A Sociotechnical Systems Analysis Approach to Playground Design

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Abstract. This paper describes an application of Work Domain Analysis (WDA) to support urban planning decisions regarding play. The study sought to determine whether WDA offers greater insight to the design requirements of playgrounds. A new understanding of the important interdependencies of objects and functional purposes of playgrounds is revealed. Constraints, complexity, and emergent behaviours are not necessarily concepts associated with urban design challenges; however this paper evidences that they have much to offer if considered within a sociotechnical systems framework.

Keywords. Playgrounds; Systems analysis; urban design; human factors.

1. Introduction

Urban planning and design is a burgeoning application area for ergonomics (Stevens, 2016; Stevens and Salmon, 2015). This is due, in part to the ability of ergonomics methods to cope with the design and evaluation of complex sociotechnical systems. The requirements of urban play environments are complex and multi-faceted (Parsons, 2011). There is a range of demands and needs for their successful design and implementation from an increasing array of stakeholder perspectives. For example, there are increasing concerns for child safety in the community; rising infrastructure and maintenance costs; increasing urban density; and budgetary constraints (MCC, 2008; Burke, 2013). Further, from a design perspective, there is the necessary understanding of the nature and purpose of play, and the psychology behind the development of engaging and purposive environments for children (Luchs and Fikus, 2013).

Historically it has proved difficult with urban planning methods to capture all of the issues required for successful urban play environments. The very nature of the various expectations placed on these spaces has resulted in much of the research and policy dealing with issues independently (Burke, 2013; Little and Eager, 2010). It is important then to explore what form of guidance would assist in the establishment of successful play environments, as ‘future planning, design and management might depend on descriptions of well-functioning examples’ (Jansson, 2010, 64). With limited research into playgrounds in urban settings, outside of the school context (Burke, 2013, 85), new approaches are needed to evaluate their current and future form and function. Ergonomics, and specifically sociotechnical systems analysis and design methods, offers an alternative approach that apparently can cope with this complexity (Stevens, 2016).

This paper describes a study that explores the efficacy of applying ergonomics approaches in urban design - largely a new paradigm (Stevens and Salmon, 2014; 2015). Specifically the study involved applying the first phase of Cognitive Work Analysis (Vincete, 1999), Work Domain Analysis (WDA), to explore the complex range of interactions and functions for urban playgrounds. The aim was to support community, industry and government to better understand the requirements for more stimulating, durable, and effective play spaces that are well utilised by the public.

2. Methods

The first phase of the study involved establishing an ‘ideal’ WDA of a playground environment within the setting of a master planned residential neighbourhood. The aim was to use WDA to specify the optimal design of the playground environment. The WDA was constructed based on data derived from: document analysis; observations; and semi-structured interviews, alongside important primary and secondary contributions from the literature. All are acknowledged sources for constructing a WDA model, and have been successfully applied in past research (Jenkins, 2012, 337; Naikar, Hopcroft and Moylan, 2005).

2.1 Document Analysis

Documents appropriate for inclusion in a WDA are; engineering and technical manuals, standards, commercial brochures, policy documents, and training manuals (Rasmussen, 1986, cited in Naikar, Hopcroft and Moylan, 2005, 70). As such, the focus during the document analysis phase was on ‘practice-based’ sources with key words relating to each level of the hierarchy (Table 1).

Table 1. Key word searches to populate the WDA model

WDA hierarchy	**Key words**
Functional Purpose	-purpose, design, objectives, rationale
Values and Priority Measures	-desired outcomes, laws and regulations, standards, criteria
Purpose-Related Functions	-function, roles and responsibilities, maintenance
Object-Related Processes	-components, use, limitations
Physical Objects	-appearance, facilities, layout, equipment

2.2 Review of Literature

The first stage of the literature review focused on the narrative and context of the research; the second stage was a systematic, ‘critical evaluation of existing research’ (Hart, 2001, 2). It involved searches within Taylor and Francis and Proquest databases utilising key words identified from the narrative review: *playground/s; playground design; urban play; and play theory*. Searching in this way identified key peer reviewed articles which were then explored utilising the key word guide for the WDA hierarchy.

2.3 Observation

Naikar, Hopcroft and Moylan (2005, 66) highlight that when performing a WDA, the researcher must establish some level of familiarity with the domain. As such, observations of three different urban playground environments were undertaken on the Sunshine Coast, Australia. The observations served to help in identifying physical objects for inclusion in the WDA abstraction hierarchy (AH). Any specific behaviours observed were also noted, with photography utilised to back up written observations and help categorise the domain.

