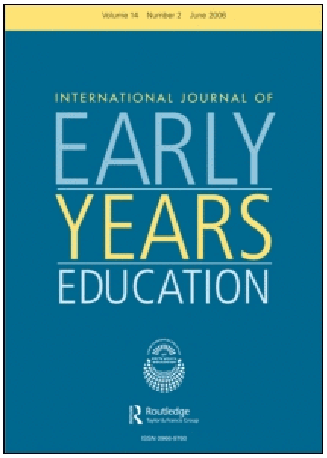

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Science Education in Kindergarten: Sociocognitive perspective

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Science Education in Kindergarten: Sociocognitive perspective

L' education en Sciences Physiques à l'école maternelle: perspective sociocognitive

La educación cientifica en el kindergarten: perspectiva sociocognitiva

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ABSTRACT *This article deals with the different didactic strategies used for the initiation of preschool children to the natural sciences. There is a reference to the general characteristics of the activities that are based either on the empiricist theoretical approach or the theory of Piaget regarding cognitive development. Some facts from the neo-piagetian, socioconstructive and vygotskian perspectives for learning are presented. Within this framework a new sociocognitive approach is put forward for the development of activities concerning the natural sciences in the kindergarten. An activity concerning the understanding of gasification is presented and used as an example of the sociocognitive perspective.*

RÉSUMÉ *Cet article porte sur les stratégies didactiques visant à l'initiation des enfants d'âge préscolaire en Sciences Physiques. On fait d'abord une référence aux caractéristiques générales des activités qui se basent soit aux courants théoriques empiristes soit à la théorie piagétienne sur la construction de l'intelligence. Ensuite on tente une approche de quelques élements de courants néo-piagétiens, socioconstructivistes et vygotskiens et dans leurs cadres on présente une description d'une perspective sociocognitive pour le déploiement des activités scientifiques dans l'école maternelle. Finalement on expose une activité portant sur la compréhension du phénomène de la vaporisation comme exemple de la perspective sociocognitive.*

RESUMEN *En este articulo se estudian las diferentes enseñanzas estratégicas para la iniciación de los niños de edad escolar en las ciencias naturales. Hay un informe referido a las caracteristicas generales de las actividades las que se basan en las experiencias de las corrientes teoricas o en la teoria de Piaget para el desarrollo de la inteligencia. A continuación se abordan algunos factores de 'neo-piagetian', 'socioconstructive' y 'vygotskian' corrientes para el aprendizaje, del cual se describe una nueva perspectiva sociocogni-*

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tiva para el desarrollo de actividades en el campo de las ciencias naturales en el kindergarten. Para finalizar se presenta una actividad con tema: la comprensión del fenómeno de la evaporación, como ejemplo de la perspectiva sociocognitiva.

Science Education and Preschool Education

Preschool curricula are not frequently founded on explicitly articulated theoretical principles. The equilibrium amongst social, emotional and cognitive aims does not usually depend on accurate selections that are justified according to psychological, epistemological and pedagogical approaches of child development. As a consequence, inequilibriums are observed in the various sections of the programmes. While ascribing autonomy to the child, it is doubtful, whether educational authorities converge or blend educational approaches or whether there are approaches just based on the possibilities that a child will soak up (Lurçat, 1985). However, these educational necessities only direct and lead to confusion and undervalue the domain of logical thought and the initiation to the physical world.

It is well known that the main psychological and epistemological trends concern the constitution of human thinking, stress the significance of discovery of physical objects, qualities and the relations which exist amongst phenomena, concepts of science and children's model of thinking (Piaget, 1947, 1929; Vygotsky, 1978, 1962). In this area, the contribution of science education research has been significant. In this research domain, the significance of preconceptions in children's thinking for the construction of scientific knowledge emerged (Driver *et al.*, 1985; Driver *et al.*, 1994). The study of children's preconceptions usually concerns children aged 10. However, the reason for focusing around this age is not clearly justified. Recently, research on this field, has also been carried out involving children in early childhood (Ravanis, 1996; Sharp, 1995). On the other hand, there is no explicit agreement or disagreement on the development of research attempts concerning preschool or first school age. The lack of abundance of research purporting to elicit the ideas of young children is probably related to the difficulties one encounters when attempting to interpret the empirical research data. This is partly due to the fact that children aged less than ten usually present a lack of concept construction, as it is, for example, the case for the concepts of conservation and reversibility.

However, it is possible that the earlier we study children's preconceptions, the better we can work with all sides of children's thought. The study of preschool children's construction of representations may permit their transformation into models that are compatible with those of the scientific community, since it can facilitate the creation of suitable teaching activities. Moreover, this approach contributes to developmental research on the evolution of mental models (Duit & Glynn, 1995; Doise & Mugny, 1981). Finally, it is difficult to forget that one of the precursors of contemporary preschool science education, Jean Piaget, devoted much of his research to children's conceptions of the physical world. Within this framework, it is possible, that some of the activities performed in nursery schools have to be devoted to the systematic initiation of science concepts and phenomena.

