CONSTRUCTING KNOWLEDGE AND TRANSFORMING THE WORLD

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The first part of this paper examines the differences between Piaget's constructivism, what Papert refers to as *"constructionism,"* and the socio-constructivist approach as portrayed by Vygotsky. All these views are developmental, and they share the notion that people actively contribute to the construction of their knowledge, by transforming their world. Yet the views also differ, each highlighting on some aspects of how children learn and grow, while leaving other questions unanswered. Attempts at integrating these views [learning through experience, through media, and through others] helps shed light on how people of different ages and venues come to make sense of their experience, and find their place—and voice—in the world. Tools, media, and cutural artifacts are the tangible forms, or *mediational means*, through which we make sense of our world and negociate meaning with others. In the second part of this paper, I speak to the articulations between make-believe activities and creative symbol-use as a guiding connection to rethink the aims of representations. *Simulacrum* and *simulation*, I show, play a key role besides language in helping children ground and mediate their experience in new ways. From computer-based microworlds for constructive learning (Papert's turtle geometry, TERC's body-syntonic graphing), to social virtual environments (MUDing). In each case, I discuss the roles of symbolic recreation, and imaginary projection (people's abilities to build and dwell in their creations) as two powerful heuristic to keep in touch with situations, to bring what's unknown to mind's reach, and to explore risky ideas on safe grounds. I draw implications for education.

Part One: CONSTRUCTIVISM, ONE OR MANY?

The beliefs we held about children's learning are deeply grounded in our own convictions onwhat it means to be knowledgeable, intelligent, experienced, and what it takes to become so. Whether implicit or explicitly stated, these convictions drive our attitudes and practices as educators, parents, teachers, and researchers.

If we think, for example, that intelligence is innate and that talents are given, we are likely to gear our interventions at helping others unfold their existing potentials. We may do so at the

cost of not giving a chance to those we think of as being "ungifted". If we believe, on the other hand, that knowledge or intelligence are a reflection of a child's surrounds, then we are more likely to "pass on" our own solutions and values. And we sometimes do so at the cost of ignoring a person's own ways of doing, of thinking, and of relating to the world. And if we believe, as constructivists do, that knowledge is actively constructed through relating to others and acting in the world, then we are tempted to step aside and just set the stage for kids to engage in hands-on explorations that fuel the constructive process. We may do so at the cost of letting them "rediscover the wheel" or drift away endlessly when shortcuts may be welcome.

Obviously, there is nothing wrong in showing youngsters the right ways of doing things, in helping them unravel their natural gifts, or in creating opportunities to let them discover things by themselves. Yet, the believe in either extreme "fixity" or extreme malleability of mind can become a formula for disaster especially when worldviews are at odds, when value systems clash, or when some "unpopular views" stubbornly persist within a community. My own life-long interest in constructivism and socio-constructivism grows out of a personal belief that wherever diversity reigns, the mere transmission of traditional values just won't do. That is when people(s), young ans old, need to become their own path-finders, speak their own voices, bring their own personal and collective experience to the world, and negotiate their differences with others.

Constructivism, in a nutshell, states that children are the builders of their own cognitive tools, as well as of their external realities. In other words, knowledge and the world are both construed and interpreted through action, and mediated through symbol use. Each gains existence and form through the construction of the other. Knowledge, to a constructivist, is not a commodity to be transmitted—delivered at one end, encoded, retained, and re-applied at the other— but an experience to be actively built, both individually and collectively. Similarly, the world is not just sitting out there waiting to be to be uncovered, but gets progressively shaped and formed through people's interactions / transactions.

Psychologists and pedagogues like Piaget, Bruner, Papert, Vygotsky, Bakt'in, but also Dewey, Freynet, Freire, Malaguzzi and many others[1], remind us that indeed, learning is less about acquiring information or transmitting existing ideas or values, than it is about

[1] For a review of constructivist and socio-constructivist as well as researchers in pragmatics, situated learning, organizational change, and cognitive scientists see

collectively designing a world in which it is worth living. What's more, this process of negotiating views with others requires the co-construction of [taken as] "shared" forms (Reddy, 1993). In what follows, I present some aspects of Piaget's constructivist theory, and I contrast them with Papert's constructionism, and Vygotsky's socio-constructivism. I flesh out what each captures and leaves out, thus setting the stage for my own attempt at integrating the two.

Eloge à l'abstraction

Piaget, the rationalist

Piaget is best known for his stages, which offer parents and educators a window into what children are generally *interested in* and *capable of* at different levels of their cognitive development. While this is an important contribution, there is more to Piaget than his stage. Piaget has forcefully shown that children have their own views of the world, which differ from those of adults, and that these views are extremely coherent and robust. They are stubborn, if you wish, i.e., not very easy to shake. Children, to Piaget are not incomplete adults. Instead, their ways of thinking have a reason to be, mostly well suited to their current needs and possibilities. This is not to say that children's views of the world, as well as of themselves, do not change through contact with others and with things. The views are continually evolving. Yet, to Piaget, knowledge grows according to complex laws of self-organization, which operate in the background according to some "logic" of their own. Thus, for a child—or an adult—to abandon a current theory, or believe system, requires more than just being exposed to a better theory. Conceptual changes in children, like theory changes in scientists (Kuhn, 1970), emerge as a result of people's action-in-the-world (their living experience) in conjunction with many "hidden" regulatory processes at play behind the scene[2]. The function of these processes is to maintain the livelihood of the cognitive system as a whole, and to compensate for surface perturbations (regulatory mechanisms).

Piaget's developmental theory emphasizes how children become progressively detached from the world of concrete objects and local contingencies, and gradually able to mentally manipulate symbolic objects, within a realm of hypothetical worlds. The focus is on the construction of *cognitive invariants* as means to interpret and organize the world. Piaget's empirical studies shed light on the conditions under which learners are likely to maintain or change their views of a phenomenon when interacting with it during a significant period of time.

