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Theoretical Perspectives of Hands-On Educational Practices — From a Review of Psychological Theories to Block Magic and INF@NZIA DIGI.Tales 3.6 Projects

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Additional information is available at the end of the chapter

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Abstract

In this chapter, the main theories related to cognitive development are discussed, starting from psychological discussion up to theories application to training, pedagogical and formation sciences issues.

We start from the classical contribution by Vygotsky and Piaget to arrive to the recent embodied cognition approach.

This theoretical excursus leads us to describe two projects we are involved in: the Block Magic project and INF@NZIA DIGI.tales 3.6. The goal of Block Magic is to introduce a new teaching methodology and technology targeting young children between the ages of 2.5 and 7 who are attending pre-school or the early years of primary school. The project aims at helping young learners to learn autonomously. This, the authors believe, is a basic life skill, of critical importance for their future development.

We then describe INF@NZIA DIGI.tales 3.6 project, an Italian project aimed to promote the use of ICT technologies and the latest paradigms of human-computer interaction (augmented reality, RFID/NFC sensors, handwriting and speech recognition, motion detection, etc.) in order to define psycho-educational practices, which are able to enhance curricular activities and facilitate acquisition processes for skills and knowledge for pupils.

Keywords: Hands-on practices, Embodied cognition, ICT tools for learning, Logic blocks, Learning processes

1. Introduction

Digital learning games have become a reference point in the educational field, in terms of positive effect of their use on learning and motivation [1,2]. However, why they are used in education is an interesting issue to be investigated from a broad perspective including, on one hand, the psychological processes underlying learning and, on the other, the potential new technologies offer. In this chapter, we will try to describe both mentioned perspectives and to illustrate how they may concretely interact through two project descriptions.

Since their birth and maybe even before, children start learning about the world around them. Day by day they can count on wider sensorimotor functions that open their cognitive development in new ways.

In the period of their life that goes from few months to 3–4 years, the hands are fundamental in conveying knowledge. A child points something and he/she handles, touches, tastes and manipulates while understanding an object's features and functions.

These everyday observations eminently reflect in psychologists' perspectives; consider, for example, Piaget [3], Papert [4] and Bruner [5] who recognise a fundamental role to manipulative activities for psychological development and cognitive representations at birth. Also Vygotsky [6], the other giant father of cognitive development theory, believed that interaction with the environment was an important way a child could learn, not the only one indeed. In his opinion, cognitive development relies on input from other people as well, thus underlying the importance of the historical and cultural context children live in.

Of course, learning in adults is not limited to pointing, reaching, touching and manipulating as, along human cognitive development and thanks to learning processes, the 'concrete' manipulative acts are gradually interiorised and become part of our neurocognitive structures. They are not actually performed as they are but they become 'simulated' actions (symbolic acts) in a virtual (mind) space [7].

In spite of this interiorisation, the use of hands (or more in general, the body) together with the related cognitive representation of physical space is a latent and essential psychological resource for learning and developmental processes. They can emerge when the context and the environmental conditions allow humans to use hands and their representation. It is a sort of bias that is, probably, the main reason why we think about Internet as a geometrical (virtual) space or why the (computer) 'mouse' and the 'touch screens' are immediately intuitive. Adopting this view, the mouse extends 'pointing' and 'reaching' actions in a computer screen graphic space, and the current 'touch-screen' technology allows us to manipulate digital virtual objects. Recently, new technologies are candidates to enhance our attitude to learn by manipulating. If we equip common objects with sensors and connect them in wireless mode with a remote computer, we build something similar to what is called Internet of Things [8] that permits an easy interaction with (smart) objects through new interfaces (glasses, gloves, visors, etc.) or by traditional manipulation coupled with (sophisticated) computer programs (see, e.g. handwriting recognition systems).

We think that the new chances offered by the smart object technology could produce innovative learning/teaching environments to enhance neurocognitive development especially in training context. Moreover, with these tools, we could recover traditional and well-known psycho-pedagogical practices that are not widely and massively applied because of their expensiveness. For example, these technologies can be applied to traditional educational materials like logic blocks or teaching tiles. These are manipulative materials specifically designed to teach a wide range of subjects (mathematics, geometry, languages, geography, etc.) and abilities or soft skills (problem solving, creative thinking, cooperative behaviour, etc.) for children aged from 3 to 10. These materials have a strong drawback: they can be used individually or in small groups of students (3–4 children maximum) and require a constant supervision by teachers, parents, educators, etc. This represents a strong constraint, also economic, for their wide employment. But we think that smart technologies (software and hardware) can be exploited to overcome this constraint and express the huge educational potential lying in these materials/practices.

The aim of this chapter is to explore the principal approaches to the learning process from the cognitive one to the embodied cognition through the constructivism. This theoretical excursus will lead us to describe two projects we are involved in: the Block Magic project and the INF@NZIA DIGI.tales 3.6 project. These projects have produced interesting educational applications that can help in enhancing traditional educational materials to make them meet the technological challenge.

2. Theoretical perspectives: General principles

Learning can be defined as an enduring and stable change in the individual potential behaviour, as a result of practice or experience (Fig. 1). Learning occurs throughout life for animals, and learned behaviour represents a large proportion of all behaviours in higher animals, especially humans. In humans, learning is strictly connected to development in cognitive, emotional and social sphere, and it implies the human skill of giving sense, coherence and meaning to experience too. The complexity of this process is evident for the reader when he/she thinks that everyone is constantly subject to a huge amount of information coming from the context the individual is immersed in. This information can potentially become learning materials, but actually most of them disappear in an individual's mental life, whereas some others are recorded in memory.

From a psychological perspective, there are three key-points of learning process (consider the definition at the beginning of this paragraph): 1) observed change in the individual's behaviour, 2) change resulting from experience and 3) 'potential' behavioural change that does not have to be actual.

Furthermore, Gagné [9] emphasises that learning is a change, observable in behaviour, that can affect attitudes or human ability, which can be stored and which cannot be simply attributed to growth.

