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Using assistive technologies to facilitate play by children with motor impairments: A methodological proposal

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Abstract. The results are presented of the SIVA research project "Technical Aids and Methodologies to facilitate Play by Children with Motor Impairments" (2000–2003).
The project has been launched with the scope of improving learning of children with motor impairment by letting them directly interact with their environment through play. For the 6 children belonging to the study group individualised solutions to access play and toys have been studied and experimented. An on-purpose playroom has been equipped with the needed technological solutions; individualised educational programs have been developed and fulfilled.
The planning of the project as well as its results are here discussed within the methodological framework of Action-Research.

1. Introduction

From 2000 to 2003, the SIVA[1] developed the "Technical Aids and Methodologies to facilitate Play by Children with Motor Impairments" research project in co-operation with the Infant Neuropsychiatry Service of the same institute[2].

Technology can offer children with motor impairments many opportunities to overcome their physical impairment so that they can gain access to play activities and undergo regular cognitive and linguistic development.

As any professional in the field knows, the play experience can be frustrating and even impossible for these children: many commercial toys are difficult to manipulate, and some building and psycho-motor exploration play activities are partially or totally precluded for evident functional reasons.

Even the subsequent symbolic play phase, usually carried out with dolls, stuffed animals, little cars and trains, and with the first graphic representations, is also difficult to accomplish since it is impossible for these children to use objects, to experiment, to fully understand and then, who knows, to invent.

What happens to the learning potential of these children, if they can't play like their peers? But above all: what can we do – which technological tools should we use – to let them play, learn to play and access the symbolic level of learning through their play activities? Which play activities, which toys should we choose and use? How should we place these toys at their disposal? And what will be the adult's role in this activity to obtain the expected results? How should we present, support and favour these play activities?

Thus, the objective of the project has been defined as follows: to develop, to test and to define an effective and transferable methodology to introduce both Assistive Technology (AT) and educational technology into the play activities of children with motor impairments, so that this experience can be included in their lives as expediently as possible, giving them the chance to modify the natural trend of their development.

[1] SIVA is the Centre for Research, Information and Counselling in the field of Assistive Technology of the Don Carlo Gnocchi Foundation in Milan, Italy.

[2] Dr. Emanuela Maggioni is the responsible physician in both this rehabilitation service and in the SIVA.

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2. Conceptual frameworks

2.1. Play and child development

According to Rubin et al. [33] play can be defined as a psychological disposition, a group of observable behaviours or a context in which some special phenomena can be observed.

One of the most distinctive features of psychological disposition is intrinsic motivation, from which the mean become a priority over the end: as Bruner et al. noted [9], the process in play activity is more important than the final outcome. The risk of failure so inherent to many activities does not pertain to play and any difficulties that arise can be regarded as a new opportunity for playing instead of as obstacles. In playing, the individual has control over the external world: he/she explores possible activities instead of seeking information, and can give real objects inventive – and even incongruous – meanings [2].

The role of play activities to support a child's social and cognitive development is widely recognized by the psychological and pedagogical sciences from their very beginnings.

Since the end of the 19th century the child has become an object of research – through the observation of play activities as the driving developmental force and as the main activity in such development – and he/she has been considered an evolving person and thus worthy of specific and special pedagogical attention by both the family and institutions.[3]

In the psychological field, infant play has been studied, classified, and evaluated from different viewpoints. According to Jean Piaget's well-known development scheme[4], the emergence of the symbolic play phase is of fundamental importance in a child's development, and is not merely related to the contemporary emergence of the expressive verbal language in the individual [30]. This paradigm has focused the attention of many researchers in the field for years in order to determine the links between the two functions (play and language) and to study their co-evolution [15].

Furthermore, Lev Vygotskij some years earlier emphasised that play activities arise, develop and become a catalyst only within a social context. To use his words, "like the focus of a magnifying lens, play contains all the possible development trends in a condensed form [. . .]. Play is a source of development and it creates the Zone of Proximal Development" [38].

According to Donald Winnicott [39], who worked within a different theoretical framework, the space-time aspect of play is an "area that cannot be easily abandoned and that does not allow any intrusions at all"; the transitional objects, the main focus of his studies, can be placed in an area of experience that arises from the need to reconcile the internal world with the constraints of the external world.

