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Using POE to Promote Young Children's Understanding of the Properties of Air

Jia-Chi Liang*
Yuan Ze University

Abstract

The purpose of this study is to assess young children's understanding of the properties of air, and to demonstrate Predict-Observe-Explain (POE) activities developed to improve their understanding. Good instructional models, such as POE, may help young children better understand abstract and invisible physical phenomena like air. POE activities create a prediction-outcome conflict that helps children to rethink and reorganize what they observe. Before performing POE experiments, the majority of young children did not think that air is everywhere; 89% of children believed that there is air in their noses, but 64% contended that there is no air in an open container. After reaching successively contradictory judgments in POE activities, 36% of children changed their initial, incorrect ideas about air. Although there was some modest success achieved in this study, for children obtaining consistent and holistic concepts in science is a long-lasting process. The conclusion of this study suggests that preschool children can benefit from a wide range of POE activities in different topics, especially in physical sciences because with professional guided learning they are more likely to develop a correct understanding of scientific concepts.

Keywords: early childhood education, science education, POE, properties of air

* jiachi@saturn.yzu.edu.tw

Introduction

There is no doubt that preschool students should be exposed to science because science is a means to satisfy their natural curiosity about the world and to engage them with everyday experiences (French, 2004). The advantages of exposing children to science at an early age include enjoying, observing, thinking about nature, developing positive attitudes towards science, and promoting scientific thinking and a better understanding of scientific concepts (Eshach & Fried, 2005). However a necessary prerequisite to early childhood education is developing a rich learning situation with efficient materials thereby opening the window for them to explore science in a meaningful way. The criteria of appropriate activities are such that: (a) the activity should provide opportunities for the child’s own action, (b) the activity should involve discrepancies between what the child predicts and what he or she observes, and (c) the activity should involve transformations and rapid changes (Kamii & DeVries, 1993). By encouraging children to observe, such activities it creates opportunities for children to construct a number of relationships between concepts and to develop operative thinking.

In addition to appropriate activities, the early childhood teachers’role should be emphasized because young children’s education can only be promoted in accordance with the teacher’s own understanding (Seefeldt & Galper, 2002). In the early childhood stage, inspiring positive attitudes about science and using appropriate scientific methods are undoubtedly the best approach for teaching children. In other words, early childhood teachers should realize their role as facilitators of the process of exploring science with children. Thus, early childhood teachers need appropriate training in in-service professional development programs. Liang (2009) suggests a required science education course that will help teachers to learn the purpose and method of children’s science education, basic scientific concepts and processing skills, children’s common misconceptions, model construction of children’s science learning, and so on. By having teachers apply these strategies in the classroom, early childhood teachers can provide a rich environment where children can explore science.

Theoretical Background

Children's Science

A number of studies have focused on young children's understanding of certain science concepts, such as biology, physical properties of objects, change of state, water, floating and sinking, astronomy, electrical currents, friction, and mechanical stability (Baillargeon, 1995; Carey, 1985; Hadzigeorgiou, 2002; Ravanis, Koliopoulos, & Hadzigeorgiou, 2004; Massey & Gelman, 1988; Solomonidou & Kakana, 2000; Spelke, 2000; Zogza & Papamichael, 2000). Young children are more likely to obtain a more holistic and coherent understanding of biology and visible physical phenomena. In contrast, their understanding of physics is usually fragmented and incoherent (diSessa, 1993). For instance, young children seem to have an intuitive understanding of the role of density in floatation, and were able to provide a correct, descriptive explanation (Havu-Nuutinen, 2005; Chien, Hsiung, & Chen, 2009). However, for topics like astronomy or physical phenomena including electricity, the formation of rain, the day/night cycle, preschool teachers should reconsider these as too ambitious for young children to grasp completely (Hannust & Kikas, 2007).

