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A PLANT IS BORN *TO* THE POTATO. PLANT MODEL EVOLUTION IN CHILDREN

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Abstract
The EU project kidsINNscience (Innovation in Science Education - Turning Kids on to Science, 2009-13; 7th Framework Programme) aims to innovate science and technology education. Starting from the common practice of plant growing in kindergarten and primary school, one of the practices suggested using potatoes to face children's common idea that they are fruits, growing on trees like apples. Adapting this idea to the Swiss school (kindergarten and primary), we stressed the inquiry-based-learning aspects of the potato growing experience, studying how children build and reorganize their discoveries and observations about plants in general and potato in particular, making science by analogy and representational redescription.

1. Introduction
Motivating science and technology (S&T) education in early years is vital to increase the science literacy in modern societies and to stimulate young people to opt for S&T careers. In this contribution we discuss a promising approach to and set of S&T activities in early school levels. This is to drive teachers to recognize child's thought about the topic studied, both "statically", what children think about it, and "dynamically", how their ideas develop toward something we call a "scientific model". Child's thought is based indeed on explicative models, usually named *conceptions,* abandoned by adults because incomplete, not structured or incoherent. Often, teachers cannot recognize the pupils' conceptions because teachers and pupils *interpret reality* using models from different paradigms, made with different concepts, relationships, languages [1-3]. Teachers' lessons shouldn't therefore *transmit,* but *trigger conceptions which reorganize learning processes* in children [4,5]. *This approach can be seen as a "child centered" Inquiry Based Teaching and Learning method* (IBTL)*, which aims to let young children develop science and methods starting from their own concepts, thought structures and strategies, looking at a possible continuity among levels.* Here, we present preliminary results of this approach applied in two field trials in primary and pre-primary school, with a S&T practice originating from Italy, adapted to and implemented in Switzerland. The trials were carried out within the project "kidsINNscience. Innovation in Science Education – Turning Kids on to Science", a collaborative SICA project funded under the Seventh Framework Programme of the European Union [6].

2. What is a potato? Field trial in kindergarten and primary school

2.1 Potatoes don't grow on trees
The practice "Potatoes don't grow on trees" emphasizes the everyday aspect of biological issues and fosters scientific competencies by offering IBTL activities and stimulating collaborative work. In the original project, over the course of five months, kindergarten pupils of age 3-7 became familiar with various aspects of potatoes: their diversity (within and among cultivars), the characteristics of tubers, their growing and developmental cycle, but also their importance in a cultural context, e.g. as part of the human diet. [7-10].

Fig. 1: Primary trial: the “Patateto”, with clearly visible growing potatoes (left), and materials from the “Patata day” (right): children reported on posters the discussion of several experiments.

Swiss teachers and teacher educators selected this practice because the potato is usually familiar to the pupils from everyday life, yet many aspects of it are unfamiliar or counter-intuitive, such as what part of the plant they actually eat. Furthermore, the many inquiry-based and hands-on activities were appreciated. In total, five Swiss schools adapted and implemented this practice to match the national and local context: two kindergartens and one primary school (1^{st} year) in the German-speaking area, one kindergarten and one primary school (2^{nd} and 3^{rd} year) in the Italian-speaking one (Ticino) [6]. In the following we give a preliminary comparison of the two latter field trials, carried out from January to June 2012.

2.2 Field trials in Ticino

Researchers of DFA (the teacher education institution in Ticino) got in contact with schools where future teachers perform their practice. A primary school in a former rural region was interested in the didactical project: teachers and pupils already farmed a school garden, and a consultant of ProSpecieRara, an independent Swiss foundation for biodiversity conservation [11], collaborated giving seeds of noncommercial cultivars, and making an intervention directly with the classes. A kindergarten teacher was involved for quite an opposite reason: living in a village in the neighbourhood of a big city, her pupils had hardly any experience with potatoes, even if seeding a potato field was a common activity of many of their grandparents. The original practice was adapted and implemented partly cooperatively by the teachers and the science education researchers. During the course of the field trials, an interdisciplinary approach has been used. The IBTL aspects became nevertheless very important, suggesting a longitudinal study on the evolution of the children’s “plant model”.