Which, however, are the difficulties manifested when science is to be taught to preschool children? Attempting to answer this question, one is led to look for teaching processes of science initiation that are different from the traditional strategies of schools. Ordinary science courses are usually addressed to students who are at least 10 years of age. They have the possibility of using a sequence of fundamental reasoning, and moreover, on the basis of concrete models, although these models are not compatible with science models, of representing and interpreting the physical world in their thought. However, in the case of preschool children, the obstacles caused by the incomplete organisation of logical reasoning, and, in addition, the limited models used by children to interpret the physical world, pose different types of difficulties. For example, in order to study the evaporation and gasification problem, a quantity of water is heated. Subsequently, students 10- to 13-years-old appear to have a model of explanation for the transition from the liquid to the gas state. Here their problems are limited to issues such as the stability of the water's temperature during evaporation (Erickson & Tiberghien, 1985). However, when the same problem is studied with 5-year-old children there is the basic obstacle that children do not know what will happen to the water after continuous heating. Moreover, when they observe the gasification procedure, most children can not offer any explanation as to what has actually happened (Bar, 1989). Additionally, almost no child aged 5 to 7 years of age refers to the transformation of a liquid to another form of matter, while one third of the children do not even allude to the conservation of water. (Russell & Watt, 1990; Russell *et al.*, 1989).

As Martinand (1986) mentions the selection of the objectives which he names objectives-obstacles, in the teaching of science can be based on two hypotheses: (a) it has been found that the students are not able to realise spontaneously certain crucial progress; (b) there is, at a certain moment of the process of every didactical activity, a crucial burden whose main aspect is placed in the important categories of the general aims, such as the attitudes, the cognitive contents, the methods. Consequently, two teaching interventions for both cases (5-year-olds and 10- to 13-years-old children) have different objectives-obstacles. For the older children, an explanation model is already used. However, in the case of younger children, a model has to be constructed, which until then was non-existent.

Other differences between early childhood and school age children are those caused by their different 'empirical references' (Martinand, 1989). The former, living mainly within the family environment, have limited and controlled access to the physical world and consequently they lack opportunities to face various physical phenomena. Moreover, the younger the children are, the more limited their social references are. Thus, they do not have efficient access to social life, to professional activities and technological applications, i.e. to sources which could offer necessary cognitive analogies, significant information and a field of drawing questions, as well as articulation of hypotheses.

If the attempt of initiation of the preschool children to science is accepted as a significant one, then the questions posed at all levels of science teaching have to be confronted as well. How can appropriate curricula for the preschool level be developed? Which teaching strategies should be used? How should preschool teachers be correctly guided concerning science and what should their in-service training comprise?

It is well known that such questions cannot be answered in the same way for all the levels of education. Thus, for nursery schools, specifically elaborated teaching approaches are needed. In this particular case, the development of teaching activities, is very different from other levels of education. Indeed, in primary or secondary schools, subjects like physics, chemistry, biology or other unified courses are constructed on the basis of specific curricula. In a nursery school, however, the science activities are more fragmentary and are confused with logico-mathematical concepts and problems of social living. The structure of a concept or phenomenon is not clearly separated. In other words, the object of an activity and its function in concrete circumstances is not explored or articulated.

Trends of Preschool Education in Regard to Science

Kamii (1982) and Kamii and De Vries (1978) believe that we should juxtapose the 'physical knowledge-activities' and the 'learning of science' for preschoolers. The activities of physical knowledge focus on the progress of children's activities and discoveries. On the contrary, the teaching of science focuses on the object to be taught, the laws, scientific terminology and research methodology. Attempts to introduce science to preschool children take two directions: They are either directed towards a type of *minimum teaching* or towards an attempt at *an initial systematic and organised contact with the physical world*. These two perspectives have different aims and consequently the instructional processes which derive from them are also different.