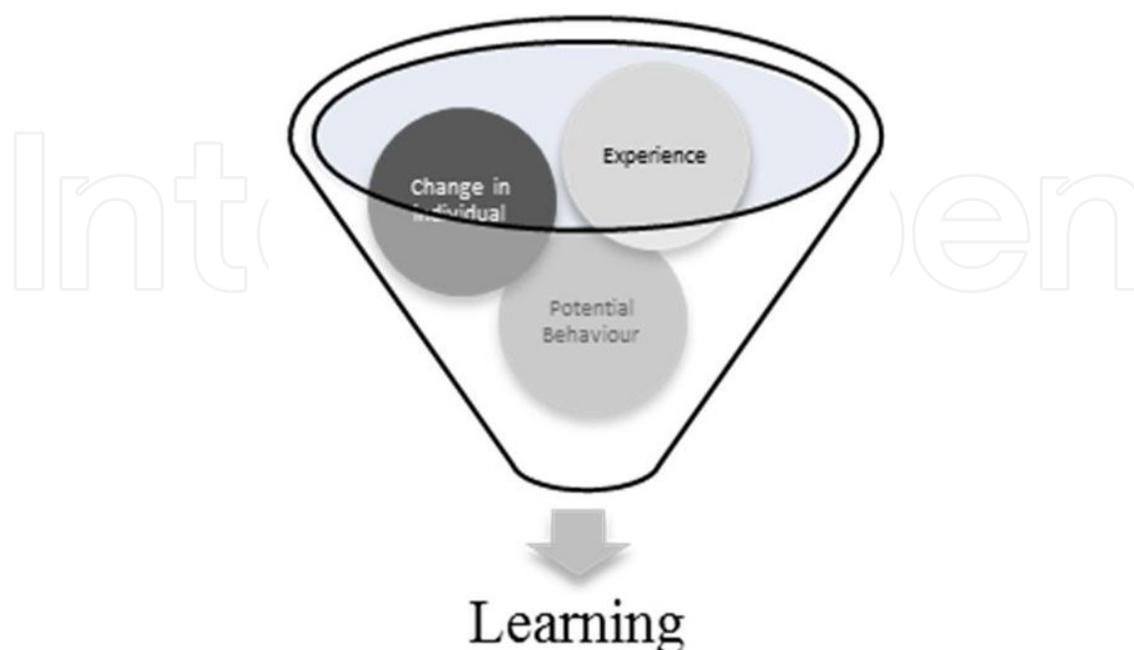


Figure 1. What is learning?

In a more practical view, learning ‘programming is not seen simply as a technological development incorporating previously established learning principles, but rather as one particular form of the ordering of stimulus and response events designed to bring about productive learning.... (If) one wants to investigate the effects of an experimental treatment on the behaviour of individuals or groups who start from the same point, he would be well advised to measure and map out for each individual the learning sets relevant to the experimental task’ [10].

Even if the practical aspect of the teaching/learning process depends on the specific didactic topics, it is possible to underline various common steps that Gagné and Briggs [11] have focused on in order to describe the learning process events. The author has broken down the process into an elementary task sequence or behavioural objectives that were presented to the learner who was given immediate feedback on his/her responses (Fig. 2).

How to accomplish these steps and how to promote and stimulate learning are relevant issues that have been variously interpreted in psychological literature. Here we report three approaches that provide interpretative frameworks and operational guidelines that are significant in educational psychology and pedagogy too: behaviourist, cognitive and embodied cognition approaches. These three approaches can be seen as points along a continuum, with continuity and discontinuity elements, leading to embodied cognition notions that represent the starting point of Block Magic project rationale referred to in this chapter.

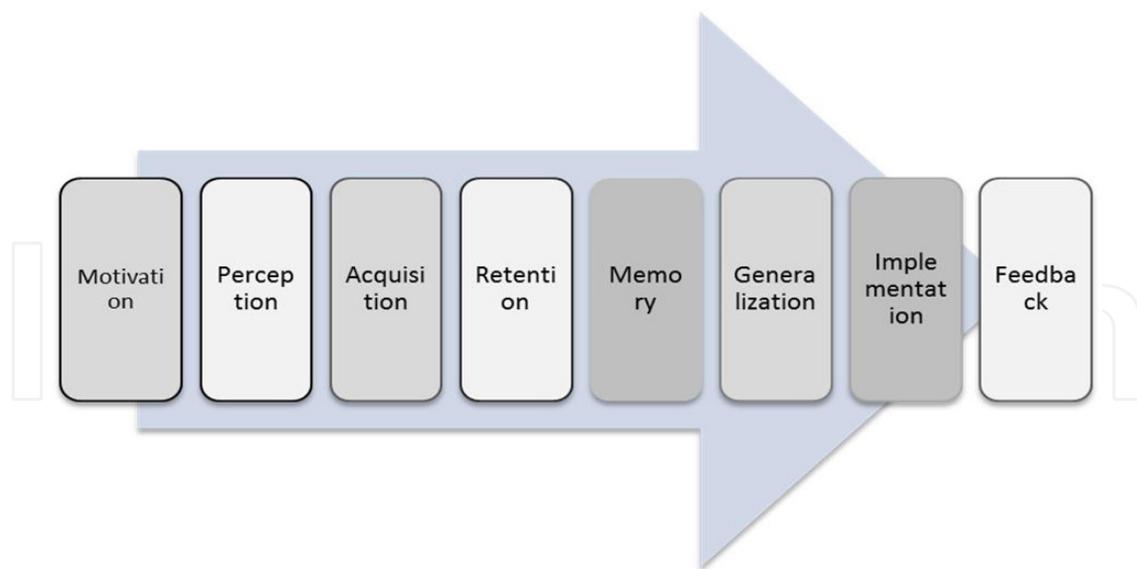


Figure 2. Basic principles of learning process

3. A Behaviorist perspective: Associative learning

According to the behaviorist approach [12], learning is seen in terms of connections (associations) between stimulus (or stimulus–situation) and response and between response and reinforcement. Learning means that behaviour (objectively observable) can be modified by reinforcements that in turn can produce conditioning [13] or operant conditioning (Fig. 3). In this context, environment is fundamental, because it can produce learning only if it is properly structured.



Figure 3. Operant conditioning

Pedagogy practice based on associative principles involves identifying the components of learning competences, sequencing these in complexity terms and providing clear tasks with immediate feedback. The sequence is then adjusted according to learner performance. The underlying assumption is that learning consists of building on simpler behaviours, a quantitative increase where existing knowledge and procedures are merely added to the previous ones.