Finally, more recently, the field of neuroscience explored the links between infant play and brain development [16].

2.2. Toys and infant play developmental phases

Garon et al. [18] proposed an interesting methodology for a psychological analysis of toys. Inspired by the play phases described by Piaget, the system proposes a clear and exhaustive classification of toys based not only on the kind of the materials used, but also on the types of play activities that these toys can suggest and favour. The basic structure of this classification is described by its acronym. In fact, the initials in ESAR[5] stand for the four main phases of child play: exercise play, symbolic play, assembling play and simple or complex rule play.

The ESAR methodology includes some descriptive tables in which the commercial toys can be inserted and classified and considered in relation to the cognitive correlates that allow them to be used, to the functional abilities they favour and support, to the social activities they imply and to the emotional behaviours they represent and develop. It is based on a set of descriptive sheets, concerning: a) the fundamental phases of infant play; b) the different levels of logical activity related to the toy use; c) the functional and instrumental abilities; d) the forms of social abilities showed by the child while playing; e) the use and development of the child's language while playing.

Owing to its clarity and completeness, the method has also been used in Spain by the AIJU[6] as a use-

[3] Maria Montessori and Friedrich Fröbel, among others, were strong advocates for supporting early childhood growth, and a driving force at that time behind the efforts to establish new kindergartens in Europe.

[4] Exercise play, in which the child varies the acquired sensor-motor schemes, making them more complex; symbolic play, through which he/she tries to manipulate symbols and, finally, rule play, in which attempts are made to deal with social processes.

[5] French for Exercice, Symbole, Assemblage, Règles.

[6] AIJU, Instituto Tecnológico del Juguete (Toy Research Institute), www.aiju.es.

ful analysis tool in a research project whose aim is to evaluate commercial toy accessibility for children with cognitive, motor and sensorial impairments.

In this project, the ESAR method served as a starting point for analysing the toys used based on the type of play activity they naturally favour, thus leading to a classification based on their increasing complexity.

2.3. *Play by children with motor impairments: the use of technologies*

But children must learn to play [26]: in fact, the quality and the quantity of their play units also depend on the social, emotional and psychological contexts in which they grow. By learning to play with others, children improve their movements and thoughts, the ability to plan their actions and social abilities and to acquire a personal playing style [34].

There are also special children who not only must be taught, but must also be given the right instruments to be able to learn to play. Many international studies deal with the issue of the differences in how children with or without a disability play [8,19].

Children with motor impairments, in particular, may find it difficult to use commercial toys, or may not be able at all to play. This is due not only to movement difficulties, but also to any associated cognitive, linguistic and sensorial impairments. Since the development of these children is sometimes rather difficult, some parents lose their natural ability to promote useful and effective play and experimentation activities [28]. According to an Austrian study (cited in [31]), parents of children with a motor impairment agree with rehabilitation professionals that play is the most important infant experience, and that it is basically a precluded activity for them.

Since ATs can offer new opportunities to persons with movement difficulties, international scientific literature in this field has focused on the issue of toy accessibility for since time [17] as well as on the use of technologies for disabilities in childhood [36]. Catalogues of accessible toys have been published, as well as others containing evaluations of commercial toys in terms of accessibility [11,18,25,32]. Furthermore, there are also specialised publications and Internet websites [7] that offer suggestions to make these toys accessible either by making a simple modification or by using them in an original way. To facilitate and enhance compatibility between the individual and technology, Scherer [35] developed a work tool to be introduced in the process of choosing a piece of technology that dedicates an entire section to children and to their use of toys and their penchant for play.

Some interesting proposals regarding product development have been presented over the last few years. Gabriele Scascighini and his group [8] developed a hardware/software system that allows children with motor impairments to use electric toys by controlling and guiding them using a personal computer. Some other research groups are investigating robotics. The most recent proposal in this field comes from the Austrian group ARC, that suggests using robots as instruments to help children to use toys rather than as toys themselves (Prazak et al., cit.).

3. The project development plan

The research project was developed in three stages, as shown in Table 1. [9] The study group consisted of 6 children (4 to 10-year-olds at the beginning of the project) with motor impairments and, in some cases, cognitive and communication impairments, attending kindergarten and elementary schools.