The greatest part of the recommended activities of science for preschool education fall within the perspective of *learning science*. These activities are based on empiricism:

> ... which assumes knowledge comes from outside an individual to inside. In the empiricist view the individual is regarded as a blank slate on which experiences are written; in educational settings this takes the form of the transmission of ready-made knowledge. (Inagaki, 1992, p. 117)

Thus, after the subject matter of the activities is selected, an attempt is made to render them simplified in order to be appropriate for preschoolers. Then, the problem is introduced in class with questions from everyday life and the teacher presents simple experiments or guides the children in making them themselves. The teacher stresses the results of the experimental situations and articulates some conclusions (Paulu & Martin, 1992; Chauvel & Michel, 1990; Halimi, 1982; Hildebrand, 1981; Harlan, 1976). During this process the opportunity arises for the presentation of the new vocabulary, of scientific instruments and the introduction to the scientific methodology. However, there are many questions which could be posed on how far these teaching strategies are pertinent and effective. On the basis of which criteria is the selection of the teaching subject matter and its simplification made? How can the success of these experimental processes be verified without taking into account the limitations which result from the level of children's cognitive development? Which of the apparatus and the technical media used in the experiments have an understandable function for the children? Without an answer or at least without forming hypotheses based on these questions, the performance of science activities in preschool education, as in other levels of education, runs the risk of becoming a simple process of exposition with random results.

Piagetian procedures, which follow the process of physical knowledge, promote the idea that the development of human intelligence is a result of the formation of cognitive structures through the activity of the individual on objects of the material world, rather than through the shapeless, sensory perception of data of the physical and social environment. It is, therefore, natural that didactic approaches based on Piaget's theory should lead to strategies which provide children with the possibility of manipulating material objects and experimenting. In short, intellectual activity is capable of leading to the assimilation of physical knowledge. With respect to the constitution of physical knowledge, educational processes have suggested that the above mentioned characteristics should be included for the teaching of the pre-school children. Situated at the centre of these procedures is the free but carefully supported initiative of the children along with the nursery-school teachers playing a particular, encouraging and analysing part in the activities (Ravanis, 1994). This framework serves to direct the initiation of younger children to science according to a priority of qualitative approaches to objects and their qualities, as well as, the elementary reactions of objects on the actions exerted on them. In the situation in which children are occupied with problems whose solution requires the use of scientific models of thought or the use of scientific methodology, Kamii (1982) proposes elementary activities for preschoolers having as its main objectives, the transposition and transformation of objects. In a similar light Crahay and Delhaxhe (1988a, b), propose initiating preschool children with elementary qualities belonging to certain objects (spirals, magnets, inclined planes, etc.).

The post-piagetian theoretical orientations of developmental psychology created conditions which permit the orientation towards different type of strategies for the development of science activities in kindergartens, which transcend the empiricist and the piagetian perspectives. In the framework of the post-piagetian conceptions of development particular attention has been given to sociocultural factors which 'tend to enhance (or inhibit) people's learning by virtually eliminating from their consideration a great number of possible hypotheses and interpretations' (Hatano & Miyake, 1991, p. 278). Moreover, in neo-piagetian socioconstructive and vygotskian research frameworks cognitive development is looked upon as a result of social interaction and negotiation strategies, where partners, via communication and collaboration processes, coordinating different perspectives, are guided to common centrations to processes of knowledge acquisition and problem solving (Tudge, 1990; Perret-Clermont, 1986; Doise & Mugny, 1981). It is possible to distinguish mainly two advantages in research attempts with this orientation. On the one hand communication leads to the decentration from the subjective perspective. Children facing the arguments of a collaborator understand that for a question or a problem there are many possible solutions, considerations and strategies of dealing with it. On the other hand the insistence of a partner to certain characteristics and sides of a situation guides the children's thought to centrations other than those which were initially realised. This results in more parameters to be taken into account in order to answer the questions posed. In this context, research has proven that even preschoolers, in appropriate learning conditions, are able to cognitively constitute certain concepts and phenomena of science (Ravanis, 1997; Springer & Keil, 1989; Inagaki & Hatano, 1988; Siegal, 1988).

The attempt to use science to develop activities for the kindergarten in post-piagetian theoretical frameworks, leads this line of research towards a systematic study of understanding simple phenomena and seeks to find the conditions under which the detection of the physical qualities of objects for preschoolers can be transcended. Indeed, if with the use of appropriate tasks the real difficulties faced by students in concrete conditions can be detected, then it is possible to orient the processes of communication towards the creation of conditions which permit children to overcome their difficulties. For this reason: (a) an attempt is made to study the cognitive burdens created by mental representations for concepts and phenomena of the physical world; (b) then, specific teaching interventions were designed using processes of social interactions, through which the educational environment can help the children construct the representations which they do not have or transform in their thought representations that are incompatible with the science models.

These attempts are in contrast to empiricist activities where emphasis is given to the transfer of knowledge from the preschool teacher to children and, they lead one to a direction, other than the piagetian approach where the centre is the childrens' autonomous activity. The above three trends are presented in Figure 1.

An endeavour to detect the real obstacles of childrens' thought is made and an adjusted teaching activity follows in the context of the sociocognitive perspective.