3.1. A cognitive perspective: Piaget, Vygotsky and Bruner and the constructivist approach

Since the 1950s and 1960s, thanks to Gestalt psychology, Tolman and Piaget contribution, psychologists have focused on the cognitive process underlying learning. In opposition to behaviorism, they explored what was behind behaviour: thought, mind and mental representation, trying to describe their mechanisms (Fig. 4).

In cognitive perspective, learning is not a sum of fragmented activities, but the knowledge of relationships, meanings and situations. Furthermore, problem solving does not derive from trial and error, but from the understanding of a certain problematic situation structure. Cognitive learning involves higher mental functions such as attention, perception, memory, intelligence and general cognitive processes belonging to humans: the change is not only in the behaviour but in internal structures and processes too, which in turn acts on individual behaviour. This change can arise from active thoughtful participation, whereas learning arises from the interaction between new experiences and existing internal pattern.

In this context, the central issue is how we represent knowledge and develop our concepts and understandings. According to McKendry [14], we learn as a result of the interaction between new experiences and existing understanding structures, previously created.

It is worth underlining that cognitivist authors have formulated some of the most relevant theories in educational and developmental psychology. We will now briefly describe the ones which have direct implications for our discussion on learning.

According to cognitive perspective, Piaget [3] – who is, as reminded above, one of the most influential developmental psychologist – has explored the process by which children develop their knowledge of the world in cognitive terms. Using a clinical–critical approach and by observing his children for a long time, Piaget came to the conclusion that two cognitive processes are responsible for human cognitive development: assimilation and accommodation. These processes are the basis of learning process and define children development in cognitive terms.

The first one (assimilation) refers to the acquisition of an object/event in pre-existing cognitive or behavioural schema; the second one (accommodation) refers to the change of the schema subsequent to new events/objects. These two processes alternate in order to achieve a dynamic equilibrium. In other words, learning is based on the balance between assimilation and accommodation, and it is based on the new information integration in pre-existing cognitive structures. The development of these structures is innate and fixed, and it is organised in universal subsequent steps/stages. Learning, in this perspective, develops with doing. The educational context can only tune itself with the developmental stage the child is in, so as to offer the proper chance of doing to learn.

According to traditional interpretation, the Piaget approach can be seen in opposition to the Vygotsky conception of learning. The key-point of this opposition is the context role. From the Piagetian point of view, social and cultural context does not play an important role in cognitive development, whereas for the Vygotskian framework, context promotes learning and development in cognitive sphere.

Vygotsky [6] holds that child cognitive development derives from the interaction between person and social context. More specifically, an individual interiorises cognitive functions through language that shapes social interaction. The social context (or other significant people in the learner's life) can help, support and facilitate the learning process and, in particular, it may have an impact on the zone of proximal development (ZPD). The ZPD is a cognitive area where the child can go beyond his/her current knowledge level and development through the support of a competent adult, representing a social stimulus. The higher mental processes are created through socially meaningful mediated activity.

Translated in pedagogical language, teachers have to encourage learners to build their own mental structures through interaction with the environment. Moreover, Vygotsky has introduced the 'scaffolding' notion to suggest that an important role is played by learners who, with the assistance by someone more experienced, can achieve cognitive results they would be otherwise unable to. The teacher's role as scaffolder involves guiding students towards activities that they are likely to find engaging and from which they will probably learn. However, rather than playing a didactic role, the teacher must encourage students to think by themselves, to raise issues and questions related to didactic activity and to identify problems they can face and solve. In brief, pedagogy based on constructivist approach bases on the following principles: creating an environment where learners can become actively involved, setting up activities that encourage experimentation and discovery and interactive and student-centred activities, locating learning within the ZPD and scaffolding through encouragement and support for raising questions and reflecting on principles.

Building on Piaget and Vygotsky theories, Bruner [5, 15], in his theory, has stressed both the learner active involvement (Piaget) and social context (Vygotsky) roles, and he has proposed a cultural approach to learning process and cognitive development. According to Bruner [16, 17], learning is a complex activity in which three processes interact: 1) information acquisition, 2) information transformation/manipulation in a new form that is suitable for problem solving and 3) checking of this transformation efficacy. Information modification (2) is linked to three representational methods that depend on individual culture and maturation: action system, iconic system and symbolic system [18].

From an ontological point of view, child learning can be divided in four stages: 1) ability of acquisition, 2) reflexivity, 3) sharing and 4) culture. Extending the social context and language importance underlined by Vygotsky, Bruner emphasises the role of culture in human development. Culture is a collective and shared interpretation of reality, and the individual mind has an interpersonal nature. Learning is an interpersonal and relational activity strictly linked to the 'where and how' of the knowledge; in other words, learning is a 'situated cognitive action' [19].

In Bruner's words: "the active participation in the learning process by the child might result in the following hypothesized benefits: an increase in intellectual potency so as to make the acquired information more readily viable in problem solving, the action of the learning activities in terms of the intrinsic reward of discovery itself (as contrasted with the drive-reduction model of learning), learning the heuristics of discovery, and making material more readily accessible in memory" [20].



Figure 4. The learning process from a cognitive perspective

Bruner intuitions have given important hints to successive cognitive authors; consider, for example, Papert and Jonassen who have emphasised the person's active role in experience comprehension using cultural and contextual resources. Other important concepts of constructivist approach such as 'discovery learning' [21] and 'meaningful learning' [22] are based on Bruner's conceptualisation of culture and manipulation.

3.2. Situated learning: The role of embodiment

As it is evident from the previous paragraphs, activity has a central role in learning process: it is a core process in Piaget theory, it is fundamental in Bruner approach and it has a transformative power if supported by external stimuli for Vygotsky. In particular, the concept of action becomes central for the situated learning theories [23, 24]. These theories belong to a theoretical framework in which authors emphasise sociocultural aspects of learning and cognition. The idea is that the knower cannot be separated from the known; knowledge and learning are the results of social activity in context [25, 26]. Therefore, situated learning includes participation as a key concept; participation can be seen as 'being a part' with a critical importance of contextualisation in learning. Teaching strategies based upon participation can encourage collaboration amongst learners [27]. This way, learners can become part of the community. Learning can be described in terms of action and participation in a community of practice. In this framework (as well as in the previous cognitive theories), the concept of activity defines a cognitive process somehow detached from the body. In the traditional vision of learning, the attention on the person complexity was simplified, focusing on mind in terms of cognitive processes.