On the basis of the multidimensional assessment carried out during the second year, [10] an individualised "play program" was defined for each child, including:

– knowledge relative to the child;
– issues related to AT;
– issues related to the play activities to be proposed (toys and educational technologies to make them run or to symbolise their use);
– issues related to the play context and to the educational relationships to establish.

The children went to the "playroom" set up on SIVA premises once a week. The play activities were carried out with the support of two rehabilitation professionals whose task was to interact with them, helping to create the play situation and to support the play activities through implementation of proper educational techniques.

Both the activities and the changes were monitored and recorded on a on-purpose sheet. They were also pe-

[7] See Kolucki [23] and Vincent [37] for a review of the topic.

[8] CID (Centro Informatica per la Disabilità), Lugano, Switzerland (CP CH-6310).

[9] The project has been described in detail in Besio [4].

[10] The assessment phase has been described in detail in Besio [5].

Table 1

First year (2000–2001)	• project planning • definition and organisation of the study group • definition and organisation of the work groups
Second year (2001–2002)	• multidimensional assessment of each child: a) clinical and family interview; b) choice of the most suitable computer access device for each child; c) MATCH questionnaire[11]; d) cognitive level evaluation of each child
Third year (2002–2003)	• draft of an individualised play program for each child, as a result of the previous evaluation phase • development of the individualised play programs, through activities carried out once a week • program follow-up, monitoring, and adjustments every three months • conclusion of the project

riodically discussed within the small group of involved rehabilitation professionals with the participation of the project co-ordinator. The individualised play programs were continuously verified and revised, as described below, according to the Action-Research methodology.

3.1. The play activities proposed and realised

In choosing the play contexts to be developed and the toys to use priority was given to the abilities and needs of each child, as well as his/her preferences and personal learning style. On the other hand, whenever children were offered the possibility to choose among various play options, they were always able to show an undeniable preference and a strong tendency to respond to personal choices and pleasures.

If the ATs allowed the children of the study group to overcome their movement difficulties, the educational technologies allowed them to bridge the (technological and educational) gap between the toys and their mental activity: finally they were able to interact with the toys, moving them and symbolically organising their own play activities.

"The system used – AGIO/DIGIO, developed and distributed by the cited CID in Lugano – consists of a hardware and software system to control electric toys through a computer. The software interface can be used to carry out multimedia activities, through the definition of "screens" in which it is possible to define some "zones" for the interaction with the user. Each zone can be assigned an image, an auditory feedback, an action, etc. The actions can be used to produce output signals through the system hardware that consists of two control units: one for the analogical and one for the digital signals. These units, using sensors, can also detect input signals that are useful for carrying out the play activity. The output signals can be used to control simple electric toys, to illuminate lamps, to activate sounds, and to control household appliances for children".[12]

Some children preferred assembling play and requested the support of an adult to provide a narrative framework. Others finally had the possibility of inventing and representing some sketches, and agreed, although with great difficulty, to put them in a logical sequence. Some children were happy to have the opportunity to make noise, "accidents", and "disasters" with the toys, while others learned to control the cause-effect relationship, demonstrating that they could wait for a certain event to occur as a result of a certain action and to share their pleasure with the adult in recognising the object that appeared on the computer screen.

A non-exhaustive list of the play activities and toys used, in increasing order of complexity, must include, according to the previously mentioned ESAR methodology, the following:

- EXERCISE PLAY, for sensor-motor and exploration activities
  - toys and small battery-powered animals activated by external switches
  - basic educational software to experiment with the cause-effect relationship
- SYMBOLIC PLAY
  - "pretend toys"
  - cars, trucks, cranes, trains, cableways, each of which can make at least two movements (forward/backward, up/down, rotation, etc.), controlled by a hardware system and software that can create interactions between them[13].
  - dollhouse with small battery-powered elements (lights, washing-machine) and relative characters

[11] The MATCH (Matching Assistive Technology and Child) is an instrument to evaluate the quality of the relationship between children and technology (Scherer, 1997; new edition 2003).

[12] Brusa, in Besio & Brusa [7].

[13] Agio/Digio di CID, Lugano, see above.

