Historical Overview and Classification of Traditional and Digital Learning Objects

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ABSTRACT

Learning objects are physical objects, specifically designed to promote learning through hands-on interaction. They are popular materials in early childhood education, at school and at home

I present a historical overview of Learning Objects, starting with John Locke's educational philosophy and design suggestions, continuing with the approaches of the educational pioneers Friedrich Froebel, Maria Montessori, and John Dewey. I illustrate the historical influences of these pioneers, and define three categories of Learning Objects, based on my interpretation of the pioneers' design approaches: Construction & Design (associated with Froebel), Conceptual Manipulation (associated with Montessori), and Reality Role Play (associated with Dewey). I classify popular Learning Objects into the categories, clarifying the differences in the natural play activities with these objects. I continue with Learning Objects from the digital era, showing that the classification can be useful for current as well as future designs of Learning Objects.

ORIGINS OF LEARNING OBJECTS

If this section I review the people that in my opinion played a key role in the development of Learning Objects, from different angles, including philosophical, epistemological, psychological, design, and actual implementation in schools and kindergartens.

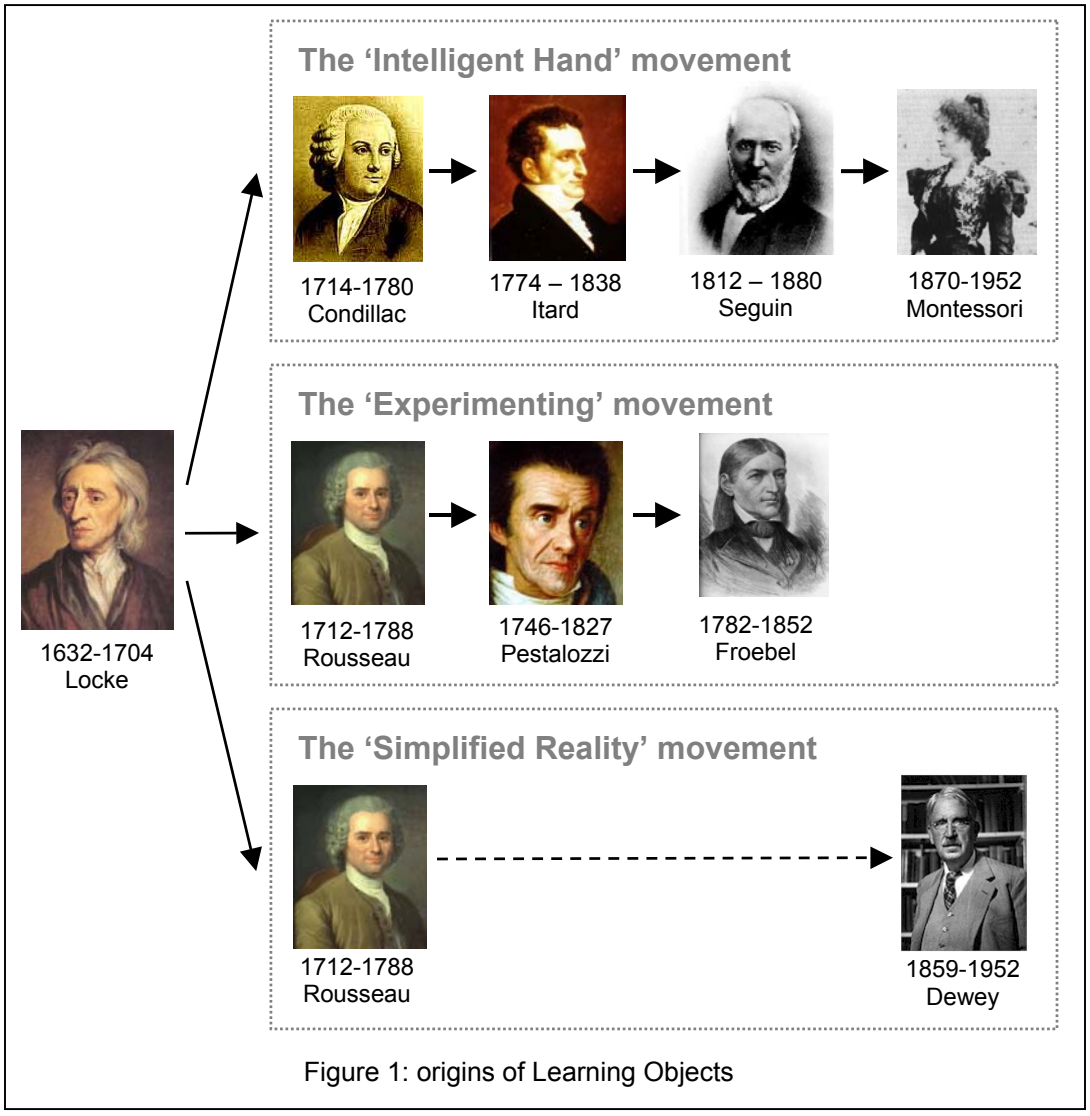

Figure 1: origins of Learning Objects

John Locke: 'knowledge comes from experience'

In the 1690s, John Locke, a key contributor to the Empiricism movement in philosophy, wrote 'An Essay Concerning Human Understanding'. In the essay, Locke laid the foundations for the 'learning from experience' movement, the ancestor of today's 'learning by doing' school of thought: 'All ideas come from sensation or reflection. Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas: How comes it to be furnished? Whence comes it by that vast store which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer, in one word, from experience.' (Locke, 1698)

In 17th century's terminology, experience meant also experiment (BBC radio, 2004). Hence, learning from experience, from sensation and reflection, is learning from hands-on experimentation and reflection. Locke suggested a design for a Learning Object: 'There may be dice and play-things, with the letters on them, to teach children the alphabet by playing; and

twenty other ways may be found, suitable to their particular tempers, to make this kind of learning a sport to them.' (Locke, 1693, P.148).

'For example; what if an ivory-ball were made like that of the Royal-Oak lottery, with thirty-two sides, or one rather of twenty-four or twenty-five sides; and upon several of those sides pasted on an A, upon several others B, on others C, and on others D? I would have you begin with but these four letters, or perhaps only two at first; and when he is perfect in them, then add another; and so on, till each side having one letter, there be on it the whole alphabet.' (Locke, 1693, P.150)

