Collaborative networked framework for the rehabilitation of children with Down's Syndrome

A M P Almeida and F M S Ramos

Department of Communication and Art, University of Aveiro, Campus de Santiago, Aveiro, Portugal

marga@ca.ua.pt, fmr@ca.ua.pt

ABSTRACT

This paper describes a reference architecture to support a multi-user virtual communication platform that enables rehabilitation and social integration of Down's Syndrome children. The platform, based on an on-line virtual collaborative environment supported by the World Wide Web, includes collaboration and interpersonal communication devices and data collection mechanisms to provide management information for system and effectiveness evaluation. It allows children with Down's Syndrome, geographically spread in schools and homes, to access a distributed virtual platform able to offer communication and shared construction processes. This will leverage the exploitation and development of communication and socialisation abilities, creating conditions to the exploitation of new rehabilitation patterns.

1. IS VIRTUAL EFFECTIVE?

Virtual derives from the Latin *virtus*, which means strength and power. In fact, it has little relationship with false or illusory. As Pierre Levy states, "the virtual is by no means the opposite of the real. On the contrary, it is a fecund and powerful mode of being that expands the process of creation, opens up the future, injects a core of meaning beneath the platitude of immediate physical presence" (Levy, 1998).

In fact, virtualisation is mostly a process of actualisation and effectiveness, a dynamic operation of transformation and creation of solutions. It is not imaginary as it produces effects (Levy, 1998). Consequently, the expression Virtual Reality seams a paradox as the virtual allows real cognitive representation and experimentation (Cadoz, 1996). Indeed, virtual tools allow objects, entities and processes representation in a universal and integral unique way: not also they are an extension of human representation, cognition and recognition, but also they extend human interaction and social abilities through a ubiquitous and interactive mean. In this context, virtual solutions are a powerful mechanism of knowledge transposition to "real world" scenarios in a dual process where, on one hand, "real word" information affects virtual interaction and, on the other hand, virtual interactions modify "real world" scenarios.

Moreover, under the context of networked virtual scenarios, there is a dynamic experience of a collective context, a virtual world of significations, which is shared by the participants and reinterpreted by them, a projection of presence in a shared environment (Levy, 1998) where contexts are not imposed but instead result from the activity of the participants.

The collaborative framework presented aims to allow the construction of a virtual shared space, a context of meaning and knowledge where usually excluded and geographically dispersed individuals can communicate, participate and learn through the transposition and change of information from real and virtual words.

2. REAL PROBLEMS, VIRTUAL EFFECTIVE SOLUTIONS

Under the context of disability, spatial dispersion scenarios are very frequent. Not only due to social exclusion but, currently and under the Portuguese special educational policies, due to the processes of integration in regular schools instead of in dedicated and geographically concentrated centres. Indeed, this new scenario creates a new gap as, nowadays, disabled children, integrated in regular schools, spend most of the time of their school days in activities that do not promote collaboration and real participatory processes toward their daily social inclusion and the rehabilitation of transversal problems. Consequently, and in order to assure communication, participation, learning and rehabilitation processes, we propose a technological tool

that will enable and promote the virtualisation of those processes between a network of individuals, specifically children with Down's Syndrome.

This tool will provide to its users the participation in a shared, situated space as a social interface platform of mediation and communication. Underling the importance of a constant interaction between the individuals and contexts (ICIDH-2, 1999), this platform is expected to create the appropriate conditions, so that individuals can build their own learning environment and collaborate in their own rehabilitation processes in a participated and autonomous way.

2.1 General Characterisation of the Down's Syndrome

Down's Syndrome or 21 Trissomy (due to an extra copy of chromosome 21) is the most frequent genetic cause of mental retardation and affects up to 1 in 700 live births (Reeves, 2000). Individuals with Down's Syndrome, besides mental retardation, also exhibit congenital heart disease, development abnormalities and other health problems.