However, it should not be neglected that the body plays a fundamental role in the interaction between the person and context. In a wider perspective, having a body is essential for agents of different kinds, and it becomes a powerful vehicle to acquire knowledge.

Let us consider, for example, artificial agents provided with bodies with sensors and actuators, such as robots [28] that have to orient in space, a quite complex cognitive task. Being embodied allows these agents to find effective solutions to spatial tasks [29, 30]: embodiment conveys knowledge. In authors' words: embodied cognition view 'emphasizes the role of coupled interactions between organisms and the environment in the development of cognitive processes, capturing the way mind, body and world interact and influence one another to promote the adaptive success of an organism' [31].

Also authors in cognitive psychology framework regarding humans exalt the body role as well.

Piaget describes it as one of the first instruments used to know the world (e.g. see sensorimotor stage in the Piagetian theory). In more recent years, Galperin [32] retrieves the body importance too. According to this author, the mental object-oriented activity is the result of initially materialised object-oriented activity. Or, in other words, the physical manipulation of objects represents the basis of human thought. Rambush and Ziemke [33] identify in Galperin approach a bridge between situated learning and embodied cognition research that affirms that cognition is a continuous process with changing boundaries and much more than what takes place within the individual mind. This idea has been considered by an increasing number of scientists in various areas of research (e.g. see [34] for neurosciences and [35] for philosophy).

As Rambush and Ziemke argued, 'the embodied cognition is in many aspect a very social process, and that embodied social process such as mimicry and imitation are significant for social relations as they help people connect, making it possible for them to communicate and to understand each other' [33]. In this trace, Roth [36] demonstrated that gestures not only reflect learning but also contribute to it, serving not only to communicate content to a public but also to help the speaker in making things clearer and more understandable.

3.3. CAI, LOGO and smart objects: Making connections between technology and learning

Learning theories have their counterpart in pedagogical practices and in learning technology. Technology is a mirror of the times, and the development of educational practices is reciprocally linked to technology advancement.

In this respect, although teaching machines may be historical artefacts, theoretical perspectives have stimulated technological applications. Behaviorist principles underlie methods such as computer-assisted instruction (CAI) where rapid feedback is given on the correctness of learner response (e.g. mathematical routines presented as a game with extrinsic rewards).

Cognitive principles underlie methods such as LOGO [37, 38], a programming language created as the first children toys with built-in computation, described as follows: 'children might come to want to learn it because they would use it in building these models. And if they did want to learn it they would, even if teaching were poor or possibly nonexistent. Moreover, since one of the reasons for poor teaching is that teachers do not enjoy teaching reluctant children, it is not implausible that teaching would become better as well as becoming less necessary. So changes in the opportunities for construction could in principle lead to deeper changes in the learning of mathematics than changes in knowledge about instruction or any amount of "teacher-proof" computer-aided instruction' [39]. LOGO and Lego/LOGO constitute outstanding examples of how technology can provide new ways to learn.

In recent years, the technology progress produced smart objects, everyday objects augmented with computational services [40] that can have a central role in educational psychology based on both situated learning and embodied cognition principles. In addition, mobile devices that are mainly used for communication, entertainment and as electronic assistants may be used as intermediaries between us and the smart objects in our surroundings for their increasing computational, storage, communicational and multimedia capabilities [41].

Starting from the innovation in the individual–environment interaction offered by the smart objects technology, our idea is that we can produce innovative learning/teaching environments (according to constructivist learning theories and extant pedagogical practices) to enhance neurocognitive development especially in training context. This proposal will be discussed in detail in the next paragraphs.

4. From TEL to STELT: Technology-enhanced learning becomes smart technologies to enhanced learning and teaching

The review proposed in the previous section highlights the fundamental role played by learning theories for building effective educational tools. Technology can be a powerful weapon in this battle, provided that we conceive it as an empty bin whose sense is given by the reference theory. In Dror's words [42], 'learning means that the cognitive system acquires information and stores it for further use...regardless whether the objective is learning new information, acquiring new skills, or knowledge sharing and transfer within or across organisations — the processes of acquiring, storing and applying the information are critical. The question is how to achieve these cornerstones of learning and whether technology can enhance them. The answer is clear: learning must fit human cognition...the difficult and tricky challenge is how to translate this theoretical and academic research into practical ways to utilise technology so as to enhance learning'. An entire area of research, known with the acronym TEL, developed in recent decades.

Technology can obviously enhance learning if it mirrors how cognition works. This can be achieved through the appropriate design. Design is indeed fundamental to the successful development of any technology-enhanced learning scenario and requires input from many diverse areas of expertise and multiple perspectives [43].

Some technologies are precisely fit to stimulate learning by doing, as they are based on the theoretical framework already described. These technologies are not purely instructional: in the past years, many tools have been conceived as teacher substitutes in a vertical unidirectional lesson transmitting their specific knowledge domain. More recently, technology offered new chances, thus allowing to build TEL environments that can offer direct experience to the learners. In particular, we would like to introduce the STELT platform precisely devoted to build active environments for learning [44, 45], represented in Fig. 5.

STELT is a software platform that combines the management of hardware components (sensors and actuators) and software components (libraries for the storyboard and provision of feedback, authoring systems to be used by nonprogrammers) which are required to construct educational, teaching and play materials that exploit the potential of new technologies into a single development environment. STELT is able to support environments based on the handling of physical object that have a central role in learning by doing framework.