Locke's vision influenced many thinkers, among them were Condillac and Rousseau. When Rousseau lived in Paris, he was the tutor of the young Abbé de Mably, and became acquainted with Mably's brilliant younger brother, Etienne de Condillac (Rousseau J, J. New School University). Condillac and Rousseau extended Locke's revolutionary educational ideas in different directions. Rousseau extended the experiential side, the open-ended interaction with nature and objects, of learning as a gradual process of experimentation. In contrast, Condillac extended the sensation side, and developed the theory of sensationalism ("all knowledge comes from the senses") (Knight, 1968). In my analysis, these two philosophers represent two distinct movements: (1) The 'Intelligent Hand' movement, led by Condillac, focused on sensorial interaction with objects as the origin of intelligence. (2) The 'Experimenting' movement, led by Rousseau, focused on open-ended exploration, real-world experimentation, and interaction with nature, as the source of knowledge.

Figure 1 above traces the key people I associate with each of these movements, progressing towards the revolutionary educational works of Friedrich Froebel, Maria Montessori, and John Dewey, who changed the history of early childhood education.

The 'Intelligent hand' movement

Etienne Condillac (1714-1780): developed the theory of sensationalism (i.e., that all knowledge comes from the senses and that there are no innate ideas). He tried to simplify Locke's theory of knowledge by arguing that all conscious experience is simply the result of passive sensations. (Knight, 1968)

Jean-Marc Gaspard Itard (1774-1838): devised several new methods for educating and treating the deaf and mute. His educational approach relied heavily on sensory-training and stimulation (Itard, 1962). He became famous while insisting on treating Victor, 'The Wild Boy of Aveyron', the boy that was found in the woods near the village of Lacaune, France in 1797. Itard worked closely with Victor, trying to teach him how to speak. Itard used common materials that he 'constructed or adapted for training', including a physical alphabet set. Itard reports on some transitory success of his methods, notably when Victor used the letters L A I T to ask for milk. (Lane, 1976)

Edward Seguin (1812 – 1880) Seguin was Itard's pupil. He improved and expanded his teacher's sensory-training approach, and put it into practice in special schools for retarded students. He earned fame both in Europe and abroad for his nonverbal intelligence test (Itard, 1962), a board with ten geometric shapes. Today, the shapes boards are a popular material in early childhood education. Seguin believed that 'the active hand stimulated intelligence', that through the use of physical exercises and sensory development, the cognitive abilities of the developmentally disabled could be increased.