As far as cognitive disorders are concerned, these individuals have linguistic incapacity because their strongest deficit is in the language area. Furthermore, limited language skills intensify the already present difficulties in the symbolic and social areas. Nevertheless, Sigman (1999) states that children with Down's Syndrome, when compared with other mental retarded groups, are socially communicative and capable of imaginary play (Sigman *et al*, 1999). The main reasons for this language deficit are, first a hearing deficit, and second, a deficit in simultaneous and sequential cognitive processes, specifically with chronological understanding, successive event synthesis, sequential hearing memory and recent acquired knowledge construction (Condeço *et al*, 1999).

Besides this, Down's Syndrome children prefer to learn by themselves through experience and without a close adult mediation as they benefit from distal communication processes and not from proximal ones. Proximal communication processes are human related and without many mediation objects, while distal ones are mediated by tools and artefacts (Condeço *et al*, 1999). This fact seems to be related to a typical Down's Syndrome phenomenon of social avoidance in learning activities.

Therefore, the fact that Down's Syndrome children have good visual performances, that they prefer distal communication processes, that they are social and communicative and that they have a great empathy with computational applications, reinforced our belief that a multi-user virtual environment could be helpful in their rehabilitation. Moreover, the proposed framework, because it is a networked environment, benefits from the World Wide Web collaborative potentialities namely concerning: targeting people that are geographically dispersed; easing the customisation and update of curricula; enabling shared construction processes (network supported collaborative work).

2.2 Theoretical Approach to the Virtual Environment

The theoretical approach to this framework follows constructivist and pos-constructivist theories form Piaget and Vygotsky as it emphasises the importance of social development, dialogue and interrelation in knowledge construction and in educational processes (Tryphon, Vonèche, 1996). Therefore, the virtual environment proposed aims to stimulate cognitive construction processes in open learning environments on a profoundly heuristic basis.

Also, it is believed that learning phenomena are situated processes as human cognition and learning are embedded in specific contexts and are constituted through processes of interdependence, socially and ecologically grounded and mediated by tools and artefacts (Littleton, Häkkinen 1999). Therefore, this framework also follows Clancey (1997) situated cognition theories, which state that cognitive processes are contextually situated. The model is, then, based on interactive role-playing schemes allowing children to participate in the activities through the manipulation of characters (avatars), scenarios and objects and the consequent shared construction of the learning environments.

The exploitation of these narrative and role-playing schemes is deeply studied by Schank (1998). This author states that intelligence depends upon the ability to translate descriptions of new events into labels that help in the retrieval of prior event in a process of constant narrative construction. Under this context, role-play and shared narrative construction improve not only knowledge consolidation and generalisation but also participatory and integration processes.

It is well known that fantasy and imagination have a great importance in childhood development. To imagine, build and shape something in a virtual environment is to experiment a solution for a real problem with a minor risk of failure or frustration; furthermore, it is also of most importance to social and emotional development, and also to improve linguistic skills, as it involves representation processes.

Moreover, shared distributed narrative environments are of most importance to isolated children because they can help to overcome the absence of a co-temporal and co-spatial playmate, enabling storytelling processes to play their triple role, even for children in different locations: cognitive (favour human memory and experience), social (favour a social construction of the self) and emotional (exteriorisation of experiences).

This collective narrative construction model is also based on the presumption that incapacity is, rather than just a dysfunctional cognitive phenomenon, a multi-dimensional issue comprehending educational, social, and behavioural aspects. Moreover, the social avoidance phenomena, the preference for distal communication processes the typical sequential cognitive difficulties of children with Down's Syndrome lead the authors to propose this narrative construction model.

3. THE MODEL

The conceptual supportive model of this framework is materialised on a networked communication system (figure 1) and aims to enable participation and integration processes of geographically and socially isolated children. According to Schroeder's virtual reality categorisation (Schroeder, 1997), this model is both "immersive" and "second person" as it allows, besides presence virtualisation, individuals representation by avatars that allow peer interaction as well as contexts manipulation and narrative construction.