2.4 Interviews

Semi-structured interviews were chosen to allow greater flexibility in the questioning and research enquiry (Anderson and Kanuka, 2003). Within WDA methodology, it is suggested to include a variety of domain experts who can shed light on the reasons for decisions and functionality (Naikar, Hopcroft and Moylan, 2005). Interviews were conducted with local and state government agencies, urban designers, maintenance personnel, and private developers. Sequenced questions generated around the WDA hierarchy formed the basis of the interviews. For example: *what do the experts recognise as the overall purpose of domain*; *how would they measure the achievement of purpose*; *the kinds of activities anticipated*; *the physical features*; and *the physical objects of this ideal urban setting*.

2.5 Case study application

The draft WDA AHs were constructed using the CWA software tool (Jenkins et al, 2007) following the inclusion of the detailed data from the interviews with domain experts. These models were then cooperatively reviewed by an urban planning expert and a human factors expert, with key aspects discussed until consensus for the final inclusion was achieved. The resultant final draft WDA AHs were then applied to case study sites (different to the observation playgrounds) for an evaluation of their alignment to the ideal system.

3. Results

The AH detailed here is a generalised representation of an 'ideal' playground environment within an urban residential context (Figure 2). It is worth noting that the lower three levels of the AH have been summarised to enable inclusion in this paper.