Maria Montessori (1870-1952) Montessori was the first woman in Italy to earn a physician degree. She was Seguin's pupil, and was passionate to help retarded children learn. Montessori studied Seguin and Itard's work intensively, and extended their sensory training and stimulation techniques. Specifically, she extended their training materials into her famous 'Montessori materials', what she called the 'didactic materials'. Montessori was extremely prolific, and created an educational philosophy (the Montessori method, 1916), extending her work with retarded

children to normal children through her network of ‘casa de bambini’. With regards to the Learning Objects she designed (the famous ‘Montessori materials’), she started with Itard’s and Seguin’s materials (such as Itard’s alphabet letters and Seguin’s shapes/forms board), and extended them into brilliant designs in four main categories: practical life, sensorial, mathematics, language.

Montessori’s method had several educational principles. I will focus on the ones related to the design of Learning Objects, mainly the principles for the ‘prepared environment’, which involved the teaching materials and the role of the teacher (Montessori, 1949). The materials should be design with the following principles in mind: developmentally appropriate, isolation of properties, stimulation of activity, design that is appealing to children, the materials should be self-guiding (facilitate self-directed learning), should support continuity (image of a ladder, the prepared environment should allow children to progress individually, moving from simple objects to more advanced ones in their own pace), support group interaction (the materials should support mixed age collaboration). The teacher’s role in the Montessori method, is to allow the child to act independently, to provide opportunities for learning through indirect teaching and educational input.

An interesting concept in Montessori’s writing is her ‘Polarization of Attention’ – the polarity between moment of activity and moments of reflection. In the following example, Montessori describes an observation of a 13-year-old girl who was deeply engaged with the cylinder blocks:

‘In the beginning I was watching the little one, without disturbing her, and began to count how often she repeated the exercise, but then, when I saw that she continued with it for a long time I took the little chair where she sat and put the little chair and the little girl on the table; the little one quickly picked up her cylinder-toy, put the wood block on the armrest of the chair, put the cylinder in her lap and continued to work. Then I asked all the kids to sing; they sang, but the girl continued to repeat the exercise, even after the short song was over. I counted 44 repetitions; and when she finally stopped she did that totally unrelated to the distractions from the environment, that could have disturbed her; and the girl looked around herself with content, as if she woke up from a refreshing sleep. My unforgettable impression was a lot like - what I think - you feel when you discover something.’ (Montessori 1952)

The ‘Experimenting’ movement

Jean-Jacques Rousseau (1712 – 1778): Rousseau was greatly influenced by Locke in many aspects, including Locke’s views on learning and the origins of knowledge (Doyle & Smith, 1997). In 1762 Rousseau wrote a novel called Emile (Rousseau, 1762), about a young boy and his tutor. In Emile, Rousseau lays the foundations for child-centered educational theory and beyond. Instead of being taught other people's ideas, Emile is encouraged to draw his own conclusions from his own experience. For example, Emile is encouraged to break a window in order to find that he gets cold if the window is not repaired. Rousseau emphasizes Individualized education - 'Every mind has its own form'. Rousseau continued to discuss the role of the educator, and described it as ‘facilitate opportunities for learning’. He claimed that education comes from three masters: (1) education of nature: the inner growth of our organs and faculties. (2) Education of men: the use we learn to make of our growth. (3) education of things: what we gain by our experience of our surroundings.

In addition, as a romanticist, Rousseau stressed wholeness and harmony through solitude with nature. Emile is not allowed to read books, but is encouraged to experience the world first hand. Rousseau makes one exception, and allows Emile to read one book until adulthood, this book is Robinson Crusoe - an expression of the solitary, independent man that Rousseau seeks to form (Doyle & Smith, 1997).