  * graphical representation tools
  * software to draw or to complete and colour drawings
  * tools to invent and tell stories
  * software to play with traditional fairytale characters
  * communication software to build stories using iconic communication codes
- ASSEMBLING PLAY
  * software to make puzzles
- RULE PLAY
  * tools and programming languages
  * software to run toys
  * small robots[14]

3.2. The methodology implemented

3.2.1. Choices Involved in the Action-Research methodology

Described first by Lewin [24], the Action-Research methodology – as it has developed to the present – can be viewed as a family of research methodologies that pursue action (or change) and research (or understanding) at the same time [14].

It proceeds in a spiral of steps consisting of planning, action and evaluation of the result of the action. The approach is naturalistic, using participant-observation techniques of ethnographic research, is generally collaborative, and includes characteristics of case study methodology [3].

The spiral of subsequent cycles is effectively represented in Fig. 1, as proposed by Kemmis [21].

Argyris and Schon [1] define the goals of action research as threefold: (a) to improve a practice; (b) to improve the understanding of the practice; and (c) to build an understanding and responsiveness in the system to support change of the practice [12].

This methodology was selected as being the most compatible with the project's methodological needs and realisation requirements: to identify and to experiment effective choice strategies but, above all, to use ATs in the play activities of the motor-impaired child.

In other words, the methodology should allow – for each child of the study group – to plan the right actions, to record the meaningful events, to identify the needed changes and to re-adapt the educational project on the basis of the identified changes.

[14]Mindstorms, distributed by Lego.

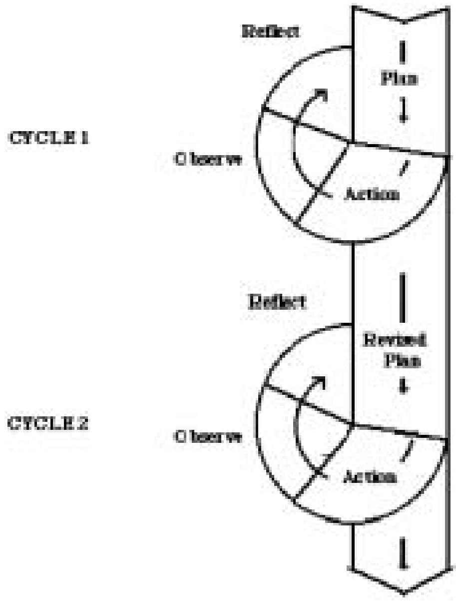

Fig. 1.

But to achieve these speculative objectives, this research project should involve human systems, and should respect and represent the complexity of their inter-relations (adult/child, group of adults) and their co-evolution.

Therefore the methodology should establish useful strategies so that the rehabilitation professionals involved in the study can act as competent observers (thus researchers) of their own actions and of the elicited changes. Following a consolidated practice in the social science field, the researchers, unlike in other disciplines, make no attempt to remain objective, but openly acknowledge their bias to the other participants. As O'Brien [29] notes, one of the main focuses of the Action-Research is to turn the people involved into researchers: people learn best, and more willingly apply what they have learned, when they do it themselves.

Finally, for each case study to which the action research methodology is applied, knowledge is strictly contextual to the specific field of application, and it results "from a synthesis of local theory and practice and external theory, e.g. subject matter expertise" (Damme, cit.).

In our case the Action-Research seems to satisfactorily explain the complexity of the field studied and to adequately emphasise the relationships and the interdependences between the different disciplines involved and the various contexts that contribute to determining the final result.

3.2.2. Applying the Action-Research to the project

In this project, implementation of each planning/action/observation/evaluation cycle was made even more complex by the strict interconnection – at different levels of the spiral process – of many concurrent fields of specific knowledge.

These fields can be listed as follows:

- relative to the child and his/her disability
  knowledge about the child's development, his/her learning style and rate, his/her preferences, his/her relationship with the technology
  methods and techniques of physical and neuropsychological rehabilitation
  (*in some cases*) *methods and techniques to teach and to use AAC*
- relative to AT
  knowledge about the existing and available ATs
  methods to evaluate and choose AT
- relative to the play activities
  knowledge about existing and available educational technologies
  methods to evaluate and choose educational technologies
  methods of evaluation and strategies in using the different types of toys
- relative to the play context to be implemented
  methodologies of educational planning
  methods and educational techniques to support situation-specific learning
  methods and strategies in using AT
  methods and strategies in using educational technologies