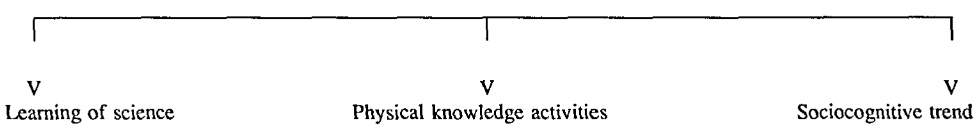

FIG. 1. Trends of preschool education in regard to science.

An Experimental Example of the Sociocognitive Trend in Regard to Science

The research presented here is an example of the sociocognitive perspective. This work has had the following objectives: (a) to detect preschool students' mental representations which concern the gasification of water, and (b) to destabilize and transform these intuitive students' representations through an appropriate teaching intervention (Papageorgiou *et al.*, 1993). A similar type of research has shown the problems of comprehension in the changes of the states of the matter not only in younger children (Russell & Watt, 1990; Russell *et al.*, 1989), but also in older students too (Hatzinikita & Koulaidis, 1997; Bar, 1989; Erickson & Tiberghien, 1985).

The Process

Forty nine subjects, attending kindergarten in Patras participated in the research process. The children's parents had no special education in science. The average age of the children was 5 years and 5 months (S.D. 4.60 months). The selection of the subjects was done by stratification random sampling (draw) from amongst those who had agreed to 'play' with us.

Pre-test. Both pre-test and post-test were done through individual semi-directed interviews which were tape-recorded. A small plate with a small quantity of water was placed on a camping-gaz store and children were asked to predict what would happen if the water was heated for a long time. During its performance and immediately after the experiment was carried out, a discussion was held with the children. In the end children were asked to give explanations about the phenomenon. The data analysis showed that children before the experimental procedure are not able to predict the evolution of the phenomenon, while after the process concentrate on points which do not help them to approach the descriptive characteristics of the situation of gasification.

It was hypothesized that the continuous interaction of the children with the teacher will lead to a destabilisation of the initial centrations, which consist of the objectives-obstacles of children thought and to the articulation of reasoning based on a descriptive schema with the use of which they will be in a position to:

1. Predict the results of gasification.
2. To determine 'where the water goes'.
3. To describe the stages of the gasification process.

Teaching intervention. During the pre-test children noticed 'what happens' during gasification. The objective of the teaching intervention, which took place one month after the pre-test, was to approach the children in a descriptive way as to 'how the transformation from the liquid to the gas state was done'. The activity was carried out individually with every student, in a specifically arranged place of the school, out of the classroom, so as to study the results of student-teacher interaction. In the context of the neo-piagetian approaches a strategy which aimed at achieving the cognitive progress through the coordination of the partners' centrations was used. The experimental procedure included: (a) The comments on a series of pictures with the successive phases of the gasification phenomenon; (b) The observation and comments of the gasification and liquefaction process in a simple transparent distillation apparatus. The liquefaction process was not included in the objectives of the teaching intervention. However, it was considered that the observation of this elementary water cycle would lead to a better understanding of the relation of water vapour to water.

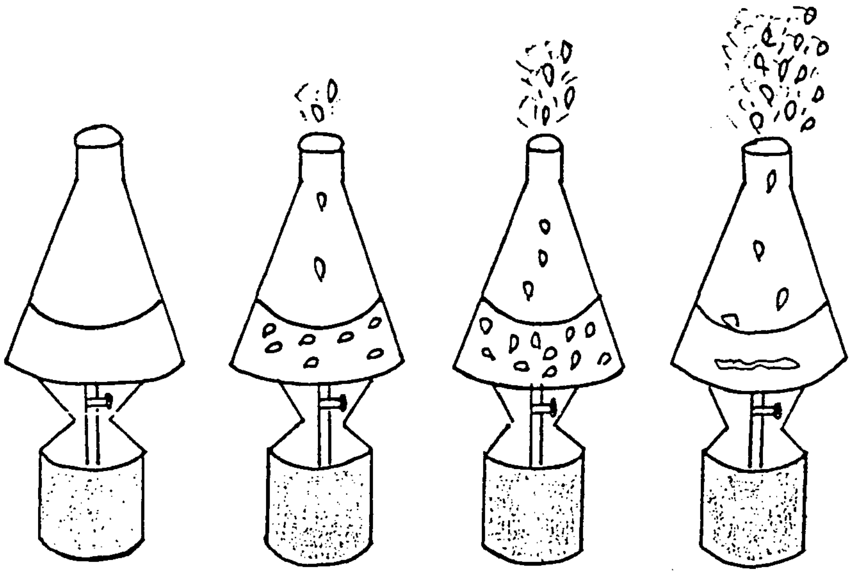

FIG. 2. Four moments in the phenomenon of water evaporation in an open bottle.