[2] For more on this cf. Piaget (1975) "l'equilibration des structures cognitives (bibliography)

The child that Piaget portrays in his theory is an idealized child. Often referred to as an epistemic subject, s/he is a representative of the most common way of thinking at a given level of development. And this “common way of thinking” is similar to that of a scientist driven by the urge to impose stability and order over an ever-changing natural world. Piaget's child, one may say, is like a young Robinson in the conquest of an unexplored territory. Robinson's conquest is solitary yet exciting since the explorer himself is very active. Piaget’s child is an inner-driven, very curious, and independent character. The ultimate goal of his adventure may not be the navigation per se, but the joy of mastering the territory under exploration.

In essence, Piaget the rationalist portrays children’s intellectual development as a progressive move away from intuitive towards rational thinking, from everyday cognition towards scientific reasoning. In his view, the path leading to higher forms of reasoning, or 'formal operations', proceeds from local to general, from context-bound to context-free, from externally-supported to internally-driven (or 'mentalised'). Accordingly, cognitive achievements are gauged according to three major acts of distancing. 1. The ability to emerge from here-and-now contingencies (characteristic of practical intelligence); 2. the ability to extract knowledge from its substrate (i.e. from contexts of use and personal goals); and 3. the ability to act mentally on virtual worlds, carrying out operations in the head instead of carrying them out externally.

The implications of Piaget’s theory for education are profound, even if Piaget himself didn’t think of his work as being “educational”. Let me mention three aspects that have captured mattention as a researcher and educator, or the main lessons I learned from working with Piaget:

1. *Teaching can’t ever be direct*. Children don’t just take-in what is being said. Instead, they interpret, or translate, what they hear in the light of their knowledge and experience. Willingly or unwillingly, that is, they transform the input to fit their level of understanding, This occurs whether we like it or not. A more radical formulation of lesson 1 would be to say that learning does not occur as a result of teaching or, in Piaget’s own provocative terms ‘whatever you tell a child, you won’t allow her to discover it by herself’.

2. *Knowledge is not information* to be delivered at one end, and encoded, stored, retrieved, and re-applied at the other end. Instead, knowledge is experience to be constructed through interactions with the world (people and things). To equate

knowledge with information—and knowledge construction with information processing—confuses matters when it comes to human learning or teaching.

3. *A theory of learning that ignores resistances to learning misses the point*. One of Piaget's main teachings is that children have extremely good reasons not to abandon their current worldviews in the light of external surface perturbations. And this is so no matter how relevant the suggestions. A good teacher, in this sense, is one that helps learners explore, express, exchange—and ultimately expand— their views, from within [not a sage on the stage, but a guide on the side]

To conclude, while capturing what is common in children's ways of thinking at different developmental stages—and describing how this commonality evolves over time— Piaget's theory tends to overlook the role of context, uses, and media, as well as the importance of individual preferences, or styles, in human learning and development. That's where Papert's "constructionism" comes in handy!

Media Matters

Papert, the Intuitionist

If Piaget did not see himself as an educator, Papert, on the other hand, used what Piaget learned about children as a basis for rethinking education in the digital age. He coined his theory "constructionism". In his words, *"Constructionism—the N word as opposed to the V word— shares contructivism's view of learning as "building knowledge structures"through progressive internalization of actions… It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe (Papert, 1991, p.1)*

To Papert, projecting out—or externalizing—our inner feelings and ideas is as important as internalizing our actions. In expressing ideas, or giving them form, we make them tangible and shareable which, in turn, helps shape and sharpen these ideas. Externalizing ideas is also a key to communicating with others. We can only negotiate meaning through tangible forms: our own expressions or existing cultural mediations (language, tools, toys). The cycle of self-directed learning is, to Papert, an iterative process by which learners invent for themselves the very tools and mediations that best support the exploration of intriguing ideas. Because of his focus on *learning through making* (on could say learning as design) Papert's "constructionism" sheds light on *how people's ideas get formed and transformed when expressed through different media, when actualized in particular contexts, when worked out*

by individual minds. The emphasis has shifted from general laws of development to individuals' conversation with their own representations, artifacts, or objects-to-think with.

Stressing the importance of external supports as a means to augment the unaided mind is not new. As will become clear in the next section, Vygotsky has spent his entire life studying the role of cultural artifacts—tools, language—as a resource for drawing the best out of every child's potential. So have many other researchers in the socio-constructivist tradition. The difference, as I see it, lays in:

1. The role such external aids are meant to play at higher levels of a person's development.
2. The types of external aid, or media studied (Papert focuses on digital media and computer-based technologies) and more important,
3. The type of initiative the learner takes in the design of her own "objects to think with".

Papert's constructionism is more *situated* & *pragmatic* than Piaget's. This is so even if Papert himself doesn't make explicit use of the terms when describing his enterprise. One of its main contributions is to remind us that intelligence should be defined and studied *in-situ*; alas, that being intelligent means being grounded, connected, and sensitive to variations in the environment.

To Papert, abstract or formal thinking may well be a powerful tool. Yet, it is not necessarily the most appropriate in all situations. Unlike Piaget, Papert thinks that "diving into" situations rather than looking at them from a distance, that connectedness rather than separation, are powerful means of gaining understanding. *Becoming one with the phenomenon under study*, in other words, is a key to learning.

The child that Papert studies is more relational than Piaget's Robinson. S/he likes to get in tune with others and situations. S/he resembles what Sherry Turkle described as a "soft" master (Turkle, 1984). Like Piaget's Robinson, s/he enjoys discovering novelties, yet more than him, she wants to be in the flow of things, and in tune with people. S/he likes to feel at one with them.[3] Like Robinson, she likes to try out things rather than being told. Unlike him, S/he is more of a conversationalist than a builder. She may prefer sharing what s/he understands while in context, rather than telling what s/he experienced in retrospect.

