Technological thinking in the kindergarten – training the teaching-team

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This paper reports about the first stage of implementation of an innovative curriculum on technological thinking and doing in the kindergarten. The main goal in this first stage was to train the teaching teams, supporting their learning of the rationale, contents and pedagogical resources of the new curricular program. The program is the result of four years of research and development in an experimental project conducted in kindergartens in center Israel, and is currently being implemented in three kindergartens in north Israel in a cooperative effort between Tel-Aviv University and World ORT - a world non-governmental organization supporting technology education and vocational training in Israel and countries worldwide.

The challenge in this training effort is to foster the introduction of an innovative program influencing multiple aspects of the kindergartens' life: it is about technology (content), technological thinking (cognitive processes and skills), technology teaching in the kindergarten (pedagogy), and novel means and environments for young children's learning-by-doing technology (learning environment). Thus in this first stage of implementation, the main goals pursued were to ensure a progressive and natural adoption of the innovative program by the teaching teams, as well as its gradual and successful implementation in the kindergartens.

In this paper we report about the first stage of training and implementation of the program using data from structured teaching-teams questionnaires, observations, and documentation of actual activities in the kindergartens.

The context: Technological thinking in the kindergarten

Technology, and in particular design, are not part of the kindergarten's curriculum in Israel. In the Israeli educational system, kindergartens for the age-level we focus on (pre-school, age 5-6) are compulsory and mostly public - about 5500 kindergartens attended by about 170000 children. Typically kindergartens are independent and self-contained, managed by the teacher and aided by an assistant. Additional teaching resources are allocated for children with special needs in the kindergarten. Although some technology-related topics are often taught within the context of science topics, technological knowledge and relevant pedagogies are not part of most teachers' background

or formal formation. Prospect for change (at least concerning selected topics) is expected when the new science and technology curriculum for this age level, currently under development, will be completed (Ministry of Education, in press). However, in our understanding a more comprehensive approach is required, encompassing goals, contents, pedagogical solutions and teacher formation efforts.

Technological contents for the kindergarten level have been integrated in curricula developed and implemented in different countries (e.g., in the UK, New Zealand, the U.S. or various countries in continental Europe - see Compton and France, 2007; ITEA, 2000; Turia, Endepohls-Ulpe & Chatoney, 2009). Although these efforts may differ in foci, emphases and conceptual approach, common sets of content categories and target skills can be identified, e.g., fostering technological awareness and literacy, acquaintance with the world of artifacts in which we live starting from the immediate and familiar environment (e.g., toys, tools and utensils at home), acquisition of materials manipulation skills and even design process skills.

In our proposal for technological thinking in the kindergarten, we put emphasis on the cognitive process involved and demanded for understanding, interacting with and designing the artificial world: the human-mind-made world. In our model we adopt a cognitive/epistemological perspective (Mioduser, 2009), claiming that we should teach/learn technology because the making of the artificial world has always been a defining characteristic of human beings' thinking and intellectual development. Thus, learning technology is learning about thinking, about learning, about the (outer) invented world vis-à-vis the (inner) inventors' world, and about the results of the co-evolution -both phylogenetic and ontogenetic- of the designed and the designers' worlds.

In the current implementation of our model the contents are organized in six main strands (Sx), running throughout the year along a developmentally-appropriate progression: S1 - the designed/artificial world (artifacts and their use/context); S2 - problem solving (from haphazard to budding systematicity in planning and implementing solutions), S3 - design and making (from free-form building to designed/reflective construction); S4 - notations (from conventional signs to computer programs); S5 - smart artifacts (from analyzing observed robot behaviours to the design of adaptive behaviours); S6 - the whole-kindergarten final project.

The teacher training process - procedure

The project is being implemented in three kindergartens differing in socio-economic status in Kiryat Yam, in the north of Israel. As part of the first stage of the implementation, the project was introduced to the different populations involved.