At first, the pictures were presented to the children and they were then asked to describe what they saw in them. Wherever they had difficulties the experimenter intervened, stressing at the same time the characteristics of the situation considered as significant for the phenomenon on which children did not concentrate on during the pre-test. In this way, by asking the children to give information about the characteristics of the situation which they did not pay attention to, they were led to centrations in regard to the formation of bubbles, their rise towards the water's surface, the formation of vapour and the parallel diminution of the water's quantity, the vapour's 'upward direction'. These centrations were considered as very significant to the approach of the phenomenon. Immediately afterwards the children were asked to tell by themselves the story of 'the water which was left' and during this narration,

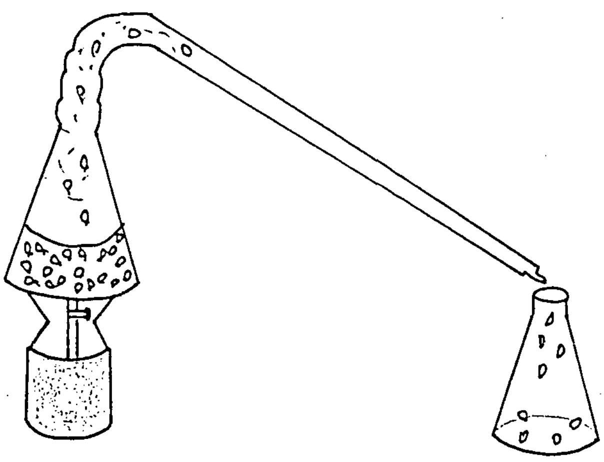

FIG. 3. Distillation apparatus.

wherever necessary, the transposition of their centrations was attempted. Immediately after the distillation apparatus was put into operation and children were asked to describe the 'water's trip', attempting through the experimenters' intervention to stress the characteristics of the phenomenon described within the child's narration.

The child started describing the process of the experiment, while the experimenter was listening to the on-going description. When the experimenter considered that the child's thought focused on elements of the apparatus which did not facilitate the understanding of the phenomenon, he tried, mainly by posing questions, to coordinate the child's centrations with the crucial stages of the phenomenon of gasification. The use of the apparatus played an important part, as it comprised the experimental basis for the development of the dialogue. This intervention was not a kind of transfer of information, but mainly a process of communication that led the children and the experimenter to the coordination of the centrations and their thoughts.

Let us now present two examples coming from the relevant dialogues. The first one is related to the creation of the bubbles during the process of the heating of the water. The dialogue is between the experimenter (E) and Niki (N).

N: ... the water is getting hotter ... and hotter ...
E: what is happening now? (the first bubbles come to the surface)
N: ... look! ... the bubbles are coming out ...E: where are they going?
N: ... they are going up ... (pointing to the bottom of the beaker and then to the surface of the water)
E: how does this happen?
N: ... it wants to leave ...E: to go where?
N: ... to go to the air ...E: does it want to leave or do we want it to leave?
N: ... we send her away, because we first warm up the water ...E: and where did you say it goes to?
N: ... it goes out ... look up here ... they burst out and they leave ...

The second example of dialogue is related to the source of the vapour. The dialogue here is between the experimenter (E) and Alexander (A).

E: what comes out of the bottle?
A: ...E: what do we see here? In the air? (pointing to the vapour)
A: ... it is smoke ...E: where does it come from?
A: ... from the saucepans ...E: do we have any saucepans here?
A: ... no ...E: so, where does vapour come from?
A: ... (looking at the beaker in which there is water boiling)
E: is there anything in this room looking like a saucepan?
A: this one ... (pointing to the beaker)
E: well?
A: the smoke comes from this ... It is because of the heat ...E: what is because of the heat?
A: the smoke ... because you heat the water ...

Post-test. The control set of results of the teaching process was collected a week later. The same process with the pre-test was followed: that is the same set of questions were posed.

Data Analysis and Results

Predictions on Water Gasification

Children were asked during the pre-test and the post-test 'what will happen to the water if it is put on the fire and it gets heated for a long time'. Here, answers of three types of categories were given:

TABLE I. Predictions concerning water gasification

	Pre-test	Post-test
Efficient answer	7	44
Everyday experience	28	3
Don't know/no answer	14	2

1. One category of answers which was characterised by us as efficient ('the water will leave the plate', 'No water will be left on the plate').
2. A second category of answers which is strongly influenced by the everyday experience of the child ('it will be burnt a lot', 'it will boil', 'it will blow up and flow').
3. A third category of answers in which children declare 'I don't know' or they do not answer.

Here, as it is shown in Table I, after the experimental procedure there is a distinct progress in the children's answers. Most of them during the post-test, can clearly predict the evolution of the phenomenon. This offers us indications for the success of the activity.