Although the mechanics of light is not appropriate for young children (Gelman & Brenneman, 2004), simple concepts like "light and shadow" are relevant to children's everyday lives, and should be investigated. Many young students believe that shadows are material entities (Feher & Rice, 1988). If teachers describe shadows as the absence of light rather than the presence of some physical thing, children will more easily understand the property of light as it relates to shadows. Children are curious and are naturally motivated to explore science phenomena in their environment. Prior to any teaching and learning in formal class, children attempt to make sense of the world in which they live in terms of their experiences, current knowledge and languages. Hence, the important core of science education in early childhood education is to take advantage of their existing knowledge by providing concrete experiences that will enable children to move further on the learning path for a particular concept.

Properties of Air

In spite of there being many studies about young children's understanding of various science concepts, there are few related to their understanding of the properties of air. Teaching the properties of air is an important lesson for young children to learn (Mizobe, 2009). Air is everywhere, it takes up space, it has weight, it can push objects and etc. To achieve a correct understanding of air is to help young children to start understanding other important processes in the surrounding world. Prior to teaching, young children live in air, feel wind and drafts. However, young children have few actual perceptions of air. Séré (1986) claimed that children have misconceptions about the distribution of air in the containers. Most children know that air is in motion, but they used anthropomorphic analogy, such as "air can be tired", to incorrectly explain the motion of the air. Stavy found that young children have no clear concept about the conservation of the weight of air and the presence of air, and young children have difficulty in conceiving gas as a substance (Stavy, 1988, 1990). In addition, some of middle school students believed that gas has no weight and some of them even believed that, since gas is light, it will make the liquid lighter after reacting with it (Séré, 1982; Stavy, Eisen, & Yaakobi, 1987). Since air has no visible attributes available to children, young children obtain clear concepts of air through good teaching design. In other words, teachers should try to present students with many contexts and confront them with contradictions as possible.

Effective Teaching for Constructing Children's Science Concepts

Kammi and DeVries (1993) have noted that the objective of physical knowledge activities is to provide opportunities for children to construct and explore scientific concepts. In other words, doing science offers extensive opportunities for manipulation and discovery. In science teaching and learning, there are a number of instructional strategies worth noting such as TWA (Teaching with Analogies Model), POE (Predict-Observe-Explain), Cognitive Conflict and 5Es (Engaging, Exploring, Explaining, Elaborating, Evaluating) (Glynn, Duit, & Thiele, 1995; Gunstone & White, 1981; Carin, Bass, & Contant, 2003; Stavy & Berkovitz, 1980). In the Teaching with Analogies Model, an analogy is drawn by transferring ideas from a familiar concept (*analog*) to an unfamiliar one (*target*). The analog with mapping a familiar and concrete representation onto that of the target concept makes the target concept more understandable and memorable. 5Es (Engaging, Exploring, Explaining, Elaborating, Evaluating) model involve asking questions, gathering evidence, constructing scientific explanations, applying understandings to new problems, and assessing developing understandings. With the 5Es model, teachers provide children chances to explore specific questions and children are guided through an inquiry-based, step-by-step doing science. These instructional models may help children to understand more abstract concepts and invisible physical phenomena.

Predict-Observe-Explain (POE)

The researcher's focus is on the Predict-Observe-Explain (POE) model in this study, which has been used not only to determine students' alternative concepts, but also to use these ideas as a medium for conceptual change. In addition, the POE process meets the criteria of appropriate activities in early childhood science education for children's own manipulation and conflict discrepancies. In the POE teaching sequence, students are asked to express their own views about a given situation, to predict what will happen and to provide reasons for their predictions. When predictions and observations are inconsistent with each other, students are asked to explain the reason, which then leads to further exploration and even a change in the students' alternative concepts (Gunstone, 1990). The POE model is a very powerful technique, especially for exploring the physical sciences, as it helps children to reach a consensus scientific view of the phenomenon. Therefore the POE model has been used widely within student groups in primary schools and high schools (Costa, 1994; Tytler, 1993; Liew & Treagust, 1995). Palmer (1995) noted that when POE experiments are conducted as written exercises, the result for young children could be loss of information. In order to avoid this weakness in the model, the researcher relied on oral communication and conducted in-person interviews with individual children in order to obtain more holistic data.

Research Purpose

The purpose of this study is to understand young children’s basic concepts of properties of air and to use POE to promote young children’s understanding of the properties of air. The consequent research questions were:

1. What types of models of the properties of air were held by young children before beginning POE activities?
2. How can POE activities promote young children’s concepts of the properties of air?