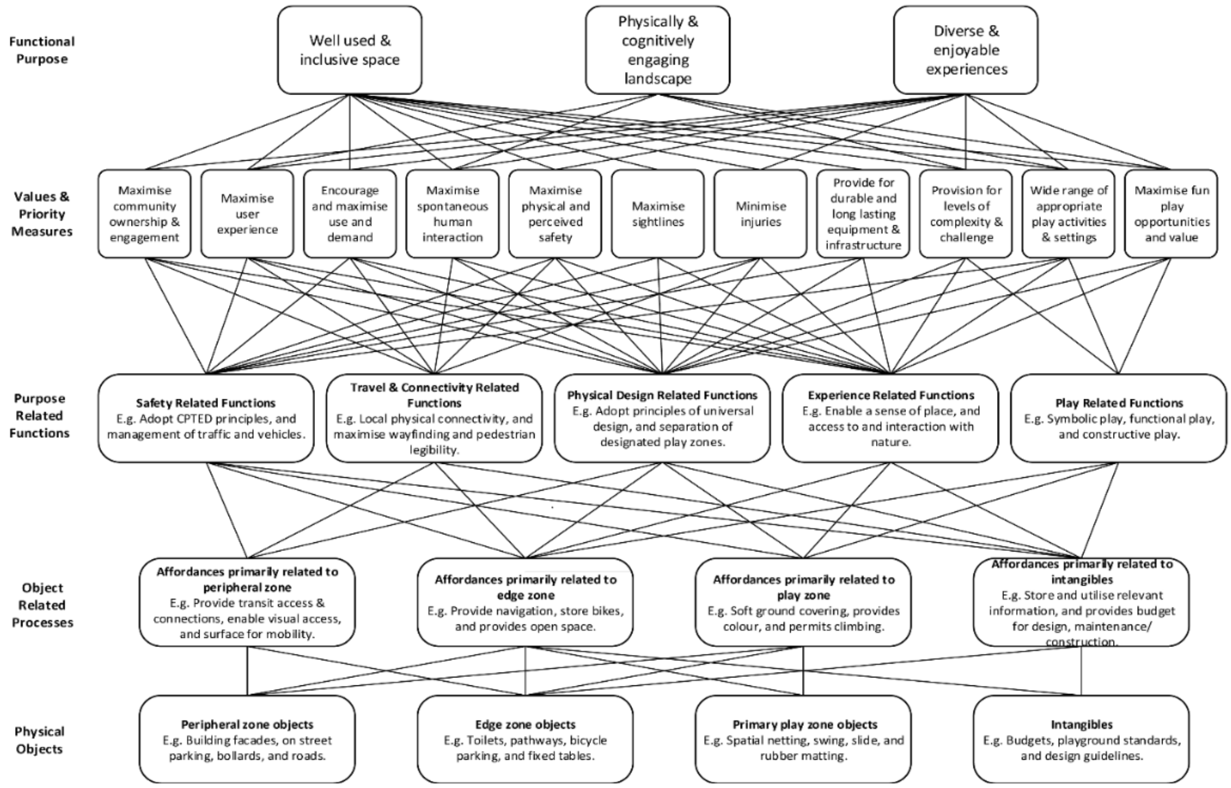

Figure 2. Summarised WDA framework for the 'ideal' Playground environment

3.1 Functional Purpose

The top level of the AH displays the reasons that a playground domain is designed and constructed - its reason for existence. The key functional purposes of an ideal playground environment were determined to be a 'well used and inclusive space', a 'physically and cognitively engaging landscape', and 'diverse and enjoyable experiences'. Each of these focuses on different aspects of the play environment, highlighting the subjective nature of the domain. While it may be tempting to include 'play', the systems process suggests that types of 'play' are better represented as purpose related functions of the above functional purposes. Relationships and interdependencies begin to emerge as the functional purposes are shown in relation to the 'Values and Priority Measures'.

3.2 Values and priority measures

The second tier of the AH is in effect criteria to measure the progress towards functional goals. A total of 11 measures were identified (Figure 3), ranging from 'encourage and maximise use and demand', to 'provision for levels of complexity and challenge'. While some measures may be easily verifiable such as ‘minimise injuries’, others are more subjective in nature i.e. ‘maximising the user experience’.

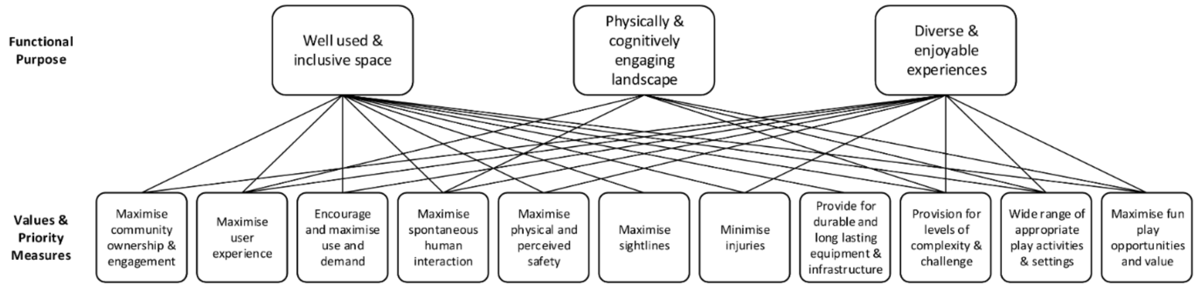

Figure 3. Top 2 tiers of the WDA Abstraction Hierarchy

As shown in figure 3, a ‘well-used and inclusive space’ connects to all 11 measures, ‘physically and cognitively engaging landscape’ to five, and ‘diverse and enjoyable experiences’ to nine measures. When analysing the relationships between nodes, it is clear that some measures are central to the success of the domain. A ‘wide range of appropriate play activities and settings’ for example, not only connects to all three functional purposes, but connects to a total of four of the five key purpose related function groups below it highlighting its importance in the overall framework.

An interesting research observation is that within the set of values and priority measures identified, there may in fact be conflict. An example is that ‘minimising injuries’ and ‘maximise physical and perceived safety’ may be in conflict with ‘provision for levels of complexity and challenge’ and ‘maximise fun play opportunities and value’. Those nodes also have the potential to conflict with other nodes on the same level, resulting in a perceived lack of challenge and therefore a lack of long term and consistent patronage. The identification of this potential for conflict is a significant advantage afforded by the development of the WDA. It allows for stakeholders to consider the opportunities and limitations of a design, and also identify nodes that share complimentary values or functions.

3.3 Purpose related functions

A total of 33 purpose-related functions were identified in the WDA, and have been grouped here into ‘play related functions’, ‘experience related functions’, ‘physical design related functions’, ‘safety related functions’, and ‘travel and connectivity related functions’.

Through the examination of one node in particular a ‘safe and secure environment’, we may trace the journey up and down the AH and build a story by examining the questions of why, what, and how. If ‘safe and secure environment’ is the what, then ‘encourage and maximise use and demand’ may be why, and ‘soft ground covering’ may be the how to achieve it. Equally, if the affordance ‘soft ground covering’ is the what, then ‘safe and secure environment’ is the why, and ‘sand’, ‘bark’, and ‘rubber matting’ is the how. This method may be achieved by isolating all nodes including types of play, and experience related functions (Figure 3).