The typical evolution of each cycle in the spiral of the Action-Research process included for each child – on the basis of the previous multidimensional evaluation – the following phases:

- *planning* of the play activity by a small group of professionals-researchers consistent with the individual educational project developed. This phase should include:
  - ∗ specification of the ATs to be used and the use modalities;
  - ∗ specification of the educational technologies not only as to the precise product, but also as to all the possible variables concerning its use (adaptation, hints, feedback, etc.) and its interface (colours, dimensions and positioning of the icons, types of sounds, etc.);
  - ∗ identification of the play situation to propose and of the toy(s) to use, on the basis of the child's preferences and his/her developmental abilities;
  - ∗ identification of the aid and support educational strategies to implement in building the relationship with the child; identification of those involved in these strategies;
- *action*, lasting one hour each time, for the purpose of realising the plan, within a context of playful interrelational exchange between the child and the adult;
- *observation* and *recording* – on the basis of the predetermined sheet – of the results obtained, and of the elements listed in the plan that facilitate and/or limit the fulfilment of the established objectives;
- *evaluation*, made within a small group, to discuss the results obtained through the action as recorded during the previous observation phase; the discussion findings are then converted into possible changes to be made at each of the previously mentioned specific planning levels;
- *revised plan*, that appropriately includes these changes at each of the levels as deemed necessary.

During the action phase the professional-researcher was closely involved in the relationship with the child. For this reason many changes were made in progress, i.e. during the action phase itself, and the results obtained concerning the quality of the play activity by these changes were immediately recorded.

In the project's totally recursive design possible changes could occur at any level and at more than one level at the same time. Thus, changes could occur at a psychological, functional or technological level, but may also involve some aspects of the activity or of the relationship established in the play context.

To allow children to fully express their potential in terms of action and creativity, available tools had to be constantly adapted to satisfy the various play needs: from the choice of the access device and its positioning to a more suitable posture of the child; from the choice of the icons (shape, size, contrast with the background) to their positioning on the screen; from the type of feedback to its presentation; from the overall appearance of the desktop to the arrangement of its various elements; from the kind of toys to their location in the room to ensure effective and expedient visual monitoring; from the activation of complex functions to the extreme simplification of functions.

Constant changes to the functions of the toys and original software configurations were also necessary to meet the children's requests, or to guide the play activity they invented in a new direction, or to surprise the children with unexpected effects. The children's preferences and attitudes, carefully recorded by the professionals, have always been exploited to suggest new types of play activities or to invent new ones.

4. Results

The results achieved by an Action-Research can be divided into two different levels: the results of the action and the results of the research [13].

In this project, the results of the action can be considered to be all the changes obtained in the play activities of the children in the study group and even the changes in overall development of those children. On the contrary, the results of the research concern the findings regarding a critical reflection about the process. Thus, on one hand, they regard the effectiveness of the adopted methodology and, on the other, offer ideas for a more theoretical analysis on the subject.

4.1. Results in terms of action

The results obtained by each child relative to the initial individual educational plan are schematically presented in Table 2.

4.1.1. At the individual development level

Necessarily omitting the details regarding the conclusions collected for each child, for the sake of brevity some general considerations will be made about the results obtained by the study group as a whole.

1. For each child a development was obtained in terms of complexity and duration of the play activities, and thus a development of the related cognitive abilities. A careful analysis of the data presented in Table 2 highlights a progression – even if with different modalities and times for each child – from symbolic play with a few units to another one with multiple units, or from play without to another one with a narrative plot, or from exercise play to symbolic or "pretend" play.
2. The development in the play activity of each child also had an important outcome in achieving a *higher level of autonomy* in the action and the creation of a play situation. In some children this also led to a new awareness about the importance of using a *communication code* (linguistic, iconic/symbolic, graphic) more precisely, the need to increase their own "vocabulary" or to be familiar with and master some strategies to do things (tracing, drawings, a part of a story, etc.).
3. For some children there was an immediate and natural *transfer* of the *skills* acquired from the experimental context to other life environments, at home or at school. In one case, the systemic solution to access a computer (access devices and the procedures for using them) was adopted from the very beginning of elementary school as a support for learning how to read and write.

4.1.2. At the technological level

As regards the technological aspects, and in particular the evaluation processes, choice, use and test of the access devices, the experimentation stressed the following points.