To conclude, while Piaget best described the genesis of internal mental stability in terms of successive plateaus of equilibrium, Papert is interested in the dynamics of change. He stresses the fragility of thought during transitional periods. His great contribution, as an educator, is to focus our attention on *how people think once their convictions break down*,

once alternative views sink in, once adjusting, stretching, and expanding their current view of the world becomes necessary. Papert always points toward this fragility, contextuality, and flexibility of knowledge under construction. A strong believer in the ideas that momentary losses are a key to learning, and that people are good at using what they don't know as a lever to grow, Papert has spent much of his life creating technology-enhanced environments, or microworlds, in which learners can mess around with otherwise risky ideas, on safe ground.

It takes a whole village to raise a child

Vygotsky: The Socio-Culturalist

At the heart of Vygotsky's socio-constructivism lays a simple idea. From the day they are born, people learn, thrive, and grow in relation with others. We "are" because of others. The theory in particular stresses the importance of caring and knowledgeable adults on a child's growing mind. Vygotsky also emphasizes the role of language—and other cultural artifacts—in ***mediating*** human transactions. In spite of his focus on culture as a teaching machine, Vygotsky saw a child's intellectual development as constructive process. This is why his socio-constructivist approach cannot be put at odds with the theories of Piaget, Papert, Bruner, and others.

To Vygotsky, and socio-cultural theorists, the "social" has a primacy over the "individual" in a very special sense: Society is the bearer of a cultural heritage without which the development of an individual is simply impossible. Parents and other members of a community create a ***developmental niche*** for the newcomer, which ***embodies*** the adults' cultural past and ***impacts*** the new generations' future. It is at once a habitat and a cultural medium, or mediation. It is at once a "terrain," or stage, for human experience and a lens, or interpretive frame, at the disposal of the terrain's inhabitants.

Vygotsky's theory of cultural appropriation is not so different from Piaget's notion that children learn through acting in the world—i.e., through relating to people and things. This being said, Vygotsky puts greater emphasis on ***how*** the presence of adults with greater expertise can "speed up" and enhance a child's self-directed learning, and how ***shared***

cultural artifacts are used to help mediate this process. More than Piaget and Papert, Vygotsky stresses the role of adults *as teachers*, and cultural artifacts as *teaching tools.*

One of the key concepts in Vygotsky's theory is the notion of *zone of proximal development*. Much quoted and often misunderstood, the "ZPD" has become a buzzword among many educators. The ZPD defines a potential *area of expansion* that each individual has at their disposal to overcome their limits, provided the social environment in which the learning takes place "pitches in". In other words, the zone of proximal development tells us "how far" we can push the envelope of what we know, when helped by others. It is, again, through social interaction, that learners can mobilize, and best use, the *psychological tools* available to them.[3]

To Vygotsky, a person's cognitive development proceeds *outside-in,* i.e., from other to self*:* "*Every function in the child's development appears twice: first, on the social level, and later on the individual level; first, between people, and then inside the child"* (Vygotsky, 1978:57 in Lock, 1989). Inter-personal relations are the precursors, and necessary conditions, for the emergence of individual/intra-mental processes: Youngsters first share their experience with others, before they become able to master and understand them, for themselves. Their development proceeds from socio-centric to egocentric.

Vygotsky's child, as I see it, is more of a *trusting disciple* than an *autonomous agent*, in Harris's sense (Harris, 2002). While curious, active, inner-driven, and autonomous, s/he also trusts that others, more experienced, can tell her things that she cannot directly experience. In other words, s/he knows that she can learn vicariously by *listening* to what others say about what interests her. The autonomous agent, in contrast, is not comfortable if he cannot check out for himself what others propose, at the cost – sometimes – of re-inventing the wheel!

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[3] Vygotsky introduced the concept of *psychological tool* to capture the idea that the cultural artifacts that surround us, once appropriated, become part of our own "psychology". Psychological tools include: *various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes, diagrams, maps, and technical drawings; all sorts of conventional signs, and so on.* (Vygotsky, 1982:137, cited in Cole & Wertsch, 1996). Note that of the psychological tools that mediate our thoughts, feelings, and behaviors, language was the most important to Vygotsky.

Integrating the views: People as World-Makers, Dwellers in the World., and Social Creatures.

In *The Evolving Self,* Kegan portrays human development as a lifelong attempt to resolve the unsolvable tension between getting embedded and emerging from embeddedness (Kegan, 1982). In a similar way, I think of cognitive or affective growth as a lifelong attempt on the part of people, young or old, to find a viable balance between fusion and separation, openness and closure, or in Piaget's own words, between assimilation and accommodation. Imposing one's order upon things [building cognitive invariants as self-orienting devices] goes hand in hand with being sensitive to variations, and letting go of one's obsolete believes—should this not jeopardize previously attained balance, or equilibrium.

Along with Piaget, I view separateness through progressive decentration as a necessary step toward relating even more intimately and sensitively to people and things. In any situation, no matter how engaging, there are moments when we need to remove ourselves and reconsider what we did from afar. This view of separateness does not preclude the value of being embedded in one's experience. I also share Papert's view that diving into the unknown, at the cost of experiencing a momentary sense of loss, is a crucial part of learning. Only when a learner actually travels in a world, by adopting different perspectives, or putting on different "glasses," can a dialogue begin between local and initially incompatible experiences. What Vygotsky adds to this equation is the notion that "it takes a whole village to raise a child". In other words, no human can "be" or "grow' without the help of many people, peers or adults. Belonging to a caring community, and knowing how to relate to others are needed to build a sense of self. And since people relate to one another through cultural mediations—tools, language, artifacts—these, in turn, get weaved into—and become an integral part of— the social transactions.

To conclude, both "dwelling in" and "stepping back" are equally important in getting the cognitive dance going. Both individuation and socialization are needed for us to grow as people. How could anyone learn from experience as long as they are totally immersed in it. There comes a time when viewing things from afar, or adopting a 'god's eyes view', is a must (Ackermann, 1996). From then on, a new cycle can begin, and the stage is set for new and deeper connectedness and understanding. How could anyone get to know who they are—and what's they are worth—of they are not "held" by others. In other words, to get the cycle of self-directed learning going, learners need to exist as persons. And to exist as a person —or know who they are—to need to belong: Any child stops to speak if her words are not heard.

