



Design and Learning (D&L) in the Kindergarten

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Abstract

This paper reports about a learning model, "Design and Learning" (D&L), in which mindful interaction with the designed world (the human-mind-made-world), and active involvement in designing objects for this world, serve as an intellectual and practical platform for promoting young children's learning of content, processes, and skills related to the artificial world. The model comprises 7 strands: S1 - the designed/artificial world (products and their use/context); S2 - problem solving (from haphazard to budding systematicity in planning and implementing solutions); S3 - design (from free-form building to reflective construction); S4 - notations (from conventional signs to computer programs); S5 - smart artifacts (from analyzing controlled behaviours to designing adaptive behaviour); S6 - special design for special needs; S7 - the integrative project. Actual implementation examples are presented.

Keywords

Technological thinking, kindergarten, design, artificial world

This paper presents a constructionist learning model, "Design and Learning" (D&L), in which mindful interaction with the designed world (the human-mind-made-world), and active involvement in designing objects for this world, serve as an intellectual and practical platform for promoting young children's learning about contents, processes, and skills related to the artificial world. The rationale of the model is based on the encounter between *Technology* and *Learning*, both taken in their broadest possible sense.

Technology in our rationale has to do with the designed world, the world of artifacts, from the perspective of the *human resources* involved in its creation, e.g., individual and socially accumulated knowledge; beliefs; perceptuo-motor, cognitive and metacognitive processes (Mioduser, 1998). Technology is obviously about tools, artifacts, and the processes and skills related to their design and use. But, more important in our model, it is about *human knowledge*: about its embodiment in an artifact; its generation and implementation for designing a solution; its social construction, accumulation and transmission; its refinement and adaptation when facing new problems. It is also about the way humans *face problems* and *plan* the optimal (not correct) way to close the gap between an existing and a desired state of affairs. It is about the way humans *overcome natural constraints*, modifying nature to satisfy objective or subjectively perceived needs and goals. Finally technology, in a broader view, is about the effect of the recursive interaction between the "inventor's mind" and the "invented world" on the construction of the



world as well as on the construction of the mind - and about the effect of this recursive interaction on the phylogeny and ontogeny of human knowledge and perceptions, (Cole & Derry, 2005; Kirlik, 2005; Ortega y Gasset, 1941).

Learning in our rationale relies on the integration of several theoretical approaches: constructivism, social-constructivism and constructionism (Kafai & Resnick, 1996; Papert, 1991; Vygotsky, 1978); situated learning (Collins, Brown, & Newman, 1989); learning-by-design (and its close associates, problem- and project-based learning, Kolodner et al., 2003). Our model locates the learner (individuals and groups) at the centre of the learning process, in the dual role of main engine and main beneficiary of it.

Upon the synergy between *technology* and *learning* we have devised the D&L model. Designing the world has always been a defining characteristic of humankind, affecting both the shaping of the *world* and the shaping of the *world-shaping-mind*. Our leading and simple claim is that *what has been a powerful philological tool supporting the cultural evolution of humankind and human knowledge, i.e., technology, is also a powerful ontological tool supporting the intellectual evolution of learners at all age levels.*

The D&L model and its implementation in the kindergarten

Overall, the D&L model comprises four main layers: (a) learning strands, (b) pedagogical interventions, (c) learning environments and materials, and (d) research activities. A comprehensive description of the model is beyond the scope of this paper and conference presentation, thus, we will focus mainly on the first layer, concerning the learning strands.

In the current implementation of the model in five kindergartens in Israel, contents, skills and processes are organized in seven main strands (S1 to S7) running throughout the year in developmentally-appropriate progression. Strands 1 to 5 are presented in the following sections (not described in this paper are **S6** - 'special design for special needs'; and **S7** - 'the integrative kindergarten project'). In the following sections we introduce each strand, and present examples of learning situations and processes observed in the kindergartens.

S1 - the designed/artificial world (artifacts and their use and context)

In this strand a twofold purpose is pursued, fostering: (a) children's acquaintance with the designed world (it's components, functioning, characteristics), and (b) with human's thinking, knowledge and considerations involved in its design.

At the **content** level, the children deal, in every task, with questions relating to an artifact's "identity" (e.g., What is it? What is it for? What name should we give it? Does it work "by itself" or do we need to operate it?) as well as its structural and causal configuration (e.g., What parts is it made of? How do the parts work together?). Dealing with these questions is frequently accompanied by classification activities, aiming towards the formation of categories on the basis of structural or functional properties. At the **processes** level the children are actively involved in diverse forms of interaction with artifacts. The artifacts are physically handled, taken apart both manually (analysing causal interrelations) and conceptually (e.g., constructing a simple functional map). Information about artifacts is searched for, and alternative solutions are discussed, and often built.

S2 - Problem solving (from haphazard to budding systematicity in planning and implementing solutions)

While working on this strand's activities, mostly emerging spontaneously in relevant situations of



the kindergarten's daily life, a problem solving culture is gradually co-constructed by children and teachers. The trigger for the process is usually a declaration -by a staff member or by one of the children- that "we do have a problem". Iconic signs are used to portray a scheme of the process. After generating and representing (e.g., drawing) several alternative solutions, and discussing their pros and cons, the children cast a vote, selecting the solution they choose to pursue.

Although the situations in which children are involved in problem solving processes relate at first to the artificial realm, very rapidly the approach and use of strategies propagate into other areas of the kindergarten's life (e.g., conflicts among children, dilemmas related to contents being learned), thus becoming a more general tool. In all cases the discussions are supported by the construction of representational charts and graphs of the problem solving process (by themselves artificial/invented constructs).

