

## Designing Games for Children with developmental disabilities in Ambient Intelligence Environments



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### ABSTRACT

This paper presents the design process and deployment of interactive games for children within an Ambient Intelligence (Aml) environment. Designing and creating games under the perspective of Ambient Intelligence has the potential to provide enhanced indoor playing experiences to children, as well as maintaining and expanding the applicability of each game as a tool in early intervention services such as preschool and special education. The developed games build on knowledge stemming from the processes and theories used in Occupational Therapy, are capable of monitoring and following the progress of each young player, adapt accordingly and provide important information regarding the abilities and skills of a child and his development over time. The design has been conducted in collaboration with occupational therapists so as to embed aspects of their work and therapeutic procedures.

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## 1. Introduction

Ambient Intelligence (Aml) refers to electronic environments that are sensitive and responsive to the presence of people. According to [1], the Aml paradigm builds upon pervasive computing, ubiquitous computing, profiling, context awareness, and human-centric interaction design. Aml environments offer opportunities that support the learning needs of children and integrate ICT into playing at home and schools in a variety of ways [2]. A large number of ICT products is available to young children that incorporate interactivity as part of a move towards pervasive or ubiquitous computing in which technology blends into the environment and is not necessarily visible (e.g., [3–6]).

Occupational Therapy (OT) is a client-centered health profession concerned with promoting health and well-being through occupation. Early Childhood occupational therapists (OTs) support and promote the development and engagement of infants, toddlers, and preschoolers, and their families or other caregivers, in everyday routines that include play, rest and sleep, activities of daily living, education, and social participation [7,8]. Since play is

one of the areas of human occupation that OTs focuses on, appropriate play activities are widely used in order to evaluate and facilitate children's individual developmental needs [9]. OTs are trained in the science and the art of analyzing an activity, based on a client's needs and interests, and making use of the activity as a highly effective therapeutic tool in a clinical setting.

This paper presents the design of interactive games for children based on OT expertise and practice. The developed games support playing through tangible interaction with physical and virtual objects and aim to monitor, evaluate and enhance child's abilities and skills. By adopting the presented design rationale, such interactive games are able to be tailored at run time to the needs of children whose functional capacity corresponds to ages of 3 to 6 years old by modifying involved activities and playing demands.

The work presented in this paper is part of the Bean framework [10–13], an Aml technological framework aiming to integrate Aml technologies into children's playtime. As a result, children are provided with interactive games that are constantly adapted to their individual and continuously changing characteristics. At the same time, information regarding children's skills and abilities is captured and analyzed according to predefined protocol and can be used for reasoning about whether the child is meeting essential developmental milestones. OTs have been involved throughout the development of the framework, which therefore encodes OT knowledge and expertise and allows OTs to customize and personalize games for children with disability- and non-disability-related needs.

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## 2. Background

### 2.1. Child development

According to [14], human development includes qualitative and quantitative changes, and is a product of intrinsic maturation and learning opportunities provided in the individual's environment. Children follow a similar developmental pattern with one stage leading to the next, even though there are individual differences in the rate and the manner that they follow the pattern. Through play children learn, practice and improve skills, involve in social roles and experience emotions; therefore, play is a significant dimension of early learning [15]. According to Piaget, play stimulates interest, initiative, experimentation, discovery, and imagination of a child in order to enhance his capacity to learn [16]. During play, children construct knowledge by combining their ideas, impressions, and intuitions, experiences and opinions. As children play, they learn to solve problems, to get along with others and to develop the fine and gross motor skills needed to grow and learn. Over time, these competencies are transferred to children's everyday behaviors [17, 18,15].

### 2.2. Developmental disabilities and intervention services

According to the American Psychiatric Glossary [19], *Developmental Disability* (i.e., a delay in development based on what is expected for a given age level or stage of development) refers to disorders originated before age 18, which may be expected to continue indefinitely and constitute a substantial impairment. A developmental delay or disability in early years, affects not only how and what child plays with but most importantly a child's ability to practice, learn and generalize skills and/or concepts through play. Most disabilities often have an impact on more than one area of development, and according to their nature of origin and severity they may affect the development of numerous motor, cognitive, language and communication, social and emotional, skills and behaviors. In more severe or profound situations (e.g. cerebral palsy, autism, mental retardation) children often need to be taught specific play skills before they can begin to learn through play.