Part Two: POWERS OF PRETENSE, SEDUCTIONS OF SIM, VIRTUES OF VIRTUAL[4]

> *"Imagine a child playing with other children, and using a stick as a horse: the child jumps around his friends, goes places, feeds the horse, claims that the horse is lazy. In creating this make-believe play, the child is making present the horse, a horse that otherwise would be absent in this child's life. Furthermore, she is not only making the horse present but doing things with it. We say that the horse is ready at hand to convey this idea that the horse is made to participate in the child's playful activities. This scene exemplifies what we call symbolizing: a creation of a lived-in space in which the absent is made present and ready at hand".*
>
> (Nemirovsky and Monk, 1998)

The formulation by Nemirovsky and Monk frames the act of symbolizing as a means to sustain a dialog between what is [believed to be] and what could be, between fact and fancy. It highlights that to represent is not merely to describe what exists but to make tangible what doesn't. The authors also remind us that beyond replicating, young pretenders often modify outcomes, and subvert the meaning of things. As in improvisational theater, they recast unfolding events, opening up new paths as they play along. Meaning and coherence both emerge as a result of this creative process. In what follows, I challenge the prevailing theory of representation, often referred to as correspondence theory (Lakoff, 1993), suggesting that there is an a-priori object out there (a territory), that the act of representation duplicates one way or another (map). I show that representations are better thought of as performative acts, or fictionalizing techniques in Iser's sense[5] (Iser, 1987)

The enactive/generative aspects of representations are particularly relevant in design activities where an artifact to be built doesn't exist before the process comes to an end. In design, it becomes clear that the representations needed to generate new forms couldn't

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[4] An extended German version of this paper appears in Ackermann, E. (1999) "Sich einrichten in Fantasie Raumen: Untersuchungen zum Gebrauch von Symbolen" (E. Renk Ed.) *Lernen und Leben aus der Welt im Kopf: Konstruktivismus in der Schule.* Neuwied, Kiftel: Luchterhand, pp. 79-99.

[5] To Iser , the English term 'representation' causes problems because it suggests a given which the act of representation duplicates. This conceals the *performative qualities* through which the act of representation brings about something that hitherto doesn't exist as a given object (Iser, 1987,p.217). Iser proposes to replace the English term with the German *Darsellung*, which does not drag this mimetic connotation.

possibly be conceived as descriptions of what's *out there*—since not much is out there yet! Designers are left with envisioning and engaging forms in the becoming. They build sketches, prototypes, and simulations as intermediary objects to generate these forms.

What is true of design is also true of other constructive processes. Most striking in this respect is children's natural tendency to invent for themselves the supports and mediations they need to reach their goals, whenever the tasks they face lay beyond their mastery. Children's extraordinary talent as learners comes in great part from their ability to set the stage that allows them to safely project themselves in the unknown. Doing *as if* and playing *what if* are the techniques they use to achieve this balance. Nemirovsky and Monk's notion of "ready at hand" (above citation) further suggests that the props used in pretense play need not be [treated by the child as] arbitrary tokens, nor do they have to be at the image of what it stands for. In other words, the stick that the child "rides and feeds" in her play is a *double* (ersatz) in that it acts on the imaginary horse's behalf. Yet, this doesn't imply, again, that the double mimics its behavior or mirrors its appearance. Symbols often take on a life of their own, and it is their ability to do so—both *be and not to be* what they stand for—in the pretender's mind, that enables their creative use.

We know from research on early pretense play that children's abilities to treat a stick *as if* it were a horse requires a decoupling between signifier and signified (Piaget, 1962, Perner, 1993). In other words, a child who uses a stick "as if" it were a horse also knows that it is not "really" a horse. What is less obvious is the notion that decoupling has to go hand in hand with its opposite, fusion, for the symbolic transform to be complete.

Along with Nemirovsky and Monk, I suggest that a child's ability to engage an "ersatz" as if it were the thing itself, i.e., to fuse signifier and signified, is a necessary condition for creative symbol-use. Fusion is what ultimately gives symbols their *dramatizing power*. Without empathic projection—engaging the double as is—no "lived" experience would be possible. Working out intriguing materials, fictional or real, requires both the creation of make-believe ground and an occasion for "true" identification.

Engaging in symbolic activities, in this sense, is not just a matter of giving form to ideas, making them tangible and shareable. It is also a matter of bringing ideas and forms to life, thus animating them. Treating doubles as if they were [as vivid and vibrant as] the ideas they stand for, is what brings the materials engaged in pretense closer to mind's reach. Like a mythical character, the make-believe horse-companion that the child plays with in her pretense is more like a unicorn than a real horse: a fictional creature that embodies hidden fears, desires, and purposes. And its appearance, the stick, once made to participate in the child's activities, helps reshape her original ideas about unicorns. It is, again, the ambiguous nature of the stick in the child's eyes, at once double (decoupling), object in its own right (separation), and extension of self (fusion) that lends it its evocative and dramatizing powers. To conclude, making the absent present, giving form to ideas, and bringing form and ideas to life are 3 important functions of the act of symbolizing.

Not just a kid's thing!

Pretense or symbolic play is not just a kid's matter. Nor is it a privilege reserved to artists and poets alone. People of all ages, stages, and styles engage in symbolic recreations. And they do so in ever more sophisticated ways as they grow older (Ackermann, 1999). As Sayeki points out in his paper "Anthropomorphic epistemology," adults, from lay people to scientists, use their imagination to project themselves into situations (Sayeki, 1989). They too dwell into their mental constructs to reach deeper understanding, and they do so, according to Sayeki, by literally dispatching little pieces of self, that he calls "kobitos" to inhabit their object of interest (little people in Japanese). Once "in there" via their imaginary doubles, they can act out and feel for what their kobitos experience, while remaining physically removed (Sayeki, 1989).