Method

Participants

The sample includes 36 young children (17 boys, 19 girls) from kindergarten aged 6 years, 2 months to 6 years, 9 months (M = 6.5 years, SD = 3.1 months). The children were selected from three regular kindergartens and from middle-class background families. None of the subjects had officially learned the topic of this study. The researcher’s assistant conducted the interviews with each student individually in a session that lasted approximately half an hour. Interviews were conducted after regular classes in the children’s homerooms. Before the interviews began, the interviewer co-taught regular classroom activities several times with the children’s teachers this was done to allow the children to become more familiar with the interviewer.

Procedure

The researcher first gauged the children’s prior knowledge of air, and current understanding that “air is everywhere” before beginning POE activities. The interviewer asked children questions such as, “Do you think that there is air in your nose?” “Do you think that there is air in your ears?” and “Do you think that there is air in an open container?” After young children offered their answers to these yes/no questions, the interviewer asked young children the reason for every answer.

The whole POE procedure with several phases is original in this study. Four phases include phase A (predict), phase A (observe & explain), phase B (predict), and phase B (observe & explain). The researcher developed semi-structured interview questions based on the POE activities created to teach the children about air. The survey was used to validate the semi-structured interview questions through a panel of experts' evaluation. Based on experts' comments, the researcher made an appropriate revision of the interview questions in the POE process. The POE experiment is to help children "see" air through a series of teaching design. The purpose of two different phases (A & B) is to know if children could transfer what they learned in phase A to another problem of phase B. Semi-structured interview questions based on the POE activities are presented in Table 1.

Table 1. *Semi-structured Interview Questions Based on POE Activities*

POE phase	Questions
POE Phase A Predict	Do you think that water will enter the glass when I put the empty glass [upside-down] straight into the fish bowl? Why?
POE Phase A Observe – Explain	What happened to the empty glass? Why do you think that this is so different from what you predicted in the beginning? Why do you think water didn't enter into the glass?
POE Phase B Predict	Do you think that the tissues in the bottom of the glass will become wet when I put the glass straight into the fish bowl? Why? In POE Phase A, did you see that water did not enter into the empty glass?
POE Phase B Observe – Explain	What happened to the tissues? Why do you think that this is so different from what you predicted in the beginning? Why do you think the tissues did not become wet?

1. POE Phase A – Predict: In the first POE activity, a fish bowl is filled with colored water. An empty transparent glass is then submerged upside-down into the fishbowl. The children were told at the outset that they would be performing an experiment, and were then asked to predict what will happen and provide reasons for their predictions. Specifically, the children were asked to predict whether or not the colored water would enter the empty glass (Figure 1).

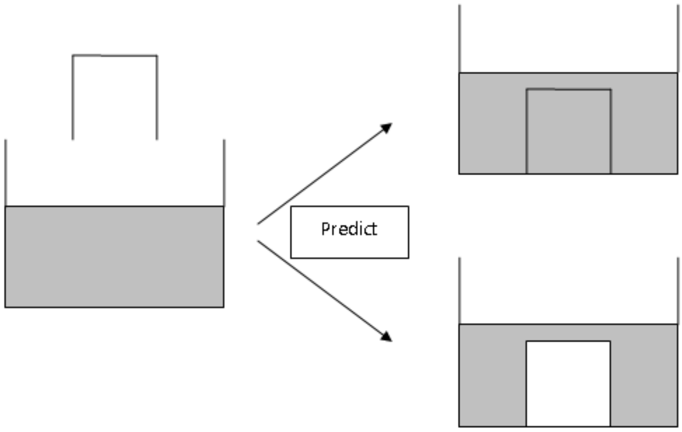

Figure 1. The first (Phase A) POE activity: an empty glass is placed upside-down into a fish bowl filled with colored water. The children are asked to predict whether or not colored water will enter into the empty glass.

2. POE Phase A – Observe – Explain: After the children made their predictions, the interviewer helped them to perform the experiment. Although children experience air at a very early age, they cannot see it. Thus the purpose of this phase is to help children "see" air. After observing the result, the children were then asked, "What happened to the empty glass?" Meanwhile, the interviewer reminded children to compare their initial prediction with their observation. They are also asked to provide a simple explanation for the result they observed.