1. The strong motivation elicited by using the computer and by the involvement in challenging and interesting activities sometimes make it possible to disregard the movement impairment when *choosing an access device*: if strongly motivated to carry out a certain activity, some children succeeded in using devices that a priori could be considered too difficult for them.
2. The child's cognitive abilities, his/her motivational involvement and his/her participation are more important to determine the *usability of a certain device* to access the computer than the limits imposed by the impairment.
3. As stressed by Cook & Hussey [10], also in the case involving technologies to access play activities, a *convenient training phase to use an access device* plays an extremely important role: not only because it improves the quality of the user's action, but also because it provides professionals with the opportunity to verify the effectiveness of the chosen device, and any needed modifications or development.
4. The development of so many different play situations during the study demonstrated the great variety of each child's specific individual needs in using the tools and educational technologies. These needs were fulfilled sometimes by finding original solutions within the same educational technologies, and sometimes by modifying the choice of the access device. The *effectiveness of an access device* must always be tested from a systemic perspective, thus including the multiple relations between the user, the educational technology, the AT and the purpose for which the device is used.

Table 2

Child	Access device or system	Initial project objectives	Final results
E.P., 4 years, dystonic cerebral palsy, no verbal language	scanning system, double entry	symbolic play (at least two units), autonomous management of the multimedia interface	symbolic play (multiple units) included in autonomously invented stories, interface management, symbolic play with virtual characters (planning and realisation capabilities), initial activities with robots (Lego Mindstorms), use of a virtual scanning mouse
D.C., 7 years, dystonic cerebral palsy, no verbal language	joystick	symbolic play, building play with multimedia interface, play with robots (Lego Mindstorms)	symbolic play not included in stories, initial activities with robots (Lego Mindstorms), some difficulties in verifying own play plans
N.O., 5 years, cerebral palsy, cognitive impairment, severe visual impairment	touch screen	recognition and understanding of symbols and icons on the monitor, management of the multimedia interfac cess the symbolic play (at least two units)	recognition of symbols and icons, symbolic play with multimedia interface, ability to plan stories but great difficulty in verifying the results obtained; instead of modifying his/her actions, the child prefers to modify the story to justify the mistake made
A.G., 10 years, cerebral palsy, cognitive impairment	key sensor	understanding the cause-effect relationship	understanding the cause-effect relationship with toys, occasional inclusion of this new ability in short narrative contexts, created with the support of the professional
S.I., 4 years metabolic disease, cognitive and motor impairment, no verbal language	touch screen, key sensors	understanding the cause-effect relationship	understanding the cause-effect relationship (with software), understanding when a play session is finished, sporadic denomination of objects, anticipation of the next play session, use of the key sensor after management of the touch screen
M.A., 4 years, cerebral palsy	big trackball	symbolic play in predefined contexts, building play with multimedia interface, autonomous management of the mouse to fulfil tasks	symbolic play (multiple units) included in autonomously made stories, management of the mouse for simple movements and clicking, then for graphic representations, symbolic play with virtual characters (ability to plan, verify the result, modify some decisions)

4.2. Results in terms of research

The Action-Research achieves its stipulated results thanks to the direct participation of those involved in the planning, observation and evaluation processes. As protagonists and critical researchers in relation to their own work and not mere executors of a procedure, these active participants lend to the flexibility and timeliness of the entire process, allowing the work plan to be continuously adapted to the emerging needs.

The more significant elements of the research methodological framework are presented here below.

1. The project's *continuous recursive* spiral features provided the professionals involved with the opportunity to maintain the needed critical-reflective point of view and to timely and precisely observe the significant elements of the play situation carried out, thus defining the needed changes within the perspective of a general educational plan.
2. The *multidisciplinary work group* established around each child to carry out the individual plan, like the whole work group created around the project as a whole, made it possible to analyse the play situations carried out under different disciplinary conditions, and to make a multidisciplinary evaluation of each critical emerging element, both at the action and at the research level.
3. The *play context* created by the professionals-researchers played a critical role in soliciting the children's interest, in evaluating their learning styles, preferences, wishes, possibilities and limits and, above all, in highlighting the changes needed each time to carry out the project but also to modify the project itself.
4. For this play context to be suitable to determine significant learning moments, the professionals-researchers constantly utilised their technical and rehabilitative skills as well as *didactic and psychological capabilities* in building and modifying the relationship with the child.
5. The context and the play activities provided the professionals with the opportunity of making a peculiar *clinical observation and evaluation* of the children involved in the experimentation.