Johann Heinrich Pestalozzi (1746-1827): Pestalozzi was inspired by the Empiricism movement and specifically by Rousseau’s Emile, and in 1805 decided to establish a revolutionary school at Yverdon, Switzerland. He argued that children should learn through activity and through concrete

things rather than dealing with books and words (Pestalozzi 1894). Pestalozzi believed that children should be free to pursue their own interests and draw their own conclusions from their observations. He placed a special emphasis on spontaneity and self-activity. Children should not be given ready-made answers but should arrive at answers themselves. The aim of his school was to educate the whole child - intellectual education is only part of a wider plan. He looked for balance, and strived to keep three elements in equilibrium: the hands, heart and head. Pestalozzi developed a method he called Anschauung - direct concrete observation, often inadequately called 'sense perception' or 'object lessons'. Based on his method, children were not allowed to use words until sufficient Anschauung, direct observation, has occurred (Smith 1997). The concept or topic must be observed in a concrete way. Pestalozzi's followers developed various sayings from his method: from the known to the unknown, from the simple to the complex, from the concrete to the abstract. (Kilpatrick 1951)

Friedrich Wilhelm August Froebel (1782 - 1852): Froebel's original concern was the teaching of young children through educational games at home, in the family environment. Froebel sought to encourage the creation of educational environments that involved practical work and the direct use of materials. He believed that through engaging with the world, understanding unfolds (Brosterman 2002).

Froebel visited Pestalozzi's school in Switzerland in the year it was founded, and was deeply inspired by Pestalozzi's educational ideas. Froebel developed a series of educational materials (the Gifts), activities (occupations) and movement activities, and linked it all with a set of educational theories. Through his education he sought to encourage the understanding of unity in all things. The "gifts" and related "occupations" helped young children learn about color, form, geometry and some physics concepts through the construction and design of 2D and 3D structures. In his occupations, Froebel directed the children to three types of different design activities using the same Gifts: forms of nature, beauty, and knowledge. With regards to his design principles, he designed objects that are developmentally appropriate and can be introduced in a gradual way, in a modular fashion, with aesthetically pleasing designs. From education point of view, he emphasized learning about the world by building and constructing models of real things from the world.

The 'Simplified Reality' movement

John Dewey (1859 - 1952): Dewey developed a broad educational philosophy. It seems he was influenced by Rousseau's writings, and like Vygotsky (1896-1934), he viewed the formation of the mind as a primarily social process. Dewey's educational philosophy focuses on three main areas: (1) Experience and reflection - a strong connection to Locke's original views. (2) Democracy and community, and (3) environments for learning (Dewey 1938). The latter is the most relevant to the focus of this paper.

Dewey argues that learning environments should be a simplification of present life: 'I believe that the school must represent present life-life as real and vital to the child as that which he carries on in the home, in the neighborhood, or on the playground' (Dewey 1897, Article II). Children should engage in social activities, learning by doing, specifically by doing activities that are part of real life, the adult's life, the life at home. An interesting example is the laboratory school Dewey and his wife Alice ran at the University of Chicago. In this school, children learned early chemistry, physics, and biology by experimenting with the natural processes involved in cooking breakfast.

CATEGORIES OF LEARNING OBJECTS

There are many common themes in their educational philosophies. They all believe in learning from experience, active learning, by interacting with learning materials and with people. They all believe that controlling the learning environment is the best way to encourage learning, and that teachers should provide opportunities for learning, rather than deliver information and facts directly to learners. In particular, Froebel and Montessori share many principles in their Learning

Objects. They both design developmentally appropriate objects, highly modular, materials that promote sensory interaction, with a simple, aesthetic design.

But there are also clear differences, clear enough to separate their designs to distinct categories.

Froebel's category
Froebel's artifacts are construction kits, building materials, that promote activities that involve design and model building. His artifacts help children understand the physical world by making models of physical things, his artifacts engage children in an expressive activity, letting them express their own ideas through design and construction. Froebel's artifacts can also be used to learn about geometric relationships, but only as a secondary goal to the design process. For example, Froebel's gifts numbers 3, 4, and 5 are carefully designed building blocks, where the blocks' sizes differ in specific geometric relationships. While children are engaged in a design process, they might also learn about the geometric relationship.
Froebel's artifacts are the forefathers of today's building toys category, toys that are design materials, that enable children to build models of physical things, and to express themselves visually using 2D and 3D construction sets. This category include toys like LEGO bricks, Tinkertoys, Knex, and materials like colored shapes, sticks, paper cuts etc.

I term Froebel's category as the '**Construction & Design**' category.