In the model, the different individuals share a collaborative environment which interface is a graphical scenario. To interact and participate, children dispose of other scenarios as well as of characters and objects that they can select and manipulate to create their own environments autonomously and that are organised in personal and collective archives allowing shared and open collaborations as well as one-to-one.

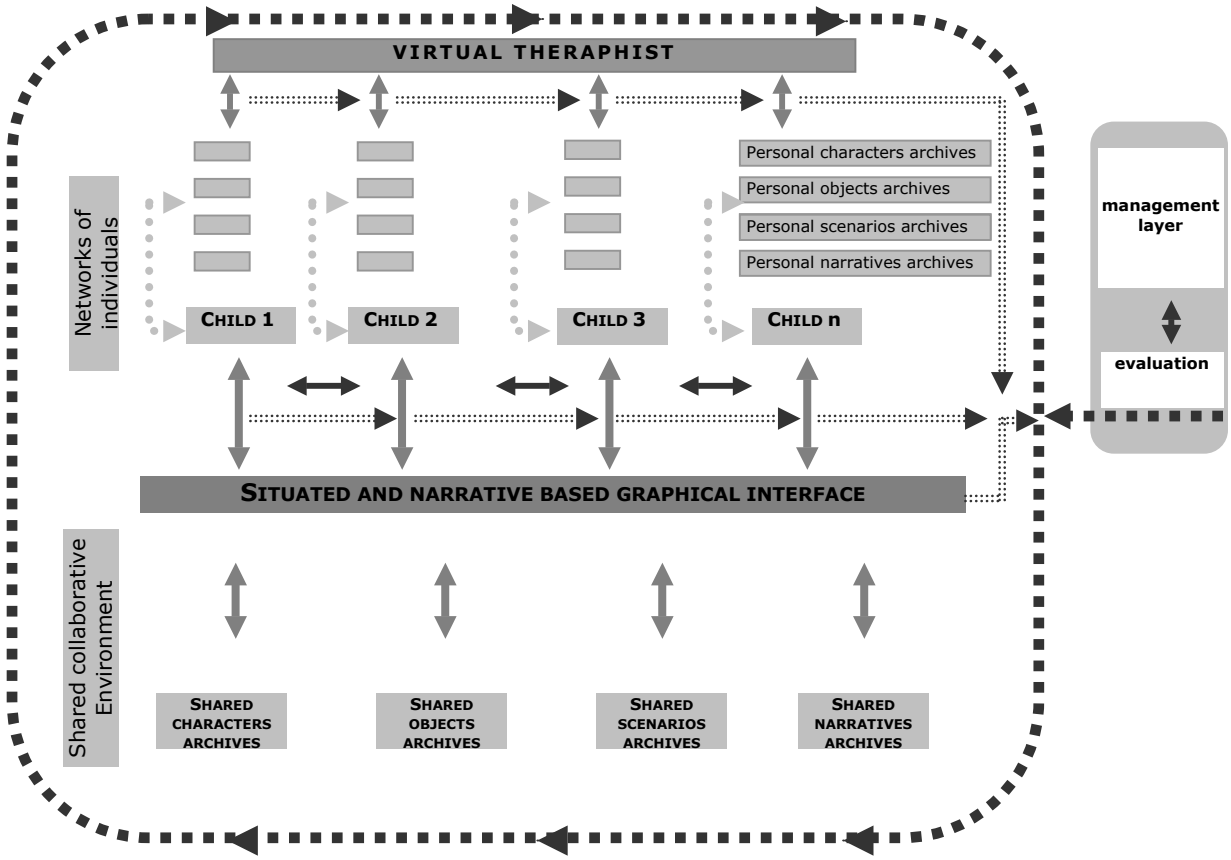

Figure 1. *Conceptual model.*

The conceptual model also comprises the possibility of intervention of a virtual therapist to mediate communications and to launch activities, which take place above this muti-modular and shared environments build by the children, favouring processes of situated learning and natural knowledge construction. Moreover, it also proposed the inclusion of a management and evaluation layer, enabling system feedback and analysis, therapeutic intervention and system management functions (configuration, updating, accounting, etc.).