STELT, created by AIDVANCED SRL, implements augmented reality systems based on RFID (radio-frequency identification) and NFC (near field communication) technology. The labels

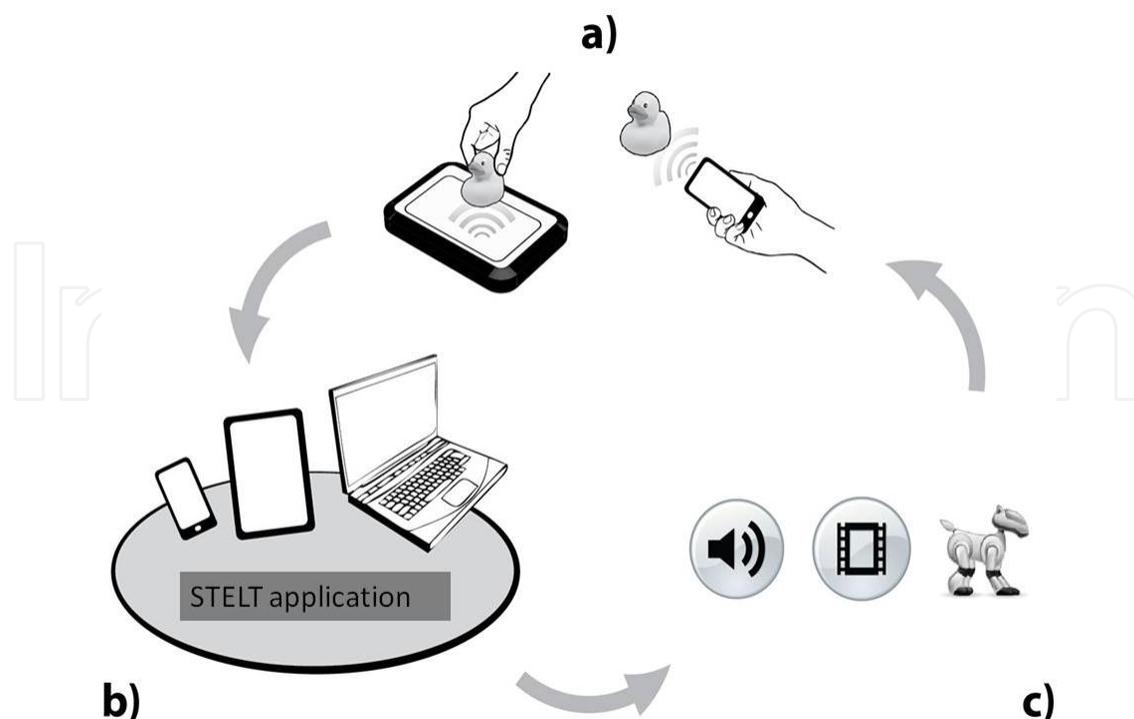


Figure 5. STELT platform functional representation

RFID/NFC (tag) are very thin transponders that can be applied to any type of object and are detected by small readers. The reader can be connected to a computer with either a wired or wireless connection or integrated into standard equipment on smartphones and tablets (NFC sensor). STELT combines communication protocols with the various hardware devices (readers and output devices), a storyboarding environment for creating various interaction scenarios, a database for tracking the user's behaviour and an adapting tutoring system that can build a user profile providing customised feedback.

This platform is functionally represented in Fig. 5: a) the learner places a «tagged» object onto a tablet reader or moves a reader or smartphone close to the «tagged» object; b) the signal containing the object's code is sent to a computer (desktop, notebook, tablet or smartphone) containing the STELT platform; and c) once it has entered the STELT system, the signal generates a number of actions from the output devices (audio system, monitors) depending on the current scenario created with the storyboarding module. Furthermore, the same signal is memorised and analysed by the adapting tutoring module, so that a customised profile is created for the user that guides the subsequent system responses. Human-machine interaction takes place solely by the handling/identification of physical objects and by the activation of audio or visual feedback. The originality of STELT resides in the combination of communication protocols with various hardware devices (readers and output devices), a storyboarding environment that allows to design many different scenarios, a database for tracking the user's behaviour that collects huge information amount and an adapting tutoring system that can analyse and interpret such behaviour and provide relevant feedback. All these components are provided into a single development environment. This combination allows the creation of

different and easily customisable application environments and the direct tracking of all the activities during the session. From a technical point of view, STELT is a SDK (software development kit) containing software libraries for sensor, storyboarding, monitoring and adapting tutoring management and for the creation of applications in Windows (Vista, 7 and 8), Android and iOS environment. The SDK also contains authoring systems that allows nontechnical people with no specific technical background to directly design educational scenarios.

STELT platform has been used to implement different products. In the next section, we will describe Block Magic, a hybrid physical/software tool that enhances traditional blocks and methods for teaching in kindergarten and primary schools.

5. Block Magic project

Block Magic is a prototype for educational materials developed in a successful European research project under the framework of LLP-Comenius programme. It aimed at creating a bridge between physical manipulation and digital technology in education. Block Magic developed a functional prototypal system that enhanced the logic blocks box. The prototype is made up of an active desk/board able to recognise concrete blocks equipped with the RFID passive tag and to communicate with a PC, an augmented reality system.

In Figs. 6 and 7, BM kit and BM functional representation are reported.



Figure 6. Block Magic kit

The BM platform consists of a set of magic blocks (48 traditional logic blocks), a magic board/tablet device and a specific software. It is based on STELT platform introduced above and links together smart technologies and physical material to support children learning processes. It unites the manipulative approach and touch-screen technologies.