3. POE Phase B – Predict: In the second POE activity, tissues are compacted at the bottom of the empty transparent glass. The glass is again submerged upside-down into the fish bowl filled with colored water. Before performing the experiment, the children were asked to predict whether or not the tissues would become wet. The key purpose of phase B was to realize if children could use what they learned in phase A and apply it to solve the problem of phase B (Figure 2).

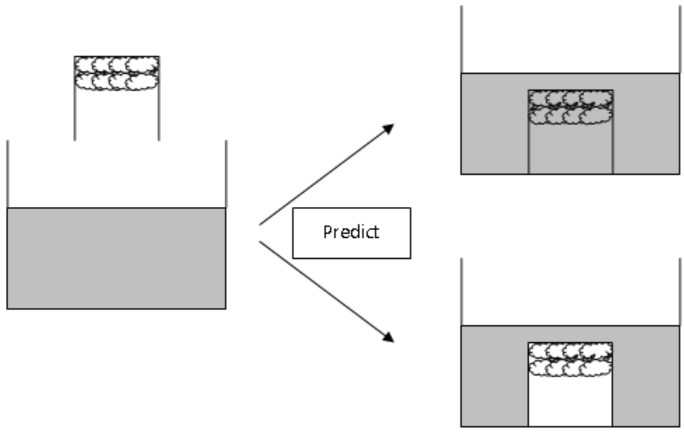

Figure 2. The second (Phase B) POE activity: after compacting tissues at the bottom of the empty glass, the glass is placed upside-down in the fish bowl filled with colored water. Children are then asked to predict whether or not the tissues will become wet and asked children whether tissues will be wet.

4. POE Phase B – Observe – Explain: After making predictions, the interviewer helped the children to perform the experiment. The interviewer then asked the children, "What happened to the tissues?" The children were asked to compare their Phase B prediction with the observed result, and to provide an explanation for this result.

Data Collection and Analysis

The interviewer had qualitative and POE teaching training and utilized this semi-structured protocol to assure coherence during the interviews. Data on children's conceptions were collected via videotape recordings, field notes, and supplementary interview reports. Each session was audio-taped and transcribed as soon as possible after the event. First, the researcher categorized children's answers into different models and showed the percentage of distribution of children's prior concepts of air before beginning POE activities.

Second, children's interview data in POE activities was segmented, categorized, coded and grouped. The answers were coded independently by peer checks, and inter-rater reliability was 0.95. To avoid personal bias, the researcher invited expert colleagues with qualitative research and science education backgrounds to validate classification and data analysis. In addition, the researcher used triangulation with using multiple data (videotape recordings, field notes, and supplementary interview reports) to promote the interpretative validity of the qualitative findings.

The researcher provided examples of children-interviewer interaction in semi-structured interviews during the POE activities to illustrate qualitative differences. In written transcripts, each student is referred to by a unique and random identification, Sn, where n = {1, 2, ⋯ , 36}. In addition, the researcher also demonstrated the percentage of distribution of children's learning changes from coded data during the POE activities, and the numerical data was as a supplement to interpretive analysis.

Research Findings

Young Children's Prior Conceptions before POE Activities

The researcher first asked the young children several questions before the POE procedure in order to find out if these young children's prior knowledge about the properties of air is fragmented or integrated into a coherent system. Assessing young children's prior understanding can help teachers identify the problem of their learning. The children were asked yes/no questions about the existence of air in the nose, in the ears, in an open container, and in a closed container. The results reveal that a majority of young children do not think that air exists everywhere (Table 2).

Table 2. *Young Children's Answers to the Question: "Is There Any Air in Each of the Following Places?"*

	Yes	No
In nose	89 % (32/36)	11 % (4/36)
In ears	31 % (11/36)	69 % (25/36)
In an open container	36 % (13/36)	64 % (23/36)
In a closed container	72 % (26/36)	28 % (10/36)

89% of children believe air to be in the nose, and 11% think that there was no air in the nose. 31% of children believe air to be in their ears, and 69% think that there was no air in their ears. In addition, 72% of children believe that there was air in a closed container, and 36% of children believe that there was air in an open container. After analyzing young children's interviews, the researcher classified responses into different models (model 1: correct model, model 2 & 3: incoherent model, model 4: breathing model) based on where they believe air exists (Table 3).