Playing autonomously, through the use of the appropriate technical devices, not only put the focus on each child's cognitive abilities (understanding and fulfilment of the task and/or the problem) as well as the meta-cognitive abilities (planning, action, test, change, etc.), but also made them more "objective". In some cases this led to a revision of the entire individual educational project, based on a different evaluation of the child's cognitive skills. As a result, in two cases the educational project had to be redefined so as to consider a more complex scenario. In one case, the child's behaviour and his attempts made some specific difficulties of logical representation and planning of the action more explicit, requiring to a significant reduction in the difficulty level of the educational project.

5. A new role for AT

In this project AT played a very special role while also acquiring an unusual meaning.

First of all it developed its real function, i.e. to allow some children to overcome the difficulties implicated by their impairment, and thus to be able to play, a typical activity for their chronological age. But, while it made activities feasible that otherwise would have been impossible, it also became the essential opportunity to expand the development of these children. In other words, it became a sort of bridge to allow them to carry out some activities that have a positive influence on their cognitive development, learning, psychological well-being, and on the construction of their personal independence.

This original role of AT merits a critical analysis also from the perspective of the existing theoretical models in the field.

Cook and Hussey's [10] HAAT model (Human – Activity – Assistive Technology), as represented in Fig. 2, shows how AT can be effectively incorporated in a general model of human performance, with particular reference to a person with an impairment.

In this model the context in which the performance takes place includes cultural, social and environmental aspects and is the background within which the relationships between the different parts acquire their proper meaning and define their reciprocal connections.

Once applied to the specific situation involving a motor impaired child's play activity, the model effectively implements the interconnection between the elements

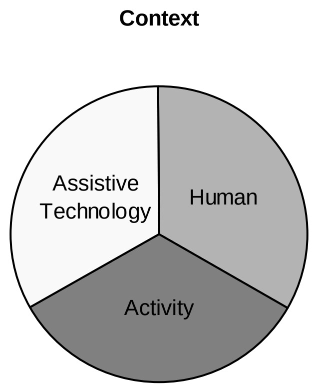

Fig. 2. From Cook and Hussey [10] (cit.), page 50.

to be considered in the AT device evaluation and selection phase. Nevertheless, as already discussed, in this case the singling out of the play activities – as well as of the best contextual situation for carrying them out – requires the inclusion of suitable psychological and pedagogical skills, in addition to the indispensable rehabilitative and technological capabilities.

Based on the results that emerged from the study, these evaluation processes can only be multidimensional and must include: the cognitive, learning, motivational and predispositional aspects, a specific evaluation of a child's preferred and accessible types of play, their level of complexity and, finally, the existing links between the growth of the play function and the other developmental functions. All these elements are indispensable to offer children a range of possible play activities that are congruent and consistent with their abilities, in which they can show and develop their preferences, by experimenting and trying.

As far as play is concerned, this process would seem to be quite recursive: if an initial evaluation (of the individual developmental characteristics – *Human* – and of the technological aspects – *Assistive Technology*) is necessary to propose the play activity (*Activity*), it is only when these activities are being carried out (the use of technology, the creation of a suitable play context) that it can be validated, confirmed or disproved, while making the modifications deemed necessary.

In addition, thanks to the psychological motivation offered by the context (strongly supported by the professional's didactic work), to the adoption of the proper devices and to the training advantages, this activity soon changes. It becomes more complex while offering new possibilities and posing new problems: the child changes, invents new solutions, expresses new needs and, as a consequence, the type and complexity of his/her play activity changes.

This process almost always requires modifications at all levels of the activity. Among others, it also requires a change in the device, or a modification of some of its operating modalities. Our experience has shown how crucial a careful evaluation of the child-machine interaction is in this phase, along with the timely implementation of all the regulations that become necessary each time, exploiting any possible regulation to achieve the highest possible level of individualisation in the use of AT.