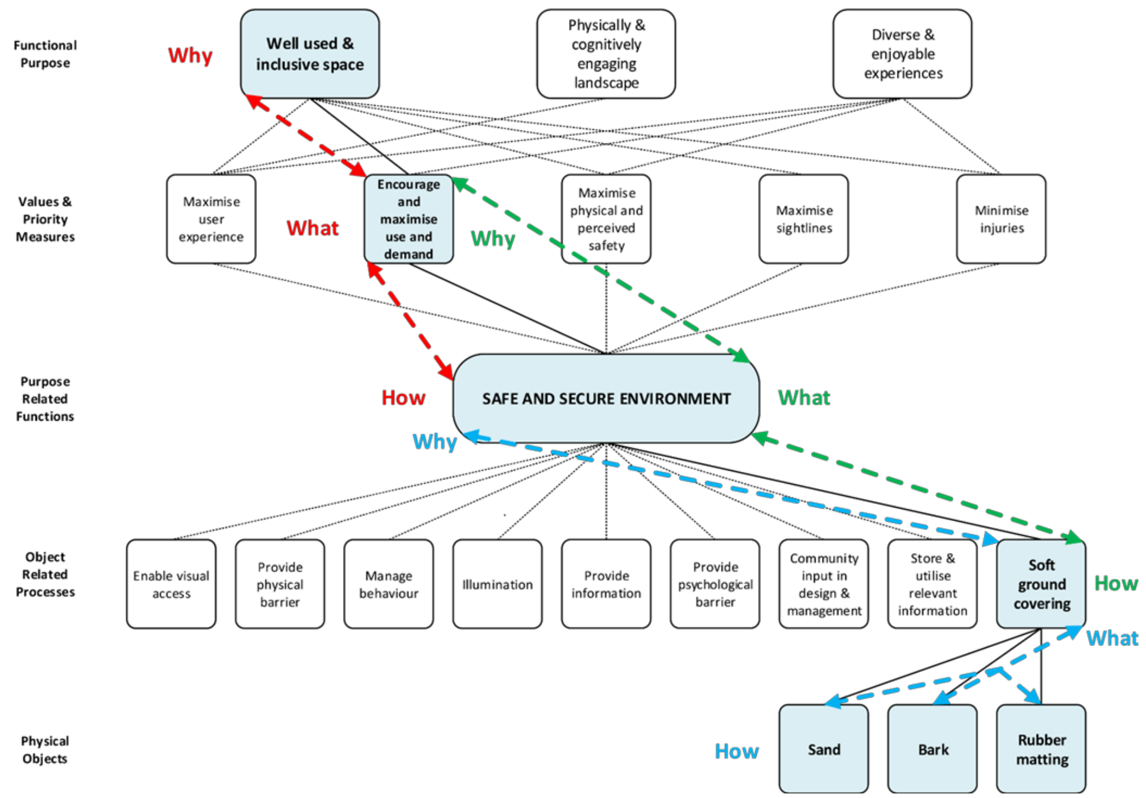

Figure 3 the relationships of a safe and secure environment

3.4 Object-related processes

Object-related processes refer to the role that each object performs or the affordances that they provide, and relate to the ability to enable key system functions. For presentation, the 52 affordances were summarised as close as possible into four groups relating directly to physical objects. As shown in Figure 2, affordances were not exclusive to any one zone. Those relating to 'primary play zone objects' were also found in the 'edge zone' and 'peripheral zone'.

It is evident through the AH that object related processes are often afforded by multiple objects, and connected to multiple purpose-related functions. For example the 'permits contact with water' node is the 'what' in the means-ends relationship. By moving up a level we answer the why; to 'provide for a variety of experiences', to 'provide for free play', 'provide for constructive play', and to 'provide for five sensory experiences'. Then by moving down to the bottom tier we see the physical objects that are provided for the affordance to occur, the how. In this example, to 'permit contact with water' a 'tap', a 'drinking fountain', and a 'water play element' may be provided.

3.5 Physical Objects

The bottom tier of the AH consists of the base objects that make up the 'ideal' playground domain from the collated data. The 90 physical objects identified were compiled into four distinct zones relating to the areas of the domain in which they were observed:

1. Peripheral zone (13) – e.g. building facades and on street parking.
2. Edge zone (38) – e.g. toilets and fixed tables.
3. Primary play zone (30) – e.g. spatial netting and rubber matting.
4. Intangibles (9) – e.g. budgets and design guidelines.