3.1 Main Facilities and Characteristics

The proposed framework favours not only the collaborative construction of narratives and visual scenarios but, also, of the learning environments in which the curricular activities take place. Nevertheless, besides curricular activities, other activities towards real system immersion and effectiveness of cognitive processes virtualisation are also proposed. Four levels of activities can be distinguished: activities promoting system interaction; activities inducing peer interaction; curricular activities; activities stimulating the construction of situated knowledge (figure 2).

Activities promoting system interaction are related with initial interaction processes in which children will be able to work on simple play tasks towards system motivation.

Activities inducing peer interaction aim the learning of socialisation abilities, namely the training of simple socialisation acts like salutations, farewells and requests by the use of games and individuals presentations.

As far as the curricular activities are concerned, relevance will be given to the learning of specific curricular areas, mainly related with semantics and pragmatics (Nadel (ed.) 1988), (Kumin, 1994). Specifically and according to Nadel and Kuman studies, we pretend to work on the following abilities: categorisation, classification and sequencing; numerical; reading; hearing discrimination. Transversally to these abilities we also propose general task schemes towards cognitive stimulation such as repetition, contrast, manipulation, generalisation and reinforcement.

The fourth level of activities (stimulating the construction of situated knowledge) is the layer of contextualisation and systematisation of the former three. It is in this last level that the dynamical holistic model is materialised in a dialectic process between the curricular activities and the social interaction contexts. This level of situated learning will assure knowledge generalisation through different contexts and, consequently, abstraction and knowledge consolidation as it allows the creation of social interaction environments in a process that privileges operative learning from natural and situated actions (Nadel (ed.) 1988).

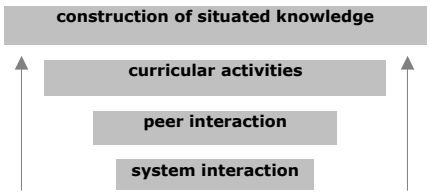

Figure 2. *Activity levels.*

The typical processes that assure this last level are exactly story-telling and role-playing schemes. For example: the curricular activity that works numerical and sequencing abilities would be situated in the environment garden or supermarket in which children would have to discriminate, select, and count objects (flowers or groceries).

In order to assure the above mentioned processes, narratives must be parameterised in order to establish patterns for used scenarios and objects in thematic groups (modules) in order to automatically or manually launch each module when a theme is invoked. Also, given opening scenarios should invoke and invite communication processes. Both the given and the shared constructed modules should be archived in order to create a relational database containing the updated versions of the available data (figure 3).

Finally, the different local and shared archives allow the creation and interrelations of scenarios, objects and characters contributing to the shared construction of the learning environment (figure 4).

3.2 Implementation Strategy

The implementation of a network virtual environment that allows multiple geographically dispersed users to interact in real time with a deep sense of realism and an immersive experience is a complex task that must be correctly assured in order to guarantee system effectiveness. As Singhal (1999) states, a network virtual environment should offer both a shared sense of space, presence and time and a way to communicate and share.

Generally, the main dimensions to consider in the implementation process are bandwidth (distributed virtual reality systems require enormous bandwidth to support multiple users, and the exchange of graphics in real time), distribution (multicast, unicast or broadcast), latency (which influences the interactive and

dynamic behaviour of the environment) and, finally, reliability which forces a compromise between the former three dimensions, assuring that data sent is always received correctly (Macedonia, Zyda, 1997).