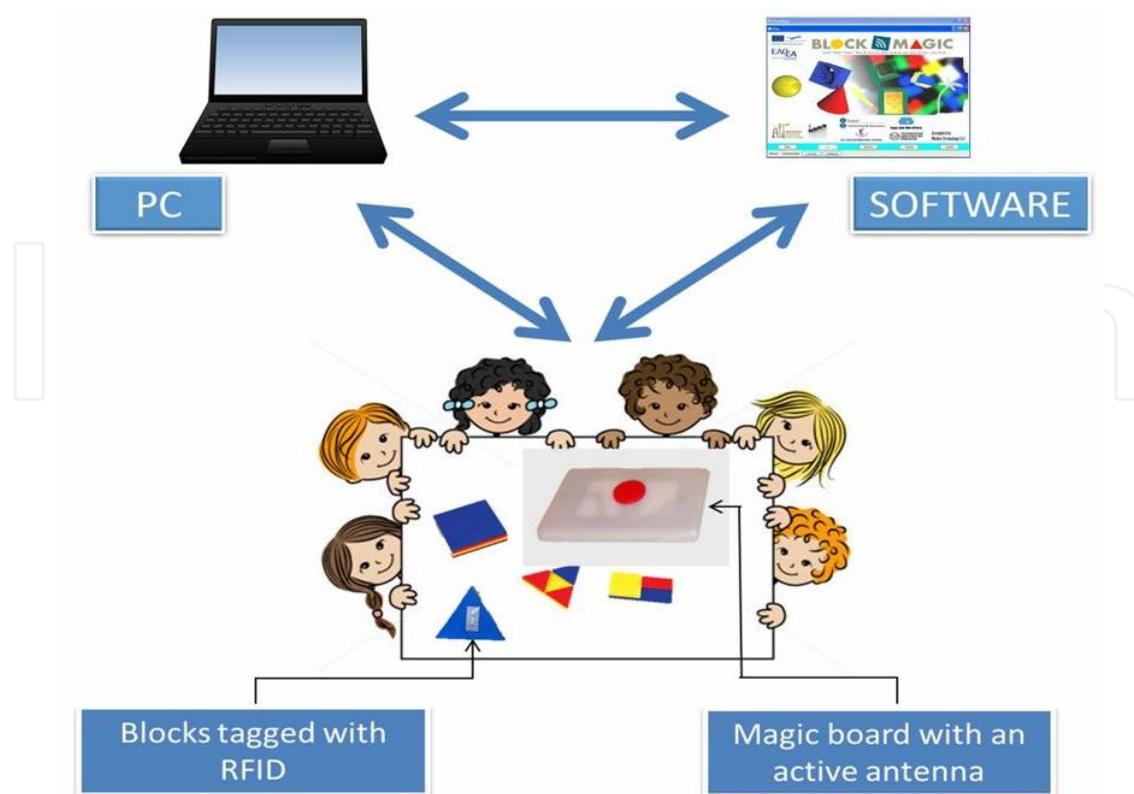


Figure 7. Block Magic functional representation

BM materials derive from structured materials, classically used in education. Structured materials have fixed numbers of ‘n’ elements, ‘m’ categories and rules to connect single parts that represent the structure. Logic blocks, cards, teaching tiles, etc., are structured materials typical examples. These materials promote analytical thought, as they segregate single qualities (e.g. dimension, shape, colour, etc.) and allow first to focalise attention on an object single part and then to develop clustering and serialisation ability in order to understand the objects’ features.

The technology used in the BM project is the RFID/NFC, radio-frequency identification/near field communication. The RFID system consists of an antenna and a transceiver, which is able to read the radio frequency and transfer the information to a device, and a small and low-cost tag, which is an integrated circuit containing the RF circuitry and information to be transmitted.

These technologies are simple to use, so they are interesting for applications rather than on technical level.

The BM teaching kit consisted of a set of magic blocks (48 traditional logic blocks) and a magic board/tablet device. Magic blocks are derived from logic blocks which are didactic materials used worldwide in kindergartens and primary schools [46]. They are made up of a set of blocks (usually 48 pieces) divided in four groups according to different attributes: geometric shape (triangular, squared, rectangular and circular), thickness (thick and thin), colour (red, yellow and blue) and dimension (big and small).

The BM project proposes a hybrid version that allows an enhancement of traditional logic blocks, equipping them with RFID tags. This configuration permits to a PC or a table, with BM software installed on, to connect with BM Magic Table, another relevant BM material. The Magic Table has a hidden antenna that recognises each block, sends a signal to the PC/tablets and produces a feedback coherently with pupils' learning path.

Each augmented magic block had an integrated/attached passive RFID sensor for wireless identification of each single block. A specially designed wireless RFID reader device, an active board, is used which could read the RFID of a block and transmit the result to the BM software.

The BM system aimed to stimulate and teach different skills such as logic, mathematics, languages, etc.; therefore, the described BM-enriched blocks together with the Magic Table are complemented with a software that includes a series of exercises that researchers involved in BM project built on the teachers' feedback and on their previous experience in pedagogy.

The BM software is mainly formed by two parts: the first one is devoted to receiving input from the active board and generating an 'action' (aural and visual). These actions implement the direct feedbacks the user can receive interacting with the system. These feedbacks are regulated by an adaptive tutor system embedded that ensures autonomous interaction between the user and the system, receiving active support, corrective indications, feedback and positive reinforcement from the digital assistant on the outcome of the actions performed.

The second software component is devoted to customisation too, but it is dedicated to teachers, educators, etc., allowing them to choose the exercises to be proposed to the child, focusing the attention on the skills the child needs to train more. The BM software moreover can collect data about the exercises.

Preliminary trials with Block Magic prototype were run in various schools in Germany, Greece, Italy and Spain, involving children aged 3 to 7. Observations were run on children and the teachers were involved in after-session focus groups. Results confirmed Block Magic educational platform effectiveness in educational context. In particular BM attractiveness emerged strongly: the tool is very attractive for children for many reasons. They especially like to use the tablet and the computer and are attracted by visual and aural stimulation as well as the mascot 'Blocki'. It is motivating for the students to use a computer-based system that the manipulation of real objects makes it even more fun. Teachers think that children found both visual and aural presentation of the tool attractive, and the use of text, graphics, sound and pictures is perceived as balanced so the children did not get bored. They stayed happily until the end of each session and even wanted to continue playing.

Teachers also notice that children like to hear their names from the computer and feel like participating in a real game. Also receiving an appropriate feedback is crucial to keep a high motivation level. Children with special needs find the tool attractive too.

The researchers investigated BM use in relation with specific skills: in teachers' opinion, it contributes to develop specific cognitive skills; in particular it is fit to improve mathematical and logical skills. All teachers accepted that the tool offers a variety of activities that encourage children to develop mathematical skills. Also imagination is stimulated by BM. In detail, the

‘Creative Drawing’, ‘Logic Train’ and ‘Slice the Shape’ were identified as the exercises that motivate children to use their imagination.

Then the questionnaire and the focus group compared the use of BM with traditional blocks: teachers agreed that the most relevant aspect was the feedback provided by BM system that allowed many children, especially the older ones, to interact autonomously with exercises. Block Magic meets the new IT generation and is an interactive tool, but there are constraints in terms of creativity and imagination that, on the contrary, are better stimulated by traditional blocks. Moreover, teachers underlined that Block Magic creates more possibilities for the teachers than the traditional logical blocks: there is a wider variety of exercises, some of which are more difficult to play in traditional settings. With Block Magic, children can work (almost) unattended and they can spend more time with it.