These zones highlight the importance of analysing a playground environment in its entirety, considering not only adjacent built form, but also essential components that may not be physically there such as planning regulations. A physical object may also have more than one affordance. A 'toilet' may provide for a 'sanitation fixture', but it might also double as 'landmark'. 'On street parking' may provide a 'parking space' and also provide for 'transit access and connections' to a playground. Equally it may provide a 'physical barrier' to a busy roadway.

3.6 Playground Case Study Applications

Two case study playgrounds (Brightwater and Peregian Breeze) within urban housing estates on the Sunshine Coast, Australia were selected as they were both recently constructed; are similar in size; and representative of urban developer provided play environments. The AH was used to assess the extent to which the playgrounds achieved the ideal design template. This involved reviewing the playgrounds and identifying which nodes and relationships from the AH were present.

The playground within Brightwater, Kawana had a total of 58 out of 90 objects present, while the Peregian Breeze case study had 45, suggesting that the Brightwater playground is closer to the 'ideal' configuration. While there is much that may be discussed, some specific results and analysis are now provided highlighting some sample objects and utilising the WDA to trace potential impacts.

Within **Brightwater**, the review highlighted that the site is high in public amenity with toilet facilities, and shade provided by 'sheltered structures', 'canopy trees', and a large 'shade sail'. Many objects recorded at the site provided for multiple affordances such as 'water play elements' afforded loose play, contact with water, and a tactile experience; and 'regulation signage' managed behaviour and provided information for users. While some of the missing objects were incidental and safety was relatively well afforded within the primary play zone, other objects such as a 'fence' impacted significantly on safety considering the adjoining roadway. Further a lack of 'on street parking' was evident with no convenient or safe location in which to disembark. While designated parking has been provided for at the site, its affordance has not been fully realised due to the difficulty of access, impacting heavily on the purpose related function 'regional connectivity'.

Within the **Peregian Breeze** case study of the 90 ideal objects, only 44 were observed at the site. While no 'fence' was present, this site cleverly utilises 'garden beds' to provide natural barriers to adjacent roadways. A lack of 'provide public amenity and comfort' related affordances and objects were recorded at the site with no 'toilets' or 'BBQs'. This was accentuated when considering the site is well provided by tables and shelters which were clearly aimed at providing for groups. The shade affordance was also not fully realised with a shade sail present but not providing its purpose related functions 'protection from climate' and 'amenity and comfort' due to poor placement.

Major issues were discovered within the primary play zone, with only 11 of 30 objects recorded, potentially impacting on the value of play within the domain. The lack of a water play element and bark instead of sand diminishes the opportunity for 'objects for loose play', with ramifications higher in the AH to five functions including 'constructive play' and 'provide for five sensory experiences'. Ultimately it would affect the measure 'wide range of appropriate play activities and settings'. Other important affordances of 'constructive play' were also affected by those missing objects, 'tactile surfaces', and 'permits contact with water'.

4. Discussion and Conclusion

The aim of this paper was to present the findings from a study examining the utility of using sociotechnical systems analysis methods to evaluate and ultimately design playgrounds. Evident through the results is that one 'ideal' play environment may not exist due to the various constraints and considerations. However, it is concluded that the application of WDA does support planning decisions by establishing a framework to assist and enable stakeholders to eliminate assumptions about a play space, and see the impacts of their decisions to either include or exclude particular elements. In future evolutions of this work the further phases of CWA will be applied. This will allow clearer identification and assessment of the tasks and strategies associated with the design of a play environment.

This work has demonstrated the applicability and usefulness of applying sociotechnical systems thinking, by way of WDA, in the context of this urban design challenge. It is the authors' opinion that that the integration of sociotechnical systems thinking within urban design provides new opportunities to better understand a range of urban environments and how they could be designed (Stevens, 2016). Constraints, complexity, and emergent behaviours are not necessarily concepts that would be associated with urban design; however, it is clear that they have much to offer when they are. Such an approach allows for an understanding of the interdependencies of intertwined functional purposes of an urban setting. Further, it lets multiple disciplines and stakeholders to recognise their place within the system, and the impacts and influences of their decision-making. It makes sense that a systems approach would allow for greater insights into the development of urban form; and planning practice and research needs new ways to interpret built environments. In closing we recommend further applications of ergonomics methods in the urban planning and design context. Whilst the present study focussed on playgrounds, other application areas could include main street design, school zones, urban laneways, and transit oriented development. Just as ergonomists play a key role in the design of safe and reliable systems such as aviation and process control, they also have a key role to play in the design of usable, safe, and enjoyable urban environments.

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