Obviously, diving into situations and putting oneself in other people's shoes, or minds, won't suffice to learn, or grow. Being grounded, or connected, requires its share of distancing and calls for achieving a balance between getting embedded and emerging from embededness (Kegan, 1982). In other words, every so often, people need to reemerge by extracting themselves from the deep waters. They need to step back and

look at things from afar. In their imagination, they generally achieve this by changing their stance in the world, by putting themselves in other people's shoes, or by adopting a *god's eye's view*, an altogether removed and all-encompassing view, that miniaturizes the worlds they just inhabited (Ackermann, 1996). To conclude, people are both world makers and beings-in-the-world: they at once create their habitats, inhabit their creations, and become "inhabited" by them. In the world of their imagination, fusion (becoming one) and separation (removing oneself) coexist. Both contribute to their personal and cognitive growths.

Creative Playpens for Constructive Learning

The uses of projective imagination are at play in many forms of symbolic activities, from drawing to scientific modeling, from remote chats in social virtual environments (VE), to reading and writing. So are our attempts at anthropomorphizing and role-play. In the following sections, I focus on two specific aspects of pretense and symbolic play: people's abilities *to dwell into their creations*, and *to fuse signifiers and signified* as ways of becoming mindfully engaged. Their role in the constructive process is discussed in different contexts: from architects' drawing, to children's exploration of mathematical ideas, to digital kids' love affair with social virtual environments. The chosen contexts, or learning stories, are of two kinds: 1. Handling tools and driving machines 2. Exploring conversational writing in digital media. In both cases, the interactivity afforded by responsive artifacts (computers) is used to tap into people's tacit body smarts and situational wisdom. I show, through examples, that the apparently most primitive side of symbol use, empathic projection, is not just a key to natural learning but can be promoted by design to help children learn better. To conclude, I draw some implications for developmental psychology and education.

Dwelling into the Drawing

A few years ago, Bonne Smith, a former student at the School of Architecture, MIT, designed a simple and compelling experiment. She asked some of her fellow students to sketch a floor plan of the house in which they lived when they were 5 years old. She

encouraged her subjects to think aloud as they drew, and she videotaped the process (Smith, 1991). What this experiment revealed, in a nutshell, is that the act of drawing was in itself a world-making technique. Moreover, the draftsman's engagement in the represented "site under construction" was quite anthropomorphic, surely more than one may expect from sophisticated architectural students.

Alternatively becoming dwellers and creators, kids and adults, giants and dwarfs, Bonne's subjects mentally moved in and out of the situation, seamlessly. They projected themselves into the pen-ball "as if" it were a prosthetic device, and driving the pen around made it possible for them to travel along in their mind. The pen became a vehicle of *mental teleportation*. Dwelling in the drawing is what allowed Bonne's subjects to evoke, revisit, and reconstruct their lost memories.

The most surprising aspect of this experiment is that the subjects' use of projected movement to bring back the "lost" place increased with their level of sophistication as architects. It was much less prevailing among young children and non-architects. This came as no surprise to Bonnie, an architect herself, who reminded me that designers often imagine themselves and set themselves in motion in a space *to be*. They do so proactively to envision what that space may be. In her eyes, the experiment confirmed her intuition that people's ability to dwell into their drawing, or use drawing as a trail-making technique (Nemirovsky and Monk, 1998) is one of the expertise that architects develop in the course of their studies and work.

Here are 3 vignettes by Roy, Emily, and Andrew, architectural students whose protocols were rich with imagined movement (Smith, 1991):

Roy: (thinks aloud) "*I am starting from the exterior and I'll be moving in. Here's the car (*draws a car*), the sidewalk moves perpendicularly from the driveway, past three shrubs, and up to the porch and then the front door. Then you move into the front hall like that*…" (traces gesture of moving in and completes by drawing front door and entrance).

What's remarkable in this account is that Roy is not the only one to move about. The sidewalk "moves" too, perpendicular to the driveway and past shrubs!

Andrew reconstructed the lived space around the concept of "boxiness" —rectangular container —the shape and content of which he adjusted and refined as he moved through the virtual house. "*This house was a breadbox. Just a good old American colonial* [draws rectangle*], brick box. Do you enter in the middle? OK* [draws entry]. *So you enter and there is this staircase* [draws stairs middle of rectangle*]. Yeah, that's pretty much the main focus when you come in* [Andrew then proceeds to locate different spaces around the stairs and adjusts sizes by invoking action in and around them]. As he mentally moves into the salon *"Wait? Can you walk behind the couch? the door?* [He reaches out to grab an imaginary doorknob to determine the door swing].

Emily's use of imaginary projection was different yet. She spoke about the visual fields, or "perspectives," that unfold before her eyes as she walked through space in her mind: the view down the main street, the view of the façade. Holding these perspectives in mind helped her restitute otherwise forgotten adjacencies and directions. Emily: "*…when you go up the stairs, on each side you have…two regular doors that you can open, that you can push into…first thing you see is the reception desk. You'll have a lot of, I think there's an old sofa here…"*

Note that all the subjects used the present tense in their accounts, which reinforces the idea that, in their minds, they were "really in there", as they were when they were kids.

Drawing Shapes by Driving Turtles

Our bodies hold quite a bit of knowledge about space in their movement. Yet, much of this knowledge remains tacit, hidden in the beholder's habitual activity and experience. It needs to be brought to the mind's reach. One of Papert's greatest insights in designing Logo-based Turtle Geometry, a software environment for building geometric shapes, was to tap children's knowledge about their own movement in space,

and to use this knowledge as a lever to help them explore spatial relations and transformations.

In turtle geometry, children “instruct” a computational creature to draw shapes by moving in prescribed directions by prescribed amounts. The turtle can be represented by cursor on the screen or, better, embodied as a mechanical toy-robot. The children communicate with the turtle using a language that it can “understand” (Logo programming language). Using Logo, a turtle can be made to move by typing commands at the keyboard. FORWARD 100 makes the turtle move in a straight line a distance of 100 turtle steps of about a millimeter each. Typing RIGHT 90 causes the turtle to pivot in place through 90 degrees. Typing PENDOWN causes the turtle to lower a pen so as to leave a visible trace of its path while PENUP instructs it to raise the pen. The commands and procedures available to drive the turtle are fairly intuitive to the child. They are also carefully chosen to enable the generation of many mathematically relevant and intriguing figures in space.