Montessori's category
Montessori's artifacts, on the other hand, are not design or construction materials. It is possible, but awkward and unnatural to use Montessori materials to create models of physical things in the world. Montessori's artifacts are about abstract concepts, not the physical world. Each of her artifacts carefully designed to represent a single abstract concept. The most dominant design guideline in her works is 'isolation of properties'. She wanted to make sure that when children interact with one of her materials, the hands-on manipulation process will help them 'absorb' the abstract concept through physical interaction alone, independently, with no teachers guidance, and without any real-world analogy (like Froebel's physical analogies: a house, a train, a tree etc.) For example, consider Montessori's 'long stairs' materials, designed help children 'absorb' the concept of 'a number'. The long stairs are large. The smallest one is 10cm long, and the longest one is 100cm long. They are painted red, to make them appealing to children. When a child plays with the long stairs, the design does not encourage her to build towers, castles, or houses using the 'blocks'. Rather, there is a limited number of configurations. When the child is engaged in the interaction, she has the opportunity to enter the special 'polarization of attention' state (as described in the Montessori section above), and through physical interaction with the hands, 'absorb' the abstract concept.

Montessori's artifacts are the forefathers of toys that we see today in toy stores, such as shapes puzzles, sorting toys and stacking toys. In addition, many classroom materials seem to belong to the same category, such as Cuisenaire rods, base-ten blocks, and fraction tiles. Historical artifacts from this category would be the Chinese Abacus, a tangible representation of the abstract concepts of addition and subtraction; or the Russian Matriochka, the wooden dolls that stack into one another, a tangible representation of the volume concept.
I term Montessori's category the '**Conceptual Manipulation**' category.

Dewey's category
Dewey did not design Learning Objects, but he made it clear what would be a good learning artifact based on his views on learning environments: a simplification of real life. So good Learning Objects should help children feel a part of the adult world, the real world. Dewey's views created a revolution in early childhood environments. Children-size real-world artifacts were developed, like kitchen appliances, kitchen tools, plates, cups, and play food. Costumes for children to dress-up as firefighters, policeman, construction workers or doctors became a popular toy. A 'Dewey Artifact' would be one that is safe for children, fit to children's dimensions, and

enable them to freely, independently, pretend in a participatory way they are part of the adult world.

I term Dewey's category the '**Reality Role Play**' category.

CLASSIFICATION OF LEARNING OBJECTS
In the previous section, I have presented the three categories of Learning Objects. In this section I will classify Learning Objects (and some Toys) into the categories. I will start with the classic (non-digital) objects, and continue with the more recent digital Learning Objects.

Classic (non-digital) Learning Objects
The classic Learning Objects are made of wood, plastic, fabric or other tactile materials. They are popular in today's Preschools, Kindergartens and elementary schools.

Construction & Design	Conceptual Manipulation	Reality Role Play
Froebel Gifts	Montessori Materials	Baby Dolls
Paper Weaving	Shape Puzzles	Food Play
Pattern Blocks	Shape Sorting & Stacking	Household Play
Unit Blocks	Color Matching	Kitchen Sets
LEGO® Bricks	Cuisenaire Rods®	Jobs Costumes: Pilot, Chef, Doctor, Nurse
Lincoln Logs®	Number Tiles	Doll Houses
K'NEX®	Alphabet Blocks	Trains

Construction & Design
Learning Objects in this category are building sets and construction kits (for 3D construction), or 2D units that connect/attach together for construction in 2D. Usually, the units are based on geometric rules, helping children explore reality through arrangement of the units in ways that resemble real-world things, such as a house, a tree, a person, a farm, an animal, or a machine – with 3D modeling, and a flower, a boat, or an animal – with 2D modeling. Geometric building blocks can be used to explore the abstract concepts encapsulated in geometry, but usually, through a design process (for example, making flowers with pattern blocks). The natural activity with these Learning Objects is modeling of real-world things.

Conceptual Manipulation
Learning Objects in this category are math manipulatives, geometric puzzles, number puzzles, alphabet blocks and alphabet puzzles. The main play activity in this category is matching, arranging, sorting, stacking, observing. Usually, there are no creations of structures that resemble real-world things, but rather an interactive exploration and/or problem solving. The natural activity with these Learning Objects is an interactive exploration of abstract concepts.