S3 - Design (from free-form building to design/reflective-construction)

Design is the heart of Technology. As a highly structured or mindful process, as a completely intuitive and unplanned process, or in any combination of these modalities, we design every time we attempt to close a perceived gap between an existing and a desired state-of-affairs by means of an invented solution. Working in this strand, the children get involved in a long journey, which starts with very basic experiences with materials and building kits and intuitive attempts to construct objects and devices. Along the journey, several activities support the construction of a cognitive toolkit for design: reflection on what is being done, verbalization and formalization of procedures, gathering of relevant information (e.g., on materials, procedures, past solutions), using representations and notations for either documentation or planning (linkage to strand 4), addressing moral and ethical questions.

The way the learning proceeds can be depicted as an evolving journey, starting from preliminary acquaintance with materials, tools and processes and the very idea of constructing, via systematic work with building kits and design situations, to the integration of knowledge and abilities in individual, group and whole kindergarten design projects.

Expanding the children's intuitive and creative encounter with the rich repertoire of building kits which normally populate any kindergarten, the children are requested to accomplish various exploration and conceptualization tasks, e.g., composing an ID card for the building parts or blocks, naming them, hypothesizing about their functions; classifying them into meaningful groups; exploring possible assemblages of parts forming functional compounds.

In addition, drawing is used as reflection and thinking aid before, while and after designing and building. First in the progression is drawing-after-building, for the purposes of documentation and communication. In this modality, drawing promotes (and even demands) reflection on the object constructed, e.g., on structural aspects, on mechanisms (e.g., types of transmissions), or representational issues (e.g., scale, 3D to 2D translation, level of detail). Gradually, drawing is introduced for planning purposes, fostering anticipatory thinking, envisioning and concrete representation of the structure and mechanisms required to materialize the object.

S4 - Notations (from conventional signs to computer programs)

Symbolic behaviour is a defining characteristic of humans, and the invention of notational systems one of the essential achievements of the human mind. The generation and manipulation of representations have been part of human's intellectual and cultural development since ever, taking countless forms and fulfilling diverse functional goals. Besides communicative referential



tools, external representations are also epistemic tools, “objects to think with”. (Tolchinsky, 2007).

Notational systems constitute a unique strand in our model for two reasons. First, because of its centrality as an intellectual tool serving all layers of technological thinking and making - thoughts get objectified allowing cognitive operations on them, e.g., reflection, analysis, decomposition, comparison, grouping, arguing for or against. By being involved in the construction of notations (e.g., defining conventions, selecting representational units and symbolic entities, establishing representational rules), children deal with both the represented content and the representing means -the 'epistemic tools'- and with the very process of inventing conventional representation and communication systems. In addition, the work within this strand naturally blends with the kindergarten's curricular requirements in the areas of literacy and numeracy.

All activities are built as progressions from concrete involvement in situations in which action and representation are intertwined, via different stages of conventionalization and symbolic translation, to the work on formal representations. One example is the devise of conventions for "telling someone how to navigate a labyrinth". The progression starts as actual navigation in a path, while trying to formalize the description of the required set of actions (e.g., 2 steps forward, right turn, 1 step forward, etc.). Next will be the generation of a description for navigating the labyrinth -and its formal representation- to be communicated to another "traveller". At the end of this progression stand programming activities by which the children construct a program required for a robot to navigate a path (link with strand 5).

S5 - Understanding and constructing artificial-behaviour

Today, controlled systems (e.g., automatic doors, domestic devices, programmable toys, communication and computational devices, robotic systems) have become obvious components of our artificial environment. With the widespread development of microprocessor-based devices, a new category of artifacts infiltrated the traditional and intuitive distinctions between the alive and not-alive, animate and inanimate, human-operated and autonomous: the realm of behaving artifacts. While pertaining to the artificial world, these devices are conceived as endowed with traits such as purposeful functioning capabilities (behaviour), programmability and knowledge accumulation capabilities (learning), autonomous decision-making and adaptive behaviour. The interaction with controlled-artifacts (either as mere user, trouble-shooter, or generator of controlled processes at home or learning settings) demands a new cognitive approach, a different mental modelling of the devices (of their structural, functional and behavioural configurations), and a new set of skills associated with the design and implementation of artifacts' behaviours.

In this strand's activities children are engaged in discussions on the nature of devices "which make decisions" (e.g., an electric kettle or an automatic door), on the physical resources required to construct behaving artifacts (e.g., to be able to move or to sense), and on the logical constructs governing their behaviour (e.g., routines, If...Then... rules). Gradually, they enter the process of constructing a robot's behaviour by means of a specially developed programming interface (Mioduser & Levy, 2010). In the programming activities, the children are engaged in recursive cycles of construction/reflexion, concrete-experimentation/abstract-symbolization, analysis/synthesis, while solving a progression of tasks of increasing complexity.

Concluding remarks

six years of implementation of the D&L model (this year already in five kindergartens) have been enlightening for us as researchers, on a wide range of learning issues emerging from the



encounter between children and the artificial world. Examples of significant insights are: perceptions and concepts development concerning the artifacts' world; situated and transferred problem solving; the development of representational and notational abilities; recursive cycles between the concrete and the abstract while constructing (programming) complex artificial behaviours; or the generalization of intellectual constructs consolidated in technological tasks for facing other subjects and even social conflicts and situations. We are currently working on formalizing other components of the model, on devising teacher training materials and procedures, and on expanding the study of the implementation process of the D&L model.

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