Recognition of 'Where Does the Water Go?'

In this question there are three categories of answers.

1. One category with efficient answers ('in the air', 'it becomes vapour and leaves upwards').
2. A second category with answers in which the children make hypotheses based on the experimental apparatus or the surrounding space ('the water went into the bottle of the camping gas through the holes that exist in its mouthpiece', 'it was sucked by the disk', 'it went to the soil').
3. A third category in which children answer 'I don't know'.

As it is shown in Table II, 43 out of 43 subjects during the post-test abandon the partial centrations which confuse them and are in a position to explain what happened to the water. Here, during the pre-test only one child suggested that the water disappeared.

Description of the Gasification Process

Presented here are the children's answers given by the children when they are asked to explain 'how the water leaves the disk'. The answers are classified in two categories. The first category comprises efficient answers in which children describe the phenomenon with a sequence of reasoning which includes the upward direction of the bubbles from the vessel into the atmosphere in the form of vapour ('it becomes bubbles ... and goes upwards ... and the smoke leaves'). In the second category there are inefficient answers in which children do not refer at all to the bubbles, or the vapour, or they do it in a way which does not lead to the description

TABLE II. Responses concerning the question 'where has the water gone?'

	Pre-test	Post-test
Efficient answer	3	43
Centrations	42	6
Don't know	4	0

TABLE III. Description of the gasification procedure

	Pre-test	Post-test
Efficient answer	3	42
Inefficient answer	46	7

of the phenomenon ('the water leaves by itself', 'the water becomes bubbles and disappears', 'the smoke leaves').

Again, in this case the results are interesting, as before the teaching intervention none of the subjects were able to be led to the direction of the bubbles and the vapour, while afterwards 42 out of 49 children realised this connection, but of course at a descriptive level.

The achievement of the three objectives gives us positive indications for the significance of teaching processes which are based on a guided social interaction having as its aim the destabilisation and the reconstruction of the intuitive representations of preschool children. Certainly, this teaching intervention was individual and took place out of the class in a laboratory situation. First attempts at tackling the problem of gasification in the kindergarten situation have also given encouraging results.

Discussion

In this article, we attempted to bring to light some open issues of preschool education, as well as its main prevailing trends concerning science teaching. Moreover, we tried to find links and convergencies of the existing preschool science teaching with recent findings in science education. We also attempted with the example of gasification to show in a post-piagetian theoretical framework that the initiation of children to some aspects of the natural world is possible even from the preschool age, in the direction where preschoolers construct descriptive models, compatible with the descriptive characteristics of scientific models. We believe that the real cognitive progress of children does not only consist of broadening the children's field of experience, but also, involves the development of cognitive and manual abilities, the possibility of confronting questions which derive from everyday life, and the broadening of possibilities of symbolism and concept formation (Weil-Barais, 1994). It is evident, that the strategy recommended for the development of activities at preschool age is only one of the possible perspectives. This does not mean that other perspectives such as the piagetian or even the one described as empiricist should be undervalued. These perspectives can develop other parameters of the children's thought such as those referred to previously.

However, in a sociocognitive perspective, the teaching is based on the student-teacher interaction. The objectives posed, firstly by the educational environment on the basis of the children's cognitive obstacles, are achieved under the presupposition that communication, although asymmetrical, is guided towards the achievement of identical reasoning. Certainly, the use of communication conditions is attempted in both other strategies. However, we think that this communication remains undervalued. In empiricist strategies the goal of the attempted interaction is to transfer experience and knowledge from the adult to the child. This fact brings the handling and the initiatives of the adult to the center of the communication. This results in strengthening the assymetry of the relation. However, the dynamic of this condition favours imitation and the cognitive subordination of the child to the adult more and the cognitive transformations less. This becomes more significant if we take into account the fact that the children are of a young age. On the other hand, in the framework of piagetian activities, the attempts of communication are defined according to the child initiatives. The interventions, if any, have as their goal to support or to extend the initiative of the teachers. This results in transforming the dynamic of communication into a possibility.

It is particularly interesting to attempt a comparison of the way the materials and experimental arrangements are used in the activities of science for the kindergarten in the three approaches. In the empiricist approaches the use of materials is predetermined aiming at the demands defined by the experiments. Some appraisals for the pertinence of the materials are made, however these appraisals are not based on research data. For this reason very often the materials, instruments of measurements and experimental arrangements used, do not correspond to the cognitive development of the children. It is obvious that this fact minimizes the possibilities of success of an activity whatever the objectives are. In piagetian activities as the main objective is the acquisition of natural knowledge for the material world surrounding us, the objects provided to the children are simple and appropriate to be handled by them. However, this selection limits the spectrum of the selected activities to a great extent, as it excludes materials that are not for various reasons possible to be used only by children themselves. In regard to the issue of handling materials, we think that the activities developed in the sociocognitive framework are better in comparison to the other two. The former, without eliminating the possibility for the children to use materials and experiment alone, enables the teacher to select other experimental arrangements or materials with which the children can work with in order to transcend their cognitive obstacles. The research that has preceeded has shown on the one hand that this material corresponds to the cognitive abilities of preschoolers, while on the other hand facilitates the preparation and the performance of the activity because it widens the possibilities of communication.