Table 3. *Model Classification Based on Young Children's Responses to "Is There Air in the Following Places?"*

	Nose	ears	an open container	a closed container	%
Model 1	✓	✓	✓	✓	5% (2/36)
Model 2	✓			✓	47% (17/36)
Model 3	✓		✓		22% (8/36)
Model 4	✓				8% (3/36)
others					17% (6/36)

Model 1 represents the correct model where children could realize "air is everywhere" only two children fall under the Model 1 classification. Model 2 and Model 3 represent incoherent understanding in young children's minds where air exists in the nose, but not always in an open or closed container. An example of a Model 2 response is as follows:

Interviewer: Do you think that there is air in an open container?
S13: I think that there is no air.
Interviewer: Why do you think that there is no air in an open container?
S13: Air will run out of the container because there is no cap on the container.
Interviewer: Is there air in a closed container?
S13: Yes, because air can't escape.
Interviewer: Why do you think that there is air in your nose, but there is no air in

an open container?

S13: Air will enter into my nose when I breathe.

Interviewer: Why do you think that there is no air in your ears, but there is air in your nose?

S13: Because we don't use our ears to breathe.

Some children have the same explanation as S13. They explain that air can move around, and that closed containers will conserve air. Regarding the nose, children know that air fills the nose because people breathe to survive. Along the same line of logic, many claim there is no air in the ears because the ears are not necessary for breathing. Nearly half of children (47%) are classified as Model 2. Meanwhile the following is an example of a Model 3 response:

Interviewer: Do you think that there is air in a closed container?

S16: No, I think there is no air.

Interviewer: Why?

S16: Air doesn't like to be closed in the container, so it runs away.

Interviewer: Is there air in an open container?

S16: Yes, air can move into the container.

Unlike Model-2 child S13, some children like S16 think the movement of air as a personified explanation. The conviction that "there is air" is unstable, and it even depends on "the ideas from air". It seems that there is no logical thinking in this kind of explanation. Less than one fourth of the children (22%) are classified as Model 3. Children classified as Model 4 claimed that air only existed in the nose because they could not see air, and so except for breathing, they had no other way to justify the existence of air elsewhere. For example:

Interviewer: Do you think that there is air in an open container?

S18: I am not sure. There should be no air in it.

Interviewer: Why do you think that there is no air in an open container?

S18: Because I can't see it.

Some young children (8%) cannot imagine where air is, because they cannot quite grasp the concept that air "exists." The responses of the rest of the young children (17%) could not be classified under one of these four models. Many seemed to respond "yes" or "no" randomly, and did not give their own reasons.

Overall, young children have different ideas and concepts related to air even though they cannot see air. In this stage the researcher did not evaluate each child's responses as scientifically acceptable or correct; responses were recorded simply to establish the children's current conceptual level. Based on these initial responses, the researcher was able to determine the effectiveness of the following POE activities that demonstrated that air is everywhere. Knowing what children think and why they think that way is important, or we have little chance of making any impact with our teaching no matter how skillfully we proceed.

Analysis of POE Phase A

From the initial phase, the researcher noted that most of the young children hold incomplete and inconsistent concepts about "air is everywhere." The researcher designed the following POE activity to help children "see" air and understand its properties.

Table 4. *Results of POE Phase A Activity*

In open container (prior knowledge)	Predict phase A	Observe-Explain phase A
36 % (13/36) Air exists	6 % (2/36) Predict: water will not enter the glass	17 % (6/36) Explain: the phenomenon related to air
64 % (23/36) Air does not exist	94 % (34/36) Predict: water will enter the glass	83 % (30/36) Explain: have no ideas

As shown in Table 4, 36% of young children answered in the initial phase that air exists in an open container, but only 6% of children predicted in Phase A that water will not enter the empty glass when placed upside-down into the fish bowl. 94% of children were pretty sure that water definitely will enter the empty glass when the interviewer put the empty glass upside-down in the fish bowl. That is to say, some children (n=13) understand "air exists in the glass," but fewer (n=2) correctly understand that "air occupies the space in the glass" and therefore water will not enter the glass. Student S12 provides his reason:

Interviewer: Do you think that water will enter the glass when I put the glass [upside-down] straight into the fish bowl?