First, its goals and implementation processes were discussed with the local education authorities. Since the city is involved in intensive educational plans emphasizing science and technology learning, the projects is perceived as fitting these goals. The next relevant population are teachers - the introduction of the project with teachers is the theme of this paper and will be detailed later. A special activity was conducted with parents, in which the goals and components of the project were presented. Many activities refer to the technological environment both in the kindergarten and at home, and even involve members of the family in tasks conducted at home. The most relevant population are obviously the children. They experience gradually the activities and tasks as part of the regular life in the kindergarten, since these are integrated in the ongoing activities. Knowledge and skills are gradually constructed while children work in the different strands intertwined with the regular kindergarten activities.

The trainees are three kindergarten teachers and their teaching assistants - six participants. All six participants are very experienced (over 15 years of experience). However, this is the first time they deal with technology subjects.

The in-service training program implemented comprised: (a) 30 hours of group training in meetings held very other week in a different kindergarten; and (b) personal tutoring in each kindergarten for half a day every two weeks (about 30 hours per kindergarten). The whole process lasted about five months. Each group meeting comprised: (a) learning and discussing a new topic

(focusing on either a conceptual issue, learning activity, or learning environment); and (b) sharing experiences, reflecting and elaborating about activities implemented in the kindergarten during the two weeks between the meetings.

The training program and schedule is summarized in Table 1.

Table 1: schedule and plan of the training

Meeting	subject
1	Conceptual framework and overview of the project. • The artificial word • Children's perceptions of the artificial world • Age-level developmental characteristics • Curricular strands
2	Problem solving as general process in daily life and technological problem solving
3	Construction tasks Sketching and representing for documentation and planning
4	Tracks and mazes - adaptive behavior design Notations
5	Robotics: building the robots
6	Robotics: the behaviour construction software
7	Robotics: Programming tasks

During the visits to the kindergartens the training tutor assists the teachers in integrating the theoretical concepts and practical ideas into the kindergarten's daily life. As well, all along the process the teachers are requested to document the experiences (digital pictures of children's work and performance, and actual products).

Data about the training and initial implementation processes are being collected using a structured questionnaire, observations, and products analyses. The questionnaire comprises 18 questions, and its foci relate to teachers': (a) understandings and perceptions of technology and technology-related concepts before and following the training program; (b) conceptions of the goals to be pursued in the implementation of technological thinking activities in the kindergarten; (c) thoughts, ideas and suggestions about curricular and pedagogical solutions for teaching technology in the kindergarten; (d) description of, and reflection about, the actual implementation of the technological thinking curriculum in the kindergartens; (e) perceived difficulties during the implementation process; (f) thoughts about the next stages of training and implementation.

Main insights from the training and early implementation stage

Due to the limited scope of this paper, in this section we present a brief and preliminary account of some of the data collected during the training sessions and implementation activities.

Teachers' perceptions as reflected in the questionnaires

Perception of Technology before and following the training

As could be expected, teachers' understandings at the beginning were related to the idea of a discipline closely related to science, which implies innovation and developments affecting all aspects of life, and fosters the generation of solutions satisfying human needs. Although after several training sessions teachers' first claimed that their understanding did not change much, the formulation of their answers indicated that they got "*improved understanding*", and that the process provided them with "*insights that helped sharpening*" their ideas about the nature of technology (italics stands for quotations of teachers answers).

They also indicated that they had no previous acquaintance with curricula related to technology in the kindergarten - the contents and approach are new for them.

Goals for technological thinking in the kindergarten

Teachers' answers revealed their perception of the importance and the potential contribution of the subject in the kindergarten: it supports "*a better understanding of reality, creativity, growth of thinking skills, and broadening of horizons*"; it stimulates "*motivation, curiosity, responsibility taking, and the development of problem solving, attention and communication skills";* it fosters *"cognitive, motor, social and affective growth*".

Curricular/pedagogical issues

Teachers noted that before the training they did not think at all about the possibility to teach the subject in the kindergarten. Even for activities that were similar to some included in the innovative program (e.g., construction using different kits), they never approached these from the perspective of technological thinking. Now they are able to think about rich possibilities concerning a variety of pedagogical aspects, such as **types of tasks** (e.g., construction, disassembling artifacts, sketching), **contents** (e.g., focused mainly on technological topics or linked with other curricular topics), **generic skills** (e.g., problem solving, linking between the concrete and the abstract)

Asked about the main pedagogical aims to be pursued, the teachers formulated the above issues in the form of goals. As well they added goals related to technological contents, and to the role of doing in learning. One teacher noted that the approach adopted towards technology and technological thinking "*actually encompasses many of the goals demanded by the kindergartens core curriculum in its different subjects*" (e.g., notational literacy, numeracy, motor skills, social skills, contents in various subject areas).