Another significant issue posed is the preschool teachers' seemingly problematic relation with science which presents additional obstacles. Therefore, some courses need to be established either within teachers' main training or in-service training to familiarize teachers with selected concepts and phenomena, experimental methodology, the use of simple instruments and performing experiments. It is also reasonable to attempt to instruct preschool teachers in the rationale of science education (so as they can interpret and assess research data useful for their work, and possibly produce new data, if required). During the last decade, it seems increasingly more difficult to discuss science teaching without efficiently focusing on science teachers (Bagakis, 1994).

Regardless of the different approaches or the various problems, it seems that part of children's thought in kindergarten can be oriented towards activities which aim at the discovery of parameters of the physical world. Some of them can be directed towards the guided study of physical phenomena. In this perspective special care needs to be taken. If the activities of this type are performed in post-piagetian or vygotskian framework, the organization of the communication between children and teachers can become fruitful. This happens because in these approaches the social mediation is considered as a presupposition for the cognitive development of children. A series of interesting research has shown the effectiveness of specific techniques such as the cognitive conflict, the analogies, the transposition or coordination of centrations used in the example. If however these are organised in order to transmit information to preschoolers, they then not only risk being ineffective, but moreover falsify the character of preschool education, and transform the kindergarten into a bad copy of school.

In any case, the research related to the development of activities in the preschool education is interesting, although it is in its beginning. Its development both in laboratory situations, as in conditions of real class situations will show its future, range, limits and significance.

References

BAGAKIS, G. (1994) Towards a teachers' epistemology in science education: the appearance of action research, in: M. LAIDLAW, P. LOMAX & J. WHITEHEAD (Eds) *Proceedings of the World Congress 3 on Action Learning Action Research and Process Management* (Bath, University of Bath).

BAR, V. (1989) Children's views about the water cycle. *Science Education*, 73(4), pp. 481–500.

CHAUVEL, C. & MICHEL, V. (1990) *Les sciences dès la maternelle* (Paris, Retz).

CRAHAY, M. & DELHAXHE, A. (1988a) *Agir avec les rouleaux. Agir avec l'eau* (Bruxelles, Labor).

CRAHAY, M. & DELHAXHE, A. (1988b) *Agir avec les aimants. Agir avec les ressorts* (Bruxelles, Labor).

DOISE, W. & MUGNY, G. (1981) *Le développement social de l'intelligence* (Paris, InterEditions).

DRIVER, R., GUESNE, E. & TIBERGHIEN, A. (Eds) (1985) *Children's Ideas in Science* (Milton Keynes, Open University Press).

DRIVER, R., SUIQUIRES, A., RUSHWORTH, P. & WOOD-ROBINSON, V. (1994) *Making Sense of Secondary: Science research into children's ideas* (London, Routledge).

DUIT, R. & GLYNN, S. (1995) *Mental modeling*. Paper presented at the conference 'Science Education Research in Europe', 7–11 April, Leeds.

ERICKSON, G. & TIBERGHIEN, A. (1985) Heat and temperature, in: R. DRIVER, E. GUESNE & A. TIBERGHIEN, A. (Eds) *Children's Ideas in Science* (Milton Keynes, Open University Press).

HALIMI, L. (1982) *Découvrons et expérimentons* (Paris, Nathan).

HARLAN, J. (1976) *Science Experiences for the Early Childhood Years* (Columbus, Ohio, Charles E. Merrill Publishing Co).

HATANO, G. & MIYAKE, N. (1991) Commentary: what does a cultural approach offer to research of learning? *Learning and Instruction*, 1, pp. 273–281.

HATZINIKITA, V. & KOULAIDIS, V. (1997) Pupils' ideas on conservation during changes in the state of water. *Research in Science and Technological Education*, 15(1), pp. 53–70.

HILDEBRAND, V. (1981) *Introduction to Early Childhood Education* (New York, Macmillan Publishing Co).

INAGAKI, K. (1992) Piagetian and post-piagetian conceptions of development and their implications for science education in early childhood. *Early Childhood Research Quarterly*, 7, pp. 115–133.