2.3 Preliminary field trial results in primary school

Before the IP took place, the pupils attending the 2^{nd} and 3^{rd} year planted bean seeds observing how a bean plant grows from them. This former experiential learning strongly conditioned the children when the reproductive cycle from tubers was taken into account. By analogy, pupils assigned to the potato the same role as to a bean seed. After a class discussion about the question: *what is a potato tuber?* pupils came to the conclusion that a potato tuber accomplishes several functions *in their model,* so that it could be considered three things in one: a seed, a root and a fruit. The challenge of the learning path was therefore to lead the children to consider potatoes (tubers) as a “box with the lunch” for the new potato plant, *differentiating/extending their actual model dynamically,* recognizing a sequence of stages. To allow the conceptions’ evolution [5], the whole vegetative cycle was considered as a trophic flow, “translated” by analogy in something natural for children: from “mother” potato to potato plant, from soil (considered as a water and salts container) and light to potato plant (the potato plant became independent from the “mother”), finally from potato plant to “baby” (new) potato tubers, growing up underground from the stolons, whose function was identified as similar to an umbilical cord in mammals. Starting from their initial "seed-root-fruit" model, the primary pupils built gradually this new one performing the activities in Tab. 1. The "Patateto" and materials from the "Patata day" are shown in Fig. 1.

1	"My potato"	Children bring their own potato from home. They observe: "my potato has eyes!", draw it, give it a name (cultivar name), cut it to look how it looks inside.
2	"My potato and the others"	Children having the same cultivar are grouped and try to describe how their potatoes look like: form, colour, dimension, smell, ...,
3	"Potatoes never seen before"	ProSpecieRara consultant presents to the children potatoes quite different from those we usually buy in a vegetable store. Children choose potatoes of one cultivar and observe them in small groups. The blue, violet and purple colours, as well as the lumpy aspect of some rare cultivars capture their attention, the sprouts became object of debate: are they sprouts, or roots?
4	"The Patateto"	Children plant their potatoes in the "patateto", a terrarium made of glass to allow growing potatoes to be seen. They begin to report their observations in a logbook.
5	"Inside potatoes"	What can we find inside a potato? With a simple experimental procedure children discover that potato tubers are made of water and starch: they are the "lunch box" for the new baby plant.
6	"Here came the water?"	Children discover that soils can be considered as a water reservoir. Some soils can retain water better than others: which is the best soil for potatoes? Just try and find it using different kind of soils, water, vessels, …,
7	"In the garden"	Children plant potatoes in the garden. Indoor/outdoor: what's the difference? Temperature, sun, humidity, silence (plants need quietness…).
8	"Leaves, flowers, roots, …and the time "	By drawing a comic strip in groups, pupils show how potatoes grow. Each picture represents a topic phase during the observed vegetative cycle, allowing the children to find relationships between the parts of the plant and their functions, observing furthermore how they evolve in time.
9	"But where are baby potatoes?"	The last picture in the comic strip shows the potato plant with flowers. So? Where do potatoes grow finally? Teachers give each child a picture of a potato tuber and ask them to put it in the model of the plant (constructed by now), where they expected potato will grow: a lot of children still put their potatoes on the stems.
10	"The discovery"	Back to the garden to solve the question: under or over the plant? Let's see what's going on in the patateto!
11	"Patata day"	Children become teachers! In the playground and in the backyard (garden) of the school a final exhibition takes place. In ten topic workshops pupils explain to the others children of the school and their parents what they discovered about potatoes. Photos, experimental activities, posters and materials allow the children to show what they did.

Table 1: Didactic sequence for the primary school field trial of the adapted practice "Potatoes don't grow on trees (2nd and 3rd year)

2.4 Preliminary field trial results in kindergarten

The strategy used to start the IP in kindergarten was to *discover* potatoes without any introduction. A list of the activities is shown in Tab. 2; some pictures are reported in Fig. 2. To collect conceptions and motivate children, during the first month the children have been stimulated with stories (Pollicina and the mole) and activities to recognize potatoes on images and express their ideas on what a potato could be or where it could be found. Children didn't recognize potatoes at all, neither knew clearly what they are. The following step was therefore to let them discover, touch, classify potatoes, choosing a personal one to keep in the classroom for affective reasons. When sprouts appeared, they hypothesized by themselves that potatoes were *growing as plants.* A*t this point children were asked to draw what the potato plant could look like.* In their drawings children represented two kinds of *"potato tree", identifying potatoes by analogy with already known models*: as fruits or as their representation of tulip bulbs (i.e. "balls" sprouting from the leaves), a surprising hyphothesis born by an activity done months before.

Fig. 2: Moments in the kindergarten trial. From left to right: personal potatoes in bowls, a "potato wood" (to model the real field, not shown), model evolution in a child: a "potato tree" before the sowing and a "potato plant" after the harvest.