Actual implementation in the kindergartens

Asked to supply examples of activities they now conduct in the kindergarten, their descriptions actually referred to the varied repertory addressed in the training sessions. In addition, they pointed that now it appears that "*everything they do in some way is technology*". This is consistent with the rationale of the program emphasizing thinking and cognitive processes, and with the linkage they now are able to recognize between these processes in the context of technology and in the context of other subject areas.

An interesting aspect of the implementation process relate to the teachers assistants. Traditionally the functions of the assistants are well defined and refer mainly to services and supporting functions. In our model they became integrated as partners in the training process, and then in the work with the children. Teacher responses are indicative of a change in their roles, in their partnership with the teacher, their understanding (and interest) of the processes undergoing in the kindergarten, and their sense of empowerment as partners in the implementation of the innovation.

Perceived difficulties in the implementation process

Teachers pointed out difficulties or issues that ought to be addressed. They perceived as a challenge that the program is not formulated as a well structured, step-by-step linear program. We remind that the curricular model is introduced into the kindergarten's life as a sort of "pedagogical toolbox" comprising different strands, instruments and resources, and the teachers are allowed to compose activities and sequences according to their needs and the opportunities continuously evolving in the dynamic life of the kindergarten. This is certainly a challenging modality for teachers used to follow well structured curricula. They pointed up the additional load imposed by the new program, in aspects such as time allocation and management to deal with all curricular subjects, "division of labor" among the team members to deal at the same time with groups working on different tasks, or the

demand for regular documentation of the processes taking place and children's work (for further reflection, elaboration and learning).

They perceive also as demanding their role as "pedagogical companions" of the children in their work: instead of "teaching" in the traditional sense, now they have to be attentive to raising needs and questions and devise ad-hoc guidance and solutions in an ongoing fashion. In addition, individual differences lead to ample variance in needs, processes and even products, adding considerable complexity to the teachers' new role.

Other perceived difficulties relate to children's differential ability to master required skills, in tasks such as constructing with kits, or sketching and drawing. Interestingly and paradoxically, one difficulty mentioned relate to children's "over-enthusiasm or over-motivation" towards the activities, making the management of the ongoing work more demanding.

At another level, so far there is little involvement of the parents in the process. They mentioned that parents express interest when they see children's work and products. However at this point they were not exposed enough to the ideas, processes and activities being implemented, and they expect to generate more involvement in the future.

What next?

Teachers responses unanimously express their willingness and motivation to go deeper into the ideas and pedagogical components of the innovative program. They evaluate the first stage of the work as highly interesting and rewarding learning experience, and look forward for the new topics to come (e.g., the robotics chapters).

Three vignettes from kindergarten's life

A detailed description of the implementation of the whole program is beyond the scope of this paper. In the following we present three representative examples of the way the teachers interpret the materials from the training sessions and adapt these for the local implementation in their kindergartens.

Vignette 1: Paths and tracks - generating and representing behavior

Strand: representations and notations

Specific goals: Construction of physical paths for performing spatial behavior tasks
Creating representations for spatial behaviors

Description of the activity

The generic model of the activity comprises the design and building of physical paths (e.g., in maze-like configuration) which children traverse in a progression of tasks focused on different aspects. An example of a progression: first tasks emphasize spatial orientation (e.g., directionality, diagonals); then children create a physical 1:1 representation of the path using footprints and arrows, which are later reproduced on paper in a smaller scale; then they are requested to invent representations for the observed spatial navigation; the representations are then refined to become more formal notations (with agreed conventions) to serve as instructions to guide "novice navigators" of the maze.