The guiding principles behind Turtle Geometry are simple and much in tune with our views: Papert’s turtles become extensions of self that the child controls using words. Giving directions — remote driving —encourages the child to reflect upon her own know-how and to express it precisely enough so that the machine can carry it out. “In teaching the computer how to think, children embark on an exploration about how they themselves think”(Papert, 1980, p.19) . More important, Papert’s turtles are designed to be “egocentric”. Directions are given in reference to a turtle’s position and heading and not as a function of some external reference system (xy coordinates). This requires that users put themselves in the turtle’s shoes, literally, to figure out where it wants to go next. The syntax of Logo further provides a rich toolkit to assemble basic available operations (like rotations and translations) in interesting and surprising ways. Using computational tools and object responsiveness offers instant feedback, which helps sustain the interaction.

In *Mindstorms,* Papert (1980) explicitel states the role of what we call mental teleportation: “A turtle has a position and a heading. In this, it is like a person or an animal or a boat (p.55). Children can identify with the turtle and are thus able to bring their knowledge about their bodies and how they move into the work of formal geometry (…) Drawing a circle in turtle geometry is body syntonic in that the circle is firmly related to children’s sense of and knowledge about their own bodies. It is ego syntonic in that it is coherent with children’s sense of themselves (one could say children’s point of view or stance in the worlds” (p.63).

Swinging a Graph

Other learning environments have been designed to facilitate the articulation between world-making and world-dwelling. A case in point is the use of a *motion detector* by researchers at TERC (Technical Education Research Center), Cambridge MA, to help children learn about graphs. The display was designed by Nemirovsky and his team to augment children’s control and understanding of graphical representations of mathematical variations over time (Nemirovsky, 1998; Tierney, Nemirovsky, Wright, Ackermann, 1993). I call the micoworld “swinging a graph” because, like Papert’s turtles, it uses body motion as a vehicle to generate and control shapes. This time the activity is mediated by a motion detector, and the shape to be “drawn” is a time / graph on a computer screen.

The motion detector used in these studies consists of a small button, the position of which is measured, of a sensor or electronic eye (also referred to as tower), and a computer. In interacting with the device, children hold the button or pin it on their shirt and move their bodies. They can also place the button on a moving object such as an electric train. The electronic eye (tower) measures the distance that separates it from the button at each moment in time, and outputs a graph that plots positions over time on the computer screen. Thus, by moving the sensitive button back and forth in front of the “eye,” children can impact the graph’s shape in real time: shapes vary as a function of the direction and speed of their, i.e., the button’s, movement.

Kids' first encounters with the motion detector are almost exclusively experiential. As they move back and forth with their button, [they realize that] the shape of the graph varies in reliable and somewhat principled ways. Very soon, though, the children learn to identify and to describe some of the changes they provoke. They tell us, for example, that as they move closer (to the tower) the graph goes up, and as they move away it drops; that if they move faster it becomes steeper, and if they slow down it flattens out. Sooner or later, kids also become interested in "swinging" very specific graph shapes. This requires that they understand, at least in action, *what* causes a graph's specific response. In doing so, they come to learn, for example, that they can't draw a circle or a square because the graph on the screen never goes backwards.

As in Turtle Geometry, mediations have been introduced to help children move away from regulation-in-action to reflection. One of the mediations proposed was to remove the distance-sensitive button from the child's body, and to place it on the "face" of an electric train. The train was placed on a straight track in front of the motion detector. The child has now to move aside and to drive the train using a rotating knob, or dial. A next step in the mediating process, which was not explored at the time, would be to let the kids instruct or program the train, digitally. This would complete the cycle between moving one's own body, driving the train by hand using an analogical dial, and programming the train or give it a set of instructions.Switching back and forth between *doing it oneself* (engaging one's body) and *giving instructions to "other"* (instructing some responsive artifact) is what brings about deeper understanding (either about geometric or arithmetic operations). In both cases, the dynamic properties of interactive tools are used to tap into learners' knowledge-in-action, while mediations are offered to favor the passage from reflection-IN-action to reflection-ON-action. In both cases, "the idea is to give children a way of thinking of themselves as "doing science" when they are doing something pleasurable with their bodies" (Papert, 1980, p 68). Children learn because they are offered an occasion to use their own experience as a lever to actively explore mathematical ideas.

Virtual virtues

Social virtual environments (SVE) like chat rooms, Alphaworld, MUDS, offer yet another rich ground to explore how children and adults project themselves into fantasy worlds, as a way to revisit, enact and work through "real" issues. SVE can be thought of as digital stages for improvisational theater, or psychodrama. They are fictionalizing devices in Iser's sense. In MUDS, [6] "players encounter other players as well as objects that have been built for the virtual environment. MUD players can communicate with each other in real time, by typing messages that are seen by other players. Some of these messages are seen by all players in the same "room", but messages can also be designated to flash on the screen of only one specific player" (Turkle, 1995, p. 181). VE inhabitants, or avatars, are extensions of the human players. Their appearances and modes of interaction are mostly created and staged by the players themselves, in dialog with others.