From this point on, children were involved in two parallel paths of activities: to explore the inside of a potato/to cook it (the affective and cultural path), and to see it growing, hypothesizing step by step what it would need, what were the parts of the plant they observed, how could have been the "final" plant (the IBTL path). The comparison of two potato fields, one farmed in classroom ("little potato wood"), the other in an outdoor garden (a real potato field), allowed the children to make and test hypotheses, and to discover both the birth of the "new" potatoes and the "final" potato plant.

3. Discussion and conclusion

Even if preliminary, a first longitudinal glance about the building of a "plant model" in children can be sketched. First of all, in front of new facts, information and experiments, both kindergarten and primary pupils *seem to extend/implement their conceptions* trying to reorganize their knowledge in a *more stable configuration.* They seem to select alternative models for one thing (potato plant is/is not a tree), or admit different models for similar processes (there are seeds as the beans and "lunch boxes" as the potatoes) taking into account their former experiences/models (beans, tulips), and the new ones in a *representational redescription* [5]. The role of the *analogy* in this kind of learning process seems to be essential. *Analogic* reasoning is indeed the precursor of the *logic* one [12]: "to see a potato *as* a apple/bulb" (analogic reasoning) doesn't require logic values (true/false), while "to see *that* a potato is a happle/bulb" (logic reasoning) does: it could be *not* a happle/bulb, too. Analogic reasoning uses above all drawing, logic one uses above all the language: a picture is not "true" or "false", like a sentence can be [12]. The analogic reasoning selects therefore models taking into account the real experience, while the logic one uses true/false values*. In this sense, we might have observed a transition from an analogic to a logic reasoning between the school levels.* To consider the plant as a whole, all children start classifying *by analogy* its *parts,* their *names* and their relative positions. *Their function,* identified by the evolution of correlating parts' during the growth of the *whole* plant, was investigated above all from primary students, with experiments requiring true/false sentences *to select alternative models*. Kindergarten pupils made experiments and models too, discuss about words to describe plant parts, but they didn't *try to prove* that the potato plant was not a tree, because their models *changed considering real things by analogy, not looking for a crucial experiment.* Of course, this evolution should be investigated in *all* the school activities, i.e. not only in the IBTL ones. A deeper analysis of these preliminary work hypotheses will be therefore performed in a more detailed paper.

1	"A story"	Children listen to a story: the winter is coming; Pollicina runs under the ground, is guest of a mole. What could she eat, under the ground?
2	"The mole's burrow"	Children project a mole's burrow (drawing), and construct it (little and big models in the gym). Where's the larder, with the food for Pollicina?
3	"The mole's larder"	What has the mole prepared for Pollicina? Children look for images of food on newspaper: what is this? And this? Is it under the ground?
4	"Potato meeting"	Children meet potatoes (in a room full with yellow, red, violet ones). They touch, observe, classify potatoes. Children and teacher choose a personal potato.
5	"What's going on?"	Children find "crusts" on their personal potatoes. What could it be?
6	"Kitchen"	Children collect and present recipes taken at home. They decide that gnocchi is the best recipe, and ask the school's cook how they can cook gnocchi at school.
7	"Gnocchi"	Children make gnocchi. They investigate how the potato looks like inside.
8	"After some days…"	Children observe the "crusts" growing on the potatoes
9	"The potato plant"	Children draw what kind of plant they think it will be, the potato plant…
10	"Water or soil"	Children decide what their personal potato plant might need: water, soil? The teacher chooses soil (for the classroom field).
11	"The spiders"	Children discover roots (called "spiders") sprouting from the potatoes.
12	"Potato field"	Children discover that many grandmothers/fathers have potato fields. Will the potatoes do the same, in the classroom and in the field? Children sow a real potato field.
13	"Roots/branches, trunk/stem" "Return to the field"	Children discuss if what they see are roots or branches, stems or trunks. They draw what the potatoes are doing in the field, under the ground, and return to the field to test their ideas.
14	"The new potatoes"	Children discover new potatoes in the "potato wood", discuss how they could appear, decide to cook them as a way to decide if they are potatoes.
15	"Flowers?"	Children discover flowers in the "potato wood". They discuss about it: flowers are beautiful and useless. No flower-fruit-seed model is present.
16	"The harvest"	Children harvest the potatoes from the "big" field.
17	"The potato plant"	Children draw the potato plants. Interestingly, they said the plant was born *to* the potato, not *from* it, as they said about the *crusts*.

Table 2: Didactic sequence for the kindergarten field trial of the adapted practice "Potatoes don't grow on trees. After the 13th activity, the order is indicative: many arguments have been discussed more than one time.

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