S12: I don't think so. Water wouldn't enter into the glass.

Interviewer: Why not?

S12: Air lives in the glass, so water cannot enter the glass.

After conducting the experiment in Phase A and discovering that water does not enter the empty glass, the majority of children experience a cognitive conflict between their prediction (water will enter the glass) and observation (water does not enter the glass). Many of the children were astounded by what they saw, and when asked to try to explain the result they often could not give a reason:

S1: Oh, it's just like magic. Water didn't enter the glass.

Interviewer: Why do you think that this is so different from what you predicted in the beginning?

S1: It's too strange. I don't know why.

For young children understanding that "air exists in the glass" it is easier than understanding that "air occupies the space in the glass". The invisible property of air makes it difficult for children to come by the reasoning. Although every child saw that water enters the glass, only 17% of children think the phenomenon is related to air. Most of the children can not believe what they saw and think that it's magic like S1. After finishing the process of POE Phase A, 11% of children (6%-17%) self-constructed a clearer and more correct understanding that "air occupies space."

S19: Wow, water didn't enter the glass.
Interviewer: Why do you think water didn't enter into the glass?
S19: Oh, it should be related to air. It's air, so water cannot be in, right?

However, when asked to explain the result of Phase A, the majority of children still cannot reconcile this conflict and simply answer, "I don't know" the interviewer then explains the phenomenon to the children.

Interviewer: There is air in the glass. Because air occupies the space in the glass inside, the water will not enter the glass.
S6: Oh, it's air. Air occupies the inside of the glass.

Generally speaking, young children only repeat what they heard from the interviewer. Since young children tend to agree what the interviewer explained, it is uncertain that their reaction is authentic understanding. Next the researcher will try to understand whether or not the interviewer's explanation and experiences in Phase A will affect the children's follow-up performance in POE Phase B.

Analysis of POE Phase B

There are two purposes of POE Phase B. One is to realize how children use what they have learned in phase A to predict, observe, and explain the POE Phase B activity; the other is to create a second example that will further convince children that air occupies space, and will help them to reconstruct their understanding of the properties of air. The difference between Phase A and Phase B is that Phase B includes compacted tissue at the bottom of the empty glass, and the children are asked to predict whether or not the tissues will become wet. As shown in Table 5, 25% of children (n=9) correctly predicted in Phase B that the tissues will not become wet; this is an improvement from 6% of children (n=2) who predicted that water will not enter the glass in Phase A. Therefore 7 children learned the concept that "air occupies space" through the experiences of POE Phase A. It seems that the cognitive conflict resulting from the POE activity does help some children to reconstruct their understanding about air.

Table 5. *Results of POE Phase A and Phase B Activities*

Predict Phase A	Observe-Explain Phase A	Predict Phase B	Observe-Explain Phase B
6% (2/36) Predict: water will not enter the glass	17% (6/36) Explain: the phenomenon related to air	25% (9/36) Predict: water will not enter the glass	42% (15/36) Explain: the phenomenon related to air
94% (34/36) Predict: water will enter the glass	83% (30/36) Explain: have no ideas	75% (27/36) Predict: water will enter the glass	58% (21/36) Explain: have no ideas

Interestingly, 75% of children still made wrong predictions a possible explanation is that the interviewer only explained the result of Phase A, and the children were not convinced. Another explanation is that children considered the POE Phase A result as magic or an exceptional case. Thus, they still think that water will enter into the glass in POE-Predict Phase B. These children did not apply what they saw in Phase A to Phase B, and consequently made the same incorrect prediction. That is to say, the children's prior knowledge and beliefs continued to affect their predictions and interpretations of new learning (Liew & Treagust, 1995). After all, correct scientific concepts including "air occupies space" are not easy to establish during a single POE activity.