Reality Role Play
Learning Objects in this category are Pretend Play objects, Dress-up costumes, train sets, dolls and doll houses. The main play activity in this category is 'imaginative' play, in which the child pretends to be an adult, using adult tools, and taking typical adult responsibilities. Based on my definition, the play activity in this category is not similar to 'fantasy play', in which children are pretending to be fairies, knights, princesses, or dragons. The key characteristic of the 'Reality Role Play' category is 'pretending to be an adult from the child's reality'. The natural activity with these objects is social interaction and interactive exploration of adult-like activities and responsibilities.

Digital Learning Objects
The early days of electronics brought us the electronic trains and later the remote control cars. In the recent decade, the decreasing costs of digital electronics brought a proliferation of digital toys. Many are merely adding flashing lights and buzzing sounds to traditional toys (like dolls and cars). Others use innovative technologies to augment school-like workbooks, creating new play

experiences, but ones that are limited to memorization and repetition. But some, usually from academia, are building on Locke's tradition of 'knowledge comes from experience'.

Digital Construction & Design	Digital Conceptual Manipulation	Digital Reality Role Play
LEGO Mindstorms	Neurosmith Music Blocks	Digital Kitchen appliances
MIT's Cricket	Queensland Univ. Electronic Duplo Blocks	Digital Pets
Osaka Univ. ActiveCubes	MIT's System Blocks	
Colorado Univ. Smart Tiles	MIT's Flow Blocks	
Colorado Univ. Cell Blocks	Sussex Univ. Chromarium	

The above table represents a sample selection of digital Learning Objects. Clearly, there are relevant toys and research project that I have not included.

Digital Construction & Design

Learning objects in this category enable construction & design of 2D and 3D structures, involving sensing and actuation. For example, Mindstorms (LEGO) enables construction and programming of robots, Cricket (Resnick 1996) enables construction of kinetic sculptures and interactive art projects, ActiveCubes (Ichida 2004) enables construction of 3D shapes with built-in sensing & actuation, Smart Tiles and Cell Blocks (Elumeze 2005) enable construction of 2D and 3D light patterns. These Learning Objects follow Froebel's design tradition, encouraging children to design and construct models of the world.

Digital Conceptual Manipulation

Learning objects in this category enable interactive, hands-on exploration of abstract concepts that involve computation or computer simulation. For example, Music blocks (neurosmith) explores dynamic musical patterns, Electronic Duplo Blocks (Wyeth 2002) explores computational logic, System Blocks (Zuckerman 2003 explores system dynamics simulation, Flow Blocks (Zuckerman 2005) explores causality over time, and Chromarium (Rogers 2002) investigates digital color mixing. These Learning Objects follow Montessori's design tradition, encouraging children to explore abstract concepts independently, through a self-guiding process, using modular, physical objects.

Digital Reality Role Play

Learning objects in this category enable active role-play, helping children engage in imaginative play scenarios involving adult responsibilities. Some digital objects are doing it successfully; others limit the child's imaginative play, and dictate specific play scenarios. Digital Kitchen appliances usually enhance the pretend scenario, bringing the child one step closer to the adult's life (the appliances are working). These learning objects follow Dewey's philosophy, encouraging children to engage in social interaction and play roles of the adult world around them.

DISCUSSION

I have presented a historical overview and a classification of Learning Objects. Clearly, the educational pioneers I discussed were not operating within a limited category. They were actively seeking new ways to help children learn in new ways, and their work should not be confined in rigid categorization. In addition, as with any classification and categorization, some items can seem to fit more than one category. This is especially true with digital objects, which are multi-functional.

Nevertheless, the categories I presented are distinct, and can be a helpful tool for designers of Learning Objects, researchers, and educators. An interesting future research would be the connection between play and learning within and between the categories. For example, if a teacher desire to help children learn about the abstract concept of 'number' through a playful hands-on activity, it can be done with Montessori's 'long stairs' or the more popular Cuisenaire rods (Conceptual Manipulation category), with Unit Blocks or LEGO bricks (Construction &

Design), or with pretend-food or pretend-money playing grocery store (Adult Role Play). Obviously, all directions are valuable. But maybe some kids are more inclined to learn in a specific way. Maybe some children are more 'Conceptual Manipulators' while others are 'Designers" or 'Pretenders'. Maybe, with further research, teachers and parents would be able to better match the Learning Object to the child, helping children learn in the way most natural to them.

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