What's particular about Social Virtual Environments, as compared with other playgrounds for pretense, is the intricacy of the connection between users and their avatars, the immediacy and unpredictability of other player's response to one's virtual appearance, and the hybrid nature of the world itself, neither representation nor reality. As Turkle points out, VE-mediated exchanges deeply change the nature of our commitment to others, as well as our sense of selves. MUDs provide a stage for anonymous interaction in which players can choose a role as close to or as far from their "out of MUD self(ves)." (Turkle, 1995, p.180)

In social VR, as in good improvisational theater, players do not recite scripts that are written by someone else. Instead, they are their own playwrights, choreographers, and actors. As in pretense play, staged events are both lived in and acted out. Players make scenario unfold and drama come to life. Dwelling in social VE allows them to mediate their experience—live their lives on the screen—while remaining mentally engaged. It is the make-believe nature of the virtual space created, in conjunction with the truthfulness

[6] Dungeons and Dragons was popular game in which a master created a world in which people take on fictional personae and play out complex adventures. The term "dungeon" persisted in high-tech culture to connote a virtual place. So when virtual places were created that many users could share and collaborate within, they were deemed multi-user dungeons, or MUDS, a new kind of social virtual reality, and the term MUD and the verb MUDding have come to refer to all of the multi-user environments. Some MUDs use screen graphics or icons to communicate place, characters, and action. Others rely entirely on plain text.

of the thoughts and feelings experienced through dialog with others, that make for the power of VE enactments.

Attached to their avatars like a puppeteer to her string puppets, players act and feel through them. Virtual string puppets are both built by the puppeteer and brought to life by her. They are masks for idealized identities, allowing players to appear in a desirable light and hide those aspects of self that are not thought of too highly. Like Sayeki's kobitos, digital avatars are extensions of self that can be launched into the VE and made to act on one's behalf. It is the creator's strong connection / identification with their avatars that allows them to vicariously experience what they "go through". More easily than traditional puppet-theater, players can endorse multiple personae and launch them into different habitats at the same time.

People's ability to put on the hats of multiple personae is not new in itself, and has its off-line equivalents in adult psychodrama and face-to-face role playing games. What's different in VE, is the ubiquitous quality of self-appearances. It's like being in two "bal masqués" at once or maintaining parallel streams of conversation. Along with Turkle, I think that digital fictionalizing tools, enriched MUDS of sorts, can be used to help people, young and old, work out intriguing mental events, foster projective imagination, and construct their inner and outer worlds.

To summarize, in VE, players can live things at a distance and get in touch with them at the same time. They can take risks on relatively safe ground. Using avatars allows them to remain anonymous, filter their appearance and control their level of engagement. Last but not least, the opportunity to come back again and again, changing face, and reconfiguring habitats (changing props) allows them to work out different versions of intriguing scenarios over extended periods of time. As in pretense, MUDers vary outcomes and rearrange story elements. Yet, as in psychodrama, they interact with others for good. What's unique in VE is that players can engage multiple dramas at once, or take on multiple hats in a same drama.

CONCLUSIONS

Fusion and separation are two poles of a continuum that are too readily opposed or placed in a developmental sequence. It has been our view, in this paper, that the abilities to put ourselves in another person's shoes, or mind, i.e. to change perspective and switch roles requires both fusion and decoupling, being simultaneously "there" and "not there," embedded and disengaged. Fusion doesn't preceed decoupling, it accompanies it. Playing "what if" or the ability to pretend (establishing a dialog between what is and what could be) is the means by which children as well as adults achieve the difficult a balance between getting immersed and emerging from embeddedness. Play is an important aspect in human learning, from identity building to constructing knowledge about the world. Erick Erickson defined play as a toy situation that allows us to reveal and commit ourselves in its unreality. Play operates within a transitional space (Winnicott, 1989), halfway between self and world, distinct from self yet under its control and, above all, more resilient that the world, in which the child can take safe risks.

Throughout this paper, the articulation between make-believe and symbol-use has been a guiding connection to rethink the aims of representation. I explored the ways in which doing *as if* and playing *what if* inform people's conversations with—and through—artifacts. I discussed the benefits of children and adults' abilities to dwell into their symbolic creations and to treat symbols as objects in their own right. To situate my argument, I presented a series of learning stories or learning environments that support both world-making and dwelling into one's world.

By way of conclusion, let me offer two suggestions that I wish were taken more seriously by developmental theorists and educators alike.

The first suggestion is that people's abilities to fuse signifiers and signified and to treat signifiers as interesting objects by themselves are two powerful heuristics in creative symbol use. Their role in knowledge construction and scientific activities has been generally underscored as being primitive and generative of confusion. A second

suggestion is that we seriously consider the significance of enactive forms of representations, from pretense play, or *simulacre*, to simulations.

As mentioned before, the French word ***simulacre*** and simulation sound very much alike. In both cases, a scenario or sequence of actions is being played out, which has been de-coupled from its usually associated contexts. What's more, scenarios are not just described, as in writing or drawing, but they are actually run, or executed, as by a calculator. From objects-to-think-with (Papert, 1980) they become operations embodied, and people tend to relate to them as partners, with whom they share a task (Ackermann, In press). The difference between the two is the medium through which the performance is run. In ***simulacres*** and rituals, the medium is a human actor, or an actor's extension. In simulations, the medium is a human-made artifact, machine or program, that runs a sequence of operations on your behalf. Simulations need not mimic something that exists. Their particularity is to execute operations that are only posed in language or notations.

At a time when computational objects make it easy to run programs, model dynamic interactions, and simulate behaviors, people's ideas on what modeling is all about are deeply changing. So are their ways of relating to existing modeling tools. More than in the past, performance and simulation are granted a new place alongside language. It's time for us, researchers in cognitive development and educators, to catch up and revisit our own views.

REFERENCES

Ackermann, E. (2001) Constructivism et Constructionism: Quelle difference?. In *Constructivismes: usages et perspectives en education.* (Volumes 1 et 2). Actes de Colloque. Geneva: Service de la recherche en edication / Cahier 8 / September 01. Pp. 85-94

Ackermann, E. (1999) "Sich einrichten in Fantasie Raumen: Untersuchungen zum Gebrauch von Symbolen" (E. Renk Ed.) *Lernen und Leben aus der Welt im Kopf: Konstruktivismus in der Schule.* Neuwied, Kiftel: Luchterhand, pp. 79-99.