Interviewer: Do you think that the tissues in the bottom of the glass will become wet?
S1: They should become wet.
Interviewer: Why?
S1: Because water will enter into the glass.
Interviewer: In POE Phase A, did you see that water did not enter into the empty

glass?

S1: I saw it. It is too strange. T his time, water should enter into the glass.

After conducting the POE activity in Phase B, children saw that the tissues in the bottom of the glass did not become wet. Compared to 17% of children who correctly explained the result of Phase A, 42% of children in Phase B could understand that water does not enter into the glass since air occupies space.

S26: Wow, the tissues are not wet.
Interviewer: Why do you think the tissues did not become wet?
S1: Oh, air blocks the water on the outside, so it protects the tissues.

Thus the experiments from Phase A to Phase B demonstrate that POE is a useful technique that produces prediction-outcome conflict that helps children to understand "air occupies space."

Discussion

Young Children's Incoherent Conceptions before POE Activities

The majority of children believe air to be in the nose because many understand that people breathe through their noses. However, fewer children think that there is air in their ears since we don't use ears to breathe. Interestingly, while comparing an open container and a closed container, young children were more likely to believe that there was air in a closed container than in an open container; the majority of young children contended that air could not escape a closed container. The results reveal that a majority of young children do not think that air exists everywhere. Despite their incoherent responses, there is a rational explanation for children who use this kind of logical thinking, such as people breathe through their noses and air escapes without a cap on the container, based on their prior knowledge system. In addition, some children's thinking is analogical, and animistic reasoning in many cases was found. Most of the young children only know that air existed in the nose and air is in motion. Since they could not see air, some of them had no other way to justify the existence of air elsewhere before beginning POE activities.

The Growth of the Concept from POE Phase A to POE Phase B

The majority of children experience a cognitive conflict between their prediction and observation in the POE activities. After finishing the process of POE Phase A, there already appears to be an improved conceptual understanding; ten percent of children could understand that water does not enter into the glass since air occupies space through hands-on experiments. After finishing the process of POE Phase B, a quarter of children self-constructed a clearer and more correct understanding that “air occupies space.” According to Piaget, a discrepancy between two cognitive entities leads to cognitive development (Piaget, 1970). Langer (1969) and Strauss (1972) also suggested that conflict training procedures were effective in inducing cognitive development. The POE activities connect two representational systems: the abstract concept of air, which is discussed verbally, and the physical and quantifiable measure of air. The abstract idea of air is hard for children to articulate, and so it is easier to use various experiments to help them “see” air. This is the reason why the researcher designed these POE activities for young children. Although young children’s written skills are limited, the researcher’s method of individual interviews was a practical way of obtaining holistic data.

During the POE procedure the researcher created a rich representation of “air is everywhere” and “air occupies space” by demonstrating the similarities and the differences across the two phases. In the POE-Predict phases, children used their everyday language and commonsense understanding of air to predict the results of experiments. After the POE-Observe-Explain phases, regardless of their predictions, children were able to form a better mental representation of what they saw and remodel their previous beliefs about air. POE activities provide young children with ample opportunities for logical thinking, and provide the conceptual foundation to support intellectual and linguistic development.

Science Teaching

Young children have misconceptions about the distribution of air in containers.

The same argument of air movement was used for the correct and incorrect answers, regardless of whether the containers were closed or not. Change of one's conceptual understanding is a gradual process, though one which should start and continue in the experimental session where activities represent ideas more concretely, and therefore help children to rethink concepts and to articulate ideas. To young children, misconceptions can be defined as conceptions that produce systematic patterns of error. Thus, the process of exploring science is one of collecting and systematizing the pieces of knowledge into larger wholes. Exploring science entails learning to question, observe, classify, measure, predict, infer, experiment, and construct models. The teacher should be a facilitator of the processes of doing science with children, and the teacher has to develop a rich environment for exploring science. Although it is difficult for young children to obtain internally holistic and consistent conceptions about properties of air, the researcher found that POE activities offer extensive opportunities for manipulation and discovery, and POE activities indeed promote in some children a better understanding of "air occupies space".