In conclusion, the driving force behind the entire process would seem to be the phase involving the *use of AT*, within the context of active play. In fact, the real *played play activity* has proven to have positive feedback on the child's change by expanding his/her possibilities and paving the way toward new play requests and the exploitation of more complex and structured ideas. This change, in turn, requires further modifications to the other two factors, i.e. activity and/or technology. The process could be represented as shown in Fig. 3 (in which: C = child; AT = Assistive Technology; A = Activity).

The initial phase involving the evaluation and the choice of a suitable AT device and the ability to envisage the proper play activity for that particular child (with his/her physical, cognitive and psychological characteristics) is followed by a phase involving use, in which the child and the AT device interact to carry out the play activity. In this case, the last factor plays a special and decisive role, becoming a proactive experience with regard to learning and development. This leads to a change – to a certain extent – in that child, thus requiring further modifications with regard to the other two factors: activity and/or technology.

These considerations clearly show how play in this model is a special, multiform and continuously changing activity that the professional must understand and know how to deal with, continuously implementing the necessary adaptations. Since playing, by its very nature, lives off itself and not because of exterior objectives, the choice of any AT device must be made to achieve a degree of functionality and effectiveness for which the device becomes invisible and thus just a "simple" tool that allows children to fully immerse themselves in the imagined play situation.

6. Brief conclusions and some possible future developments

In conclusion, this experience – even considering its limited duration and restricted size of the study group – does provide some basic suggestions and possible methodologies for future developments regarding play by children with motor impairments: a sector considered very relevant and quite promising by many researchers.

In particular, this project made it possible:

- to confirm that the context of the play action is the real driving force behind the entire project, and affects all the necessary pedagogical, psychological and technological choices and modulations;
- to define the peculiar role played by AT in this case, making it possible to single out the differences and the reciprocal interactions between the evaluation and choice phase and the use phase, i.e. the play phase;
- to apply the Action-Research methodology to this specific and complex field, validating its effectiveness as a guide both for the action and for a critical review and research.

Some key points would seem to merit more in-depth theoretical and experimental analysis:

- the role played by the child-machine interaction in play development and in the activity in its entirety, and the specific characteristics of this interaction;
- the role played by the professionals who act as partners in the child's play activity, supporting the pedagogical aspects but also supervising the emerging technological needs; this role seems to activate Vygotskij's "Proximal Development Zone" of the child;
- the possibility of developing similar research and development projects, with a greater focus on the technological aspects, such as in the field of robotics;
- but, above all[15], the possibility of transferring the knowledge acquired from the study-group situation to children's life contexts (home, school, etc.). If it is evident for the case involving children with motor impairments that the play activity requires significant technological and scientific support, it is just as evident that play cannot develop within an artificial context if it is to help children unleash all their creativeness. In the near future perhaps it will be possible to reconsider, while updating and adapting it to the present situation, the method-

[15] My sincere gratitude to my colleague Maria Grazia Chinato for the conversation that provided the incentive for this final consideration.

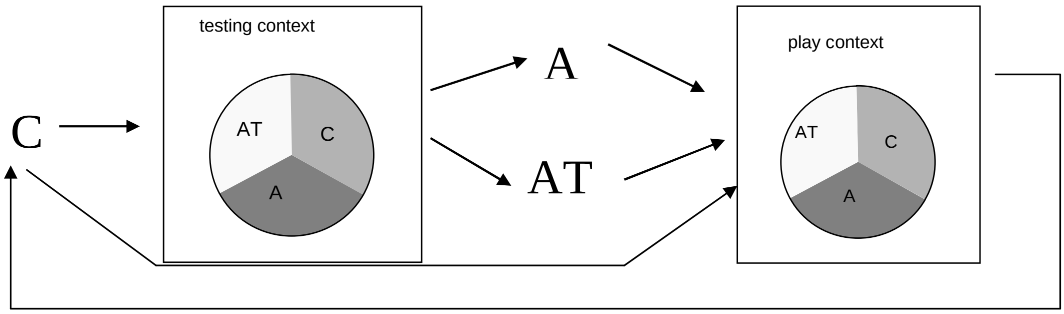

Fig. 3.

ological and philosophical approach suggested by Adriano Milani Comparetti [27]. He suggested that the rehabilitation professional should act as a competent consultant towards the family and the motor-impaired child to ensure that rehabilitation respects the rhythm and needs of the child's and promotes development that is as natural as possible.

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