Ackermann, E. (1999) "Enactive representations in learning: pretense, models, machines". In *Learning Sites: Social and technological Resources for Learning* (J. Bliss, P. Light, & R. Saljo, Eds) Elsevier Serie: Advances in Learning and Instruction, 144-155

Ackermann, E. (1996) “Perspective-taking and object construction: Two keys to learning”. In Constructionism in Practice: Designing, Thinking, and learning in a Digital World (J. Kafai, & M. Resnick, Eds.). Mahwah, NJ: Lawrence Erlbaun, Publishers, pp. 25-37.

Ackermann, E. (1993). “Systèmes de notations chez l’enfant: Leur place dans la genèse de l’écrit”. In *Entretiens Nathan 3: Parole, Ecrit, Image*. Paris: Editions Nathan, 51-69Brown, J.S., Collins, A., & Duguid, P. (1989). Situated knowledge and the culture of learning. *Educational Researcher*. *Vol. 18* (1). pp. 32-42.

Carey, S. (1983) Cognitive Development: The Descriptive Problem. In Gazzaniga (Ed.). Handbook for Cognitive Neurology. Hillsdale, NJ: Lawrence & Erlbaum.

Carey, S. (1987). *Conceptual Change in Childhood.* Cambridge, MA: MIT Press.

Cole, M. (1996) Culture in mind. Cambridge, MA: Harvard University Press.

Fox-Keller, E. (1985). *Reflections on Gender and Science.* New Haven. Yale University Press.

Harris, P. (2003). Paper presented at the Jean Piaget Society Conference On Play and Development. Chicago, IL.

Iser, W. (1987). “Representation: A performative act”. In (Krieger, Ed*.) The aims of Representation: Subject/text/History.* New York: Columbia University Press. Reissued (1993) Stanford, CA. Stanford University Press.

Kegan, R. (1982). *The Evolving Self.* Cambridge, MA: Harvard University Press.

Kuhn, T. (1970) *The structure of scientific revolutions.* SecondEd. . University of Chicago Press.

Lakoff, G. (1993) “The contemporary theory of metaphor” In *Metaphors and Thought* (Ed. A. Ortony). Cambridge University Press. pp. 202 -252.

Lock, A., Service, V., Brito, A. & Chandler, P (1989) The social structuring of infant cognition. In A. Slater and G. Bremner (Eds) *Infant Development* Chapter 10. Pp 243-72.

Nemirovsky R., and Monk, S., (1998) “If you look at it the other way: An exploration into the nature of Symbolizing”. In Cobb, Yackel, and Mc Clain (Eds*.) Symbolizing and Communicating in Mathematics Classrooms: Perspectives on Discourse, Tools, and Instructional Desig*n. Mahwah, NJ: Lawrence Erlbaum.

Papert, S. (1980). *Mindstorms. Children, Computers and Powerful Ideas.* New York: Basic books.

Perner, J. (1993). *Understanding the Representational Mind.* Cambridge, MA: MIT Press. A Bradford Book.

Piaget, J. (1962) *Play, Dreams, and Imitation in Childhood.* New York: W.W. Norton & Co.

Piaget, J. & Inhelder, B. (1967). The Child's Conception of Space. See especially “Systems of Reference and Horizontal-Vertical Coordinates.” p. 375-418. New York: W. W. Norton &Co.

Piaget, J. (1975). *L’equilibration des structires cognitives.* Paris: PUF

Reddy, M. (1993). The conduit metaphor: A case of frame conflict in our language about language" In: Metaphor and thought (Ortony Andrew, Ed.). Cambridge University Press, Chapter 2 p.164-202.

Rogoff, B., Lave, J. (Ed.) (1984). *Everyday Cognition: Its Development in Social Context.* Cambridge, MA: Harvard University Press.

Sayeki, Y.(1989) *Anthropomorhic Epistemology*. Unpublished Paper. Laboratory of Comparative Human Cognition. University of California. San Diego
Smith B. (1991) *Dwelling in the Drawing: An inquiry into actual movement, imagined movement, and spatial representation.* Unpublished Paper. Cambridge, MA.: MIT School of Architecture.
Suchman, L; (1987). *Plans and Situated Actions.* Cambridge, MA: Cambridge University Press.
Tierney, C., Nemirovsky, R., Wright, T., and Ackermann, E. (1993) "Body motion and children's understanding of graphs. In (J.R. Becker & B.J. Pence Eds.) Proceedings of the XV Annual Meeting of the North American Conference for Mathematics Education. pp. 192-198
Turkle, S. (1984). *The Second Self: Computers and the Human Spirit.* New York: Simon and Schuster.
Turkle, S. (1995) *Life on the Screen.* New York: Simon and Schuster
Vygotsky, L.S. (1962). Thought and Language. Cambridge, MA: MIT Press.
Vygotsky, L.S. (1978). Mind in Society. Cambridge, MA: Harvard University Press**.**
Wertsch, J. (1991) Voices of the Mind: A Socio-culotural approach to mediated action. Cambridge, MA: Harvard University Press.
Winnicott, D.W. (1989) *Playing and Reality*. London, New York: Routledge.
Witkin, H. & Goodenough, D. (1981). *Cognitive Styles: Essence and Origins.* International University Press.

SUGGESTED READINGS

Aries, P. (1962) *Centuries of childhood: A social history of family life*. New york: Vintage Books.
Ginsburg, H., an Opper, S. (1969) *Piaget's theory of intellectual development*. Englewood Cliffs. Prentice Hall, Inc.
Harel, I. and Papert, S. (Eds) (1991). *Constructionism*. Ablex Publishing Corporation. Norwood, NJ.
Hutchins, E. (1995) Cognition in the wild. Cambridge, MA: MIT Press.
Piaget, J. *The Essential Piaget* (Gruber, H. and Voneche, J. Eds) Basic Books, Inc. New York: 1977
Leont'ev, A.N. (1932) Studies on the cultural development of the child. Journal of genetic psychology, 40, 52-83.
Luria, A.R. (1928) The problem of the cultural development of the child. Journal of Genetic Psychology, 35, 493-506.

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