In one kindergarten the localization of the generic model brought about the construction of an intersection of streets with traffic lights and crosswalks (Figure 1). Arrows were used to indicate directionality. Children navigated the space playing either the cars or the pedestrians roles - the whole system was controlled by children manipulating the lights. In the next stage the idea

of discrete steps was introduced (as basis for further work on units, measurement and notations), when children navigated the space according to the steps indicated by a dice. Stations in the path required answering questions about road behaviour and security - conventions and rules.

Figure 1

Figure 2

Conclusion

This activity encompasses manifold aspects, knowledge and skills: e.g., spatial orientation and mobility, directionality, receiving and giving instructions, decision making, knowing and using conventions and conventional signs and notations (using representational means which are concrete, e.g., footprints, or symbolic, e.g., arrows, marks, numbers). This activity has been naturally linked to the topic "road safety" being treated at that time in the kindergarten. Thus, a generic activity from one strand of the technology program was localized by the teacher, and naturally integrated within the ongoing curriculum. The observations all along the process -planning, constructing, navigating the space, inventing representations, formalizing notations, formalizing the control rules- unveiled children's high level of motivation and enthusiasm as well as evident mastery of the complex set of skills involved in performing the task.

Vignette 2: Constructing, sketching and drawing

Strand: Design and making

Specific goals: Construction with modular building kits
Documenting the constructed form from different perspectives

Description of the activity

The generic model of the activity relates to the construction process of static and dynamic structures using modular building kits. The teacher's choice for localizing the activity was to emphasize observation and reflection about the constructed object using drawings as thinking aid. The children were encouraged to draw their object from different perspectives or projections - sides, upper and bottom views (Figure 2). She suggested to divide the drawing space in three parts with the titles of the projections.

Conclusion

The discussions conducted with the children focused on the properties of the different views, their nature as partial representations (what is missing?). The children were amazed with the way their object looked by the different views. The activity is demanding, however it allows reflection about the properties of the object (structure, form, dimensions, construction details) intertwining con-

crete and conceptual aspects, i.e., the drawing process and the drawings (reflecting by making) and the verbal elaboration (reflecting by conceptualizing).

Figure 3

Vignette 3: Representing problem-solving

Strand: Problem solving

Specific goals: Experiencing a problem solving process
Using concrete representations for the solution selection stage

Description of the activity
The generic model of the activity demands the repeated involvement in numerous problem solving processes fostering the development of systematic strategies and the acquisition of relevant skills. The problems to be solved are related not only to technology related topics, but to numerous situations from the kindergarten's life as well. After a few experiences triggered by the teacher, the problems then are normally raised by the children themselves within any possible context of their activities in the kindergarten. The structure of the problem solving process is gradually constructed and agreed fro conventional use. A critical stage is the one in which children raise alternative solutions supported by convincing arguments. Then the group is requested to define the chosen solution, by personal vote of the preferred option. In one kindergarten the teacher decided to elaborate with the children about the representation of the results of the vote, first by constructing a "human histogram" (Figure 3): every child in her/his turn made a choice and went to site in line in the appropriate "column". The teacher conducted a discussion about the dimension represented in the columns, the meaning of the unit used and their accumulation, and he configurations generated. Then they translated the representation into paper creating conventional graphic representations of the quantitative data.

Conclusion
The problem solving strand becomes powerful thinking and acting resource in the kindergartens' work on technological thinking. It encompasses many aspects that are gradually constructed by the children through repeated experience. The representational aspects are central to many stages in the process, including the consolidation of formal and conventional ways to express things. The focus chosen by the teacher, i.e., the graphic depiction of quantitative aspects, was implemented on the basis of the interplay between the concrete play and the symbolic representation - first as "concrete-symbolic" human-graph, then, once constructed and understood by experience, switching to only symbolic representation.

Concluding remarks

This paper presents only a very succinct glimpse into a very rich and complex process taking place in the kindergartens. We have witnessed a substantial transformation in teachers knowledge, perceptions and practices as well. More important, we do have evidences of teachers' appropriation of the components of the proposed model and their localization the generic ideas in correspondence with the idiosyncrasy and needs of each kindergarten and teaching team. The implementation of the model has already created important changes in the kindergartens' culture and life, and we expect to collect richer experiences as we move towards the advanced stages of the program.

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