental and children behaviors with the health status of preschool children', *Preventive Medicine*, 42: 297–300.

Webster's Third International Dictionary (1981), Springfield, MA.: Merriam-Webster, Inc.

Wellington, J. (1990) 'Formal and informal learning science: the role of interactive science centres', *Physical Education,* 25: 247–52.

Wells, N. M. and Evans, G. W. (2003) 'Nearby nature: a buffer of life stress among rural children', *Environment and Behavior,* 35: 311-30.

Williams, C. H. (2007) 'The built environment and physical activity: what is the relationship?' New Jersey: Robert Wood Johnson Foundation., available at: <http://www.rwjf.org/pr/product.jsp?id=20112> (accessed 21 December 2008).

Worth, K. (2000) 'The power of children's thinking', *Foundations,* 2: 25–32, available at: <http://www.nsf.gov/pubs/2000/nsf99148/> (accessed 31 July 2009).

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Despite our increasing longevity, modern lifestyles have become associated with a number of health problems. Our work, leisure and home activities are becoming more sedentary, our eating habits encourage obesity and our lack of physical exercise, combined with stress from urban living, result in increasing levels of cardiovascular diseases, diabetes and mental illness. With such pressures on public health, we need to understand better how interaction with the outdoor environment might impact or improve health.

This book addresses the growing interest in salutogenic environments – those that support healthy lifestyles and promote well-being – and the particular need for appropriate methods to research the links between landscape and health. Drawing on multidisciplinary approaches from environmental psychology, health sciences, urban design, landscape architecture and horticulture, it goes beyond the conventional theories and methods to explore what new possibilities might offer.

The authors are international leaders in their fields, brought together by the directors of the OPENspace research centre, Edinburgh. Their unique contribution is a resource to help the research, policy and practice community identify key issues, and commission, undertake and apply research in landscape and health. It also contributes to framing research questions and developing appropriate methods to address the urgent needs for a healthy society.

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