Although we agree that the correct analysis of the above mentioned dimensions is crucial to system effectiveness, throughout this research, we are specifically concentrated on investigating data distribution and peer communication mechanisms. According to Macedonia and Zylda (1997), data can be distribute in four different ways: replicated homogeneous world database (every participating system must be initialised with the same and unique database), shared centralised databases (only one user at a time can modify the database), shared distributed databases with peer-to-peer updates (shared memory architecture dynamically updated and multicast based) and, finally, shared distributed client server databases (partitioned among users and mediated by a central server).

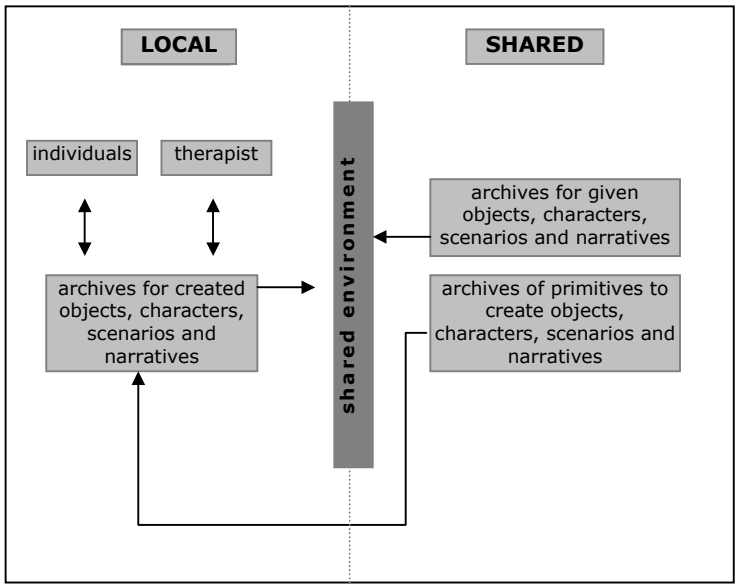

Figure 3. *Example of the interrelations among the modules.*

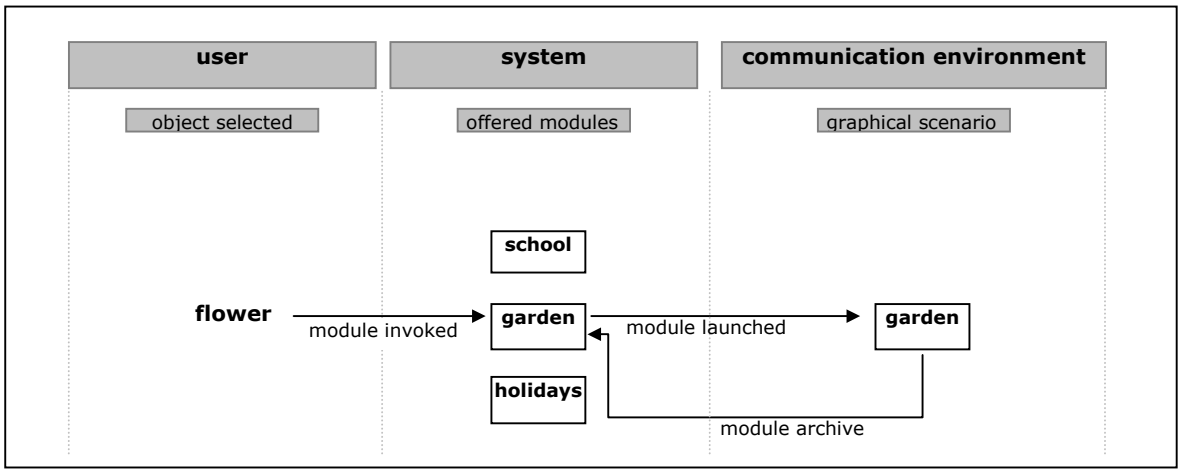

Figure 4. *Local and shared archives.*

As the aim of this project is to conceive a technologically flexible architecture, the solution chosen must be compatible with the conceptual characteristics of the presented collaborative environment as it will influence and support global communication and visualisation aspects. Under this context, special attention will be given to social and communicational requirements and collaborative activity requirements. Globally, this discussion should also consider the need to implement virtual environments capable to emulate real participation scenarios, especially concerning: graphical representations of real world metaphors, spatial representation, manipulation and navigation possibilities, multi-dimensional representation, dynamism and realism.