INAGAKI, K. & HATANO, G. (1988) *Young children's understanding of mind-body distinction*. Paper presented at American Educational Research Association Annual Meeting, 1–4 September, New Orleans.

KAMII, C. (1982) *La connaissance physique et le nombre à l' école enfantine: Approche piagetiénne* (Genéve, Université de Genéve).

KAMII, C. & DE VRIES, R. (1978) *Physical Knowledge in Preschool Education: Implications of Piaget's theory* (New Jersey, Prentice-Hall).

LURÇAT, L. (1985) Imprégnation et transmission à l'école maternelle. *Revue Française de Pédagogie*, 71, pp. 39–46.

MARTINAND, J.L. (1986) *Connaître et transformer la matière* (Berne, Peter Lang).

MARTINAND, J.L. (1989) Des objectifs-capacités aux objectifs-obstacles, in: N. BEDNARZ & C. GARNIER (Eds) *Construction des savoirs, obstacles et conflits* (Ottawa, Agence d'ARC).

PAPAGEORGIOU, E., VAITSI, M., RAVANIS, K. & BAGAKIS, G. (1993) *Empirical study on the preschool children understanding of the liquids'gasification.* Paper at EARLI 5th European Conference, 31 August–5 September, Aix-en-Provence.

PAULU, N. & MARTIN, M. (1992) *Helping Your Child Learn Science* (Washington, US Department of Education).

PERRET-CLERMONT, A.N. (1986) *La construction de l' intelligence dans l' interaction social* (Berne, P. Lang).

PIAGET, J. (1929) *The Child's Conception of World* (London, Routledge & Kegan Paul).

PIAGET, J. (1947) *Understanding Causality* (New York, W.W. Norton & Co Inc).

RAVANIS, K. (1994) The discovery of elementary magnetic properties in pre-school age. A qualitative and quantitative research within a Piagetian framework. *European Early Childhood Education Research Journal*, 2(2), pp. 79–91.

RAVANIS, K. (1996) Stratégies d'interventions didactiques pour l'initiation des enfants de l'école maternelle en sciences physiques. *Spirale*, 17, pp. 161–176.

RAVANIS, K. (1998) Procédures didactiques de déstabilisation des représentations spontanées des élèves de 5 et 10 ans. Le cas de la formation des ombres, in: A. DUMAS CARRÉ & A. WEIL-BARAIS (Eds) *Tutelle et médiation dans l'éducation scientifique* (Berne, P. Lang).

RUSSELL, T., HARLEN, W. & WATT, D. (1989) Children's ideas about evaporation. *International Journal of Science Education*, 11, pp. 566–576.

RUSSELL, T. & WATT, D. (1990) *Evaporation and Condensation. Primary SPACE Project Research Report* (Liverpool, Liverpool University Press).

SHARP, J. (1995) Children's astronomy: implications for curriculum developments at Key Stage 1 and the future of infant science in England and Wales. *International Journal of Early Years Education*, 3(3), pp. 17–49.

SIEGAL, M. (1988) Children's knowledge of contagion and contamination as causes of illness. *Child Development*, 59, pp. 1353–1359.

SPRINGER, K. & KEIL, F.C. (1989) On the development of biologically specific beliefs: the case of inheritance. *Cognitive development*, 60, pp. 637–684.

TUDGE, J. (1990) Vygotsky, the zone of proximal development, and peer collaboration: Implications for classroom

practice, in: L.C. MOLL (Ed.) *Vygotsky and Education: Instructional implications and applications of socio-historical psychology* (New York, Cambridge University Press).
VYGOTSKY, L.S (1962) *Thought and Language* (Cambridge, MA, M.I.T. Press).
VYGOTSKY, L.S. (1978) *Mind in Society* (Cambridge, MA, Harvard University Press).
WEIL-BARAIS, A. (1994) L'initiation scientifique et technique auprès de jeunes enfants: points de vue épistémplogique et psychologique, in: A. GIORDAN, J.L. MARTINAND & D. RAICHVARG (Eds) *L'Alphabétisation Scientifique et Technique* (Chamonix, Centre J. Franco).

Appendix 1

	Empiricist Trend	Piagetian Trend	Sociocognitive Trend
Theoretical references	—Behaviourism —Empiricism	—Theory of Piaget for cognition	—Post-Piagetian and Vygotskian frameworks
Main aspects of children activity	—Attending of performance of proposed experiments, descriptions and explanations	—Free interaction with materials within the framework of the designed environment	—Discovery through social interaction within the framework of the experimental activities
Main aspects of the teacher activity	—Presentation and guidance —Teacher in the centre of the activity	—Animation —Teacher supports and extends children's selections interaction towards	—Organisation of communication situations —Orientation of the transcendence of cognitive obstacles