Children experiencing some kind of developmental disorder are likely to need childhood intervention services that promotes their age-appropriate growth and development and support families during the critical childhood years. In this context, early childhood interventions may include special education, therapy, counseling, service planning and coordination, assistance and support access to child care settings, such as kindergarten and daycare centers. Such settings usually offer additional therapeutic and educational services e.g. different approaches to learning, the use of assistive technology, and specifically adapted play and learning materials [20].

Play, as an occupational therapy intervention area for children, is directed towards the most basic experiencing of play as a source of pleasure, as well as providing the child with an opportunity to participate in play activities. Play activities are activities that are generally internally motivated and provide pleasure, entertainment and learning. Early intervention OTs focus on monitoring appropriate play activities that children conduct, in order to habilitate or facilitate their skills and abilities. In addition, play activities represent a treatment method to support child for learning and practicing his/her functional skills. Activity analysis is an important process carried out by OTs in order to understand the various demands that a specific activity requires for execution and completion [7]. OTs are familiar with grading or adaptation of a chosen activity for an individual to promote successful performance or elicit a particular response [21].

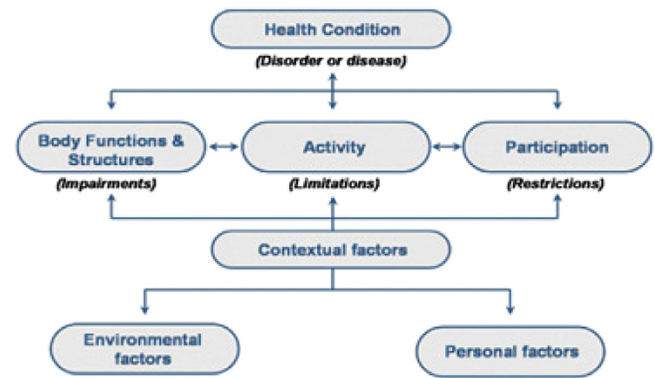


Fig. 1. ICF-CY components and their functions.

### 2.3. Knowledge models and assessment tools for children

A variety of tools is used by childhood professionals in order to record issues involving functions and structures of the body, activity limitations and participation restrictions during child development (see as examples [22,23]). The work reported in this paper is based on the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY [24]) of the World Health Organization (WHO) as a universal modeling framework, and on Denver II [25], as a developmental screening test.

ICF-CY provides an essential basis for the standardization of data concerning all aspects of human functioning and disability in the pediatric population by taking into account two relevant issues: (a) the dimensions of childhood disability which include health conditions, disorder, impairments, activity limitations as well as participation restrictions, and (b) the influence of the environment on the child's performance and functioning. Fig. 1 shows these components and their corresponding functions. ICF-CY is designed to record the characteristics of a child's development and the influence of its surrounding environment and can be used by providers, consumers and all those concerned with health, education, and well-being of children and youth [24].

Development tests are tools used by childhood professionals to measure a child's developmental progress from infancy through adolescence [26]. The Denver II Test [27] is widely accepted as a screening tool for ages up to 6 years old and is frequently used for assessing personal social, fine motor adaptive, language and gross motor skills in preschool children. It enables to identify children whose development deviates significantly from that of his/her coevals, while warranting further investigation to determine the potential need for intervention.

### 2.4. Occupational therapy expertise in participatory design

OT expertise and knowledge often constitutes a fundamental part of participatory and multidisciplinary design projects targeted to children with or without various types of disabilities. The collaboration of therapists is frequently sought in the requirements and evaluation phases towards ensuring that the designed systems meet the abilities as well as the developmental and therapy needs of the target users. For example in [3], a tangible training game was developed through a participatory design process involving occupational and physical therapists and children with cerebral palsy. The significant role of the direct involvement of therapists in the design of therapy games for children with Autistic Spectrum Disorders (ASD) is stressed in [28]. In [29], teachers of a school for children with ASD participated as proxies of their students in the design of two systems meant to enhance occupational therapy, namely an assistive communication system developed on tablets

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