It is useful to underline that these aspects emerged in all trials, thus meaning that children interact with BM platform in a similar way across different countries and cultures.

6. INF@NZIA DIGI.tales 3.6 project

The second project we are going to describe in this chapter is INF@NZIA DIGI.tales 3.6. It is an Italian project aimed to promote the use of ICT technologies and the latest paradigms of human–computer interaction (augmented reality, RFID/NFC sensors, handwriting and speech recognition, motion detection, etc.) in order to define psycho-educational practices, which are able to enhance curricular activities and facilitate acquisition processes for skills and knowledge for pupils.

According to the literature described in the first part of this chapter and basing on evidences from Block Magic, the INF@NZIA DIGI.tales 3.6 project addresses a specific topic related to the link between cognitive development in childhood and technology use in both formal and informal teaching/learning contexts. Developmental psychology highlighted that multiple levels of organisation contribute to child growth: biological, psychological and environmental conditions influence each other in a dynamical way. This interaction is easily observable during school time (kindergarten and primary school), a period in which the complexity of systems and environments that begin to interact with each other is amplified. It is precisely the interaction between different factors (cognitive and socio-relational) and different settings to highlight gaps. One of these gaps, particularly relevant in our opinion, is that many children today are living with a serious technological gap between the various educational contexts in their lives: on one hand, they attend schools that are still technologically stagnant; on the other hand, they can use much technology at home, made up by platforms for game consoles, smartphones, Internet, etc. This technological imbalance has increased recently, due to the introduction of touch-screen tablets and their numerous ‘educational’ applications, which are particularly suitable for very small children (2–6 age group). Indeed, the domestic environment is experiencing an ever-increasing use of technology: it is foreseen that tablet use in Italy, for example, will increase from 15 % to 28 % by 2016 (source: eMarketer), while greater increases have been projected for other European nations, such as the UK, Germany, France and Spain.

Projections issued by the International Data Corporation (IDC), updated in March 2013, predict that the global tablet market reaches 190.9 million units this year, an increase of 11 % between 2013 and 2016 that will reach 350 million by the end of 2017.

Tablet technology for children aged 2 or more precisely has a strong educational potential as confirmed by large-scale distribution and commercial success of educational Apps both for iOS and for Android (to mention the most popular operating systems) implemented by compatible software house. These new technologies and their content cognitively stimulate children, but the downside is that they often engage children alone and without the intervention and supervision of a responsible adult.

Specifically in Italian context, the Digital School curriculum of the Ministry for Education has ensured that Italian schools are gradually making use of the well-known interactive digital whiteboards, but distribution is still marginal and the technology, in the meantime, has been rendered obsolete by more modern touch-screen technologies. Most of the instruments used in preprimary and primary schools are not based on ICT technology: preprimary institutions mainly use materials which involve handling, as is the case for the first years of the primary cycle where initial fundamental learning is based on the acquisition of cognitive skills by way of developing natural motor and sensory abilities.

In order to achieve this gap overcoming, the INF@NZIA DIGI.tales 3.6 project is defining psycho-educational practices able to foster curricular activities and facilitate the acquisition processes of skills and knowledge in pupils and to implement an innovative model for the digital educational publishing for the primary school. Thus, this model will support the curricular school activities through the digital and technological empowering of the materials (e.g. schoolbooks) of the institutional and regulatory educational framework (see European Digital Agenda 2012). The sphere of action chosen for the project is constituted by preprimary and primary school system, which has been charged by the Italian Ministry for Education to promote the development, identity and abilities of our youngest citizens and introducing them to their civic duties, in accordance with the right to education and care, in coherence with principles of cultural pluralism as stated in our constitution, the International Convention on the Rights of the Child and in various other reference documents of the European Union. More specifically, the INF@NZIA DIGI.tales 3.6 project is aimed at children aged 3 to 6, thus including the first year of primary school, with the goal of renewing teaching and learning models in an educational context in this teaching segment. The INF@NZIA DIGI.tales 3.6 project also involves the 'significant others', actors of teaching/learning process in both formal and informal contexts: teachers, parents and families.

In brief, the model consists of interactions between different components and steps. The first of these steps consists of transforming curricular activities in digital micro-games that could be selected by teachers or tutoring systems. The child answers (in other words, the successful/not successful conclusion of micro-games) impact on the proposal of subsequent micro-games in a manner akin to the personalisation of school curriculum. A broader tutoring system could retrieve and analyse the data/answers to micro-games and socialise the results to the other actors of the teaching/learning process.