Conclusions and Implications

Choosing central concepts for children's science education is crucial in order to provide a solid foundation of knowledge and to engage children with the world. Early childhood teachers should take advantage of children's existing knowledge, and use it as a platform to explore topics further or to move further to connect new concepts. The knowledge systems in young children, like in novices, consist of an unstructured collection of many simple elements. Thus, it is even more important for teachers to design appropriate activities that work within children's current language ability and their prior. The properties of air are abstract, but children can still manage to use everyday language to describe their basic intuitions about air. Naïve responses originate from intuitive and superficial interpretations. Teachers can take advantage of language in a useful way that challenges children's ideas for example, instead of phrases such as, "air lives in the glass", they can say "air occupies space."

In this study, the researcher found that the POE conflict training procedure encouraged cognitive development in children, particularly for the concept that "air is everywhere" and "air occupies space." Although some children's explanation for the conflict between prediction and observation were correct, POE is still considered a successful tool that builds positive attitudes toward science. POE activities capture children's attention, arouse curiosity, create motivation, and also provide the teacher with information about the level of children's understanding. The research indicates that there is some meaningful success achieved, but obtaining consistent and holistic concepts for young children is a long-lasting process. However, inferences that the researcher drew based on the data gathered should be considered tentative in light of the small sample size as a narrow range. In addition, the entire organization of activities in this study is not in the actual conditions in the kindergarten. Nevertheless, these results allow us to hypothesize that the possible can be transformed to the feasible. Future research may be needed to verify the results.

Since POE activities reflect a constructivist view of learning, it is suggested that preschool teachers should gain further experience in inventing and implementing POE activities in different topics, especially physical sciences. The results imply that POE activities can be used by teachers to insightfully design science activities that start with children's viewpoint rather than the teacher's. Further research could focus on designing more POE activities to promote children's understanding of the physical properties of air. Another potential research direction would be to examine if POE activities increase young children's scientific reasoning and keep them interested and engaged in science.

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Table 3. *Number of Words Related to Ethnicity or Language, Special Needs or Pre-primary Education, Education Principles*

Document	1 Ethnic	2 minority	3 multi cultural	4 non-Chinese	5 NCS	6 NAC/ new	7 South Asian	8 special ed	9 special needs	10 marginalized	11 kinder-garten	12 pre-primary	13 preschool	14 early childhood	15 integrate	16 inclusion
1965 EdP	0	0	0	0	0	0	0	5	0	0	2	2	1	0	0	0
1981 PEPPS	0	0	0	0	0	0	0	3	1	0	115	17	0	0	0	0
1986 ECR2	0	0	0	0	0	0	0	51	0	0	300	50	1	4	1	0
1995 WPKed	0	0	0	0	0	0	0	0	1	0	353	50	0	8	0	0
1996 GPC1996	0	0	0	0	0	0	0	0	2	0	37	445	0	0	0	0
1998 ECR7	0	0	0	0	0	0	0	4	0	0	5	4	0	0	0	2
2000 EdR	0	0	0	0	0	0	0	10	0	0	14	1	3	71	19	3
2001 QER2001	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
2002 HPPS	0	0	0	0	0	0	0	0	2	0	0	49	0	3	4	0
2004 NCS (Chinese)	20	6	3	40	X	0	2	0	0	0	2	0	0	0	23	0
2006 GPC2006	0	0	0	0	0	0	0	4	9	0	51	42	5	31	1	0
2007 D&D	0	0	0	0	0	0	0	0	1	0	4	2	0	0	0	0
2007 LNCS (unr)	7	7	0	3	20	0	0	0	0	0	2	2	0	0	2	0
2007 LNCS (rev)	1	1	0	13	3	6	0	0	0	0	0	0	0	0	3	0
2008 SuppG	31	12	2	20	300	4	1	0	0	0	7	0	0	1	30	1
2008 EdNCS	2	0	0	8	21	5	0	10	0	0	19	3	0	0	5	0

Dark Shade: Major education documents
No Shade: Pre-primary curriculum guides
Light Shade: Resources and leaflets relating to non-Chinese speaking students