Considering the evaluation layer, and in order to provide the necessary and organised information to system adaptation and optimisation and to support immediate monitoring and intervention, the authors also aim to implement data collection, parameterisation and visualisation mechanisms.

3. FUTURE WORK

The collaborative networked framework proposed, as an open and shared communication environment, points to a new approach to distance learning and rehabilitation interventions. It explores the potentialities of virtual environments while powerful tools for real multi-modal interaction and shared knowledge construction.

The authors, of course, believe that the main challenge is to capture the complexity of human learning processes in a systematic manner and to express them metaphorically in real platforms of effective interaction and communication.

In the future, and besides a continuous work toward the research area of technological platforms for people with special needs, the authors aim to consolidate and develop research activities on methodologies and technologies for other networked collaborative environments, specifically to global distance learning systems.

4. REFERENCES

A. Tryphon, J. Vonèche (editors) (1996), *Piaget – Vygotsky, The Social Genesis of Thought*, Psychology Press, East Sussex, 1996.

C. Cadoz (1996), *A Realidade Virtual*, Biblioteca Básica de Ciência e Cultura, Instituto Piaget, Lisboa.

ICIDH-2, International Classification of Functioning and Disability (1999), Beta-2 Draft, Short Version, July 1999, Assessment, Classification and Epidemiology Group, World Health Organisation, Geneve.

K. Litteton, P. Häkkinen (1999), Learning Together: Understanding the Processes of Computer-Based Collaborative Learning, *Collaborative Learning, Cognitive and Computational Approaches,* edited by Pierre Dillenbourg, Pregamon, Elsevier Science, Oxford.

L. Kumin (1994), *Communication Skills in Children with Down's Syndrome*, Topics in Down's Syndrome, Woodbine House.

L. Nadel (editor) (1998), *The Psychobiology of Down's Syndrome*, Bradford Book, The MIT PRESS, London, 1988.

M. Sigman, E. Rusjin (1999), *Continuity and Change in the Social Competence of Children with Autism, Down's Syndrome and Development Delays*, Monographs of the Society for research in Child Development, Oxford, 1999.

M. Macedonia, M. Zyda (1997), A Taxonomy for Networked Virtual Environments, IEEE Multimedia Vol. 2, nº 4, page 48-56.

P. Lévy (1998), *Becoming Virtual: Reality In The Digital Age,* Plenum Press, New York.

R. Schroeder (1997), Networked Worlds: Social Aspects of Multi-User Virtual Reality Technology, *Sociological Research Online*, vol. 2, n. 4, in: *http://www.socresonline.org.uk/socresonline/2/4/5.html.*

R. Schank (1998), *Tell me a Story, Narrative and Intelligence*, Northwestern University Press, Illinois, 1998.

R. H. Reeves (2000), Recounting a Genetic Story, *Nature magazine*, vol. 405.

S. Singhal, M. Zylda (1999), *Network Virtual Environments, Design and Implementation*, New York: Addison-Wesley.

T. Condeço, L. Cotrim, M. Palha, S. Buckley (1999), Ensino da Leitura Para o Desenvolvimento da Linguagem, *Revista Integrar* nº. 17, Setembro/Janeiro 1999, Secretariado Nacional para a Reabilitação das Pessoas com Deficiência.

W. Clancey, (1997), *Situated Cognition: On Human Knowledge and Computer Representations*, Cambridge University Press, Cambridge.