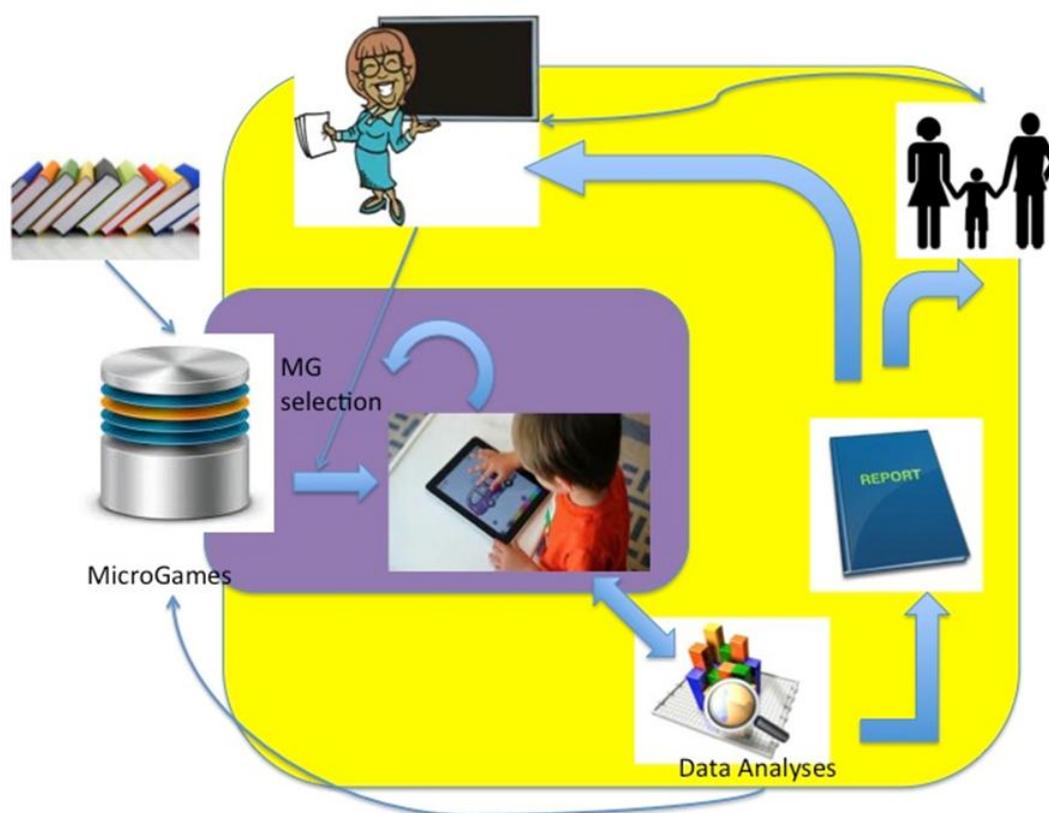


Figure 8. The INF@NZIA DIGI.tales 3.6 functional model

More in detail, on the basis of the state of art in the field of developmental psychology, school activities and new technologies, the INF@NZIA DIGI.tales 3.6 project individuates the following key elements as central for the empowering of the current curricular learning materials:

- Multimedia = the ability to develop a digital and empowered learning material available on different tools and OS. This approach allows different learning processes and different stimuli that each teacher could tailor on his/her own needs.
- Multimodal = the opportunity of the platform to exploit more interactive solutions. The user will interact with the platform developed in the project with different modes, i.e. voice, gesture, materials, handwriting and touch.
- Computing = the technologies that allow the customisation of the contents and the advanced adaptive assessment and assistance for the users.

In our opinion, these key elements could be essential for modernised learning, teaching and assessment practices through digital technologies, namely, through the following actions:

- Tracking the learner data during the execution of the training activities: the system could record each activity during the game session, and then the teacher will be able to access the personal control panel to check the raw tracking data collected from the platform.
- Using an immediate feedback for the learning activity: the child has immediate confirmation of response correctness. Currently, the child has to perform exercises, but the feedback is given collectively only in certain time windows, which can potentially be far from the intellectual effort made by the child. This discrepancy can lead, in the worst cases, to the ineffectiveness of the correction. The digital technologies could easily prevent this problem, correcting immediately incorrect answers and giving positive feedback when the exercise is well performed.
- Developing advanced reporting: the system will provide data analysis about results obtained from the exercises execution, which will be visible only to certain users (teachers, enabled parents, etc.). Teachers and parents will be able to see the pupil's learning evolution, with a final assessment that will contain tips, suggestions and observations.
- Allowing the surprise and interactivity increase: the child will have a higher satisfaction degree in the use of interactive material, both from the point of view of internal game dynamics and from the recognition point of view (the system calls by name every single child).

A secondary effect of the use of INF@NZIA DIGI.tales model addresses the social identity formation process that is one of the most important developmental tasks for the child, and it is strictly linked to learning. According to this view, the building of knowledge emerges concurrently and is facilitated by the formation of a social identity, which is shared with the community, by means of carrying out common activities. INF@NZIA DIGI.tales allows to achieve both learning and social identity through 1) conceiving designing and creating Smart Learning & Teaching Environments, which can be integrated into the school curriculum cycle; 2) creating favourable conditions for learning, maturity and teaching, in accordance with the principles of continuity and the wholesome and harmonious youngest members of society growth; and 3) building areas for free expression and multisensory experience which permit symbolic play, the greater and more incisive participation of different people involved in education process. With regard to the child, the INF@NZIA DIGI.tales model addresses socialisation and cooperation with classmates during school hours: interaction with peers, friends and parents outside school hours, communication dynamics, using cultural stimuli, which may be rooted in the local area.

7. Conclusions

The aim of this chapter was to illustrate the close connection between psychological/cognitive processes and using and building new technologies especially in the education field.

In doing so, we have examined the classical approaches to human learning, highlighting continuity and discontinuity in psychological theories. Overall, the nature of teaching/learning process is mainly interactive, based on context and culture, actually relational. Various approaches (cognitive approach, behaviourist theory, cultural psychology, constructivism and embodiment cognition) have tried to explain the process of interaction between person and context in different ways, but all these have taken in consideration its transactional nature. The person and context, during the learning process, are mutually interrelated, and a change in one element implies a change in the other element. This 'intimacy' is well evidenced by the embodiment cognition theory and by the successive and continuous development of new technologies in the educational field. Indeed, this latter pays most attention on the teaching/learning context and tools analyses. Context and tools constitute key elements in children, adolescent and adult learning process. They are sensitive to individual development (in cognitive, emotional and psychological terms) and cultural stimuli.

Following this circular approach (in which individual context and tools affect each other), in this chapter we have described two projects (Block Magic and INF@NZIA DIGI.tales 3.6), which offer two examples of new technologies used in supporting teaching/learning processes.

The Block Magic project was aimed at creating a bridge between physical manipulation and digital technology in education; to do this, Block Magic developed a functional prototypal system that enhanced the traditional logic blocks box. The INF@NZIA DIGI.tales 3.6 project aimed to promote the use of ICT technologies and the latest paradigms of human-computer interaction in order to define psycho-educational practices in order to enhance curricular activities and facilitate acquisition processes for skills and knowledge for pupils. Both projects were built on STELT platform that links together smart technologies and physical material to support children learning processes. The two projects, basing on STELT technology, show a possible methodology to unify the manipulative approach to the learning processes and touch-screen technologies.

According to encouraging preliminary findings of the projects, our conclusion is that they could offer examples of new technologies used in educational contexts and that they both are in line with previous research providing effectiveness of use for new technologies in the learning process. In conclusion, this chapter has set out to provide additional insights and new research models for using new technologies in formal and informal learning contexts for children.

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