PRESCHOOL SCIENCE AT MUSEUMS*

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Science at the preschool level (under six years old) is not usually a topic at AAPT/APS meetings. I chose to talk about it in this session, devoted to New Teaching Tools in New Environments, for two reasons. One was to try to avoid repeating what my colleagues preceding me would say; the other was because I find there are lessons of value for the whole range of science teaching which come from thinking about preschool science.

This talk addresses three questions: 1) what is science for preschoolers, 2) is science appropriate for that age group, and 3) how can it be taught--particularly through a museum.

The Cycle of Science

The first step in delineating science for preschoolers is to have an overview of science in general, and I give my version of that as the "Cycle of Science" (Slide 1).

The cycle starts by recognizing two realms: the "mind" and the "real world." Through observation and its refinement, measurement, parts of that real world are brought into the mind as what we call "facts," "data," or "information."

The whole purpose of science (and of other disciplines as well) is to bring some degree of understanding to that raw experience. Understanding, for science, means seeking ever more general statements that organize our specific data of experience. These generalizations bear such names as "patterns," "concepts," "relationships," "laws," "principles," and, ultimately, "theories." The more general the theory, the better it is considered to be.

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The path from specific experience to general principles is entirely in the mind and includes such things as comparing, classifying, inferring, modeling, and hypothesizing. Altogether this is called "inductive reasoning."

Science is not satisfied, however, with just arriving at a generalization. It then takes the critical step, which is the distinguishing feature of science, of testing the validity of the generalization by going back and checking with the real world. This step involves two parts. The first part is to use deductive reasoning to go "back down the ladder." This takes the following form: "if my general statement is true and such and such conditions are present, then the following specific things should happen in the real world." The second part is to do an experiment, which means to establish in the real world the conditions of the deductive statement and then to see whether the predicted things do indeed happen. If they do, the scientist takes that as validation--which is not the same as proof--of the general statement. If the predicted things do not happen, the scientist can conclude either that the experiment was faulty, the deductive reasoning was incorrect, or the initial general statement was in fact not true. In any case, the experiment produces new observations and the cycle continues, encompassing more experience and reaching broader generalizations.

Lessons for Science Teaching

Based on the "cycle of science" diagram, three key lessons can be drawn that bear critically on science teaching.

1. The subject of science is the entire cycle illustrated by the diagram. This is the same for all people at any age and regardless of whether the cycle is operating at the everyday experience level or at the boundaries of the universe. It follows that while the goal of science may be to develop theories, the goal of science education should be to get people "moving around the cycle." The mistake of a great deal of science teaching is to jump too quickly into the conceptual level while paying little or no attention to the underlying experience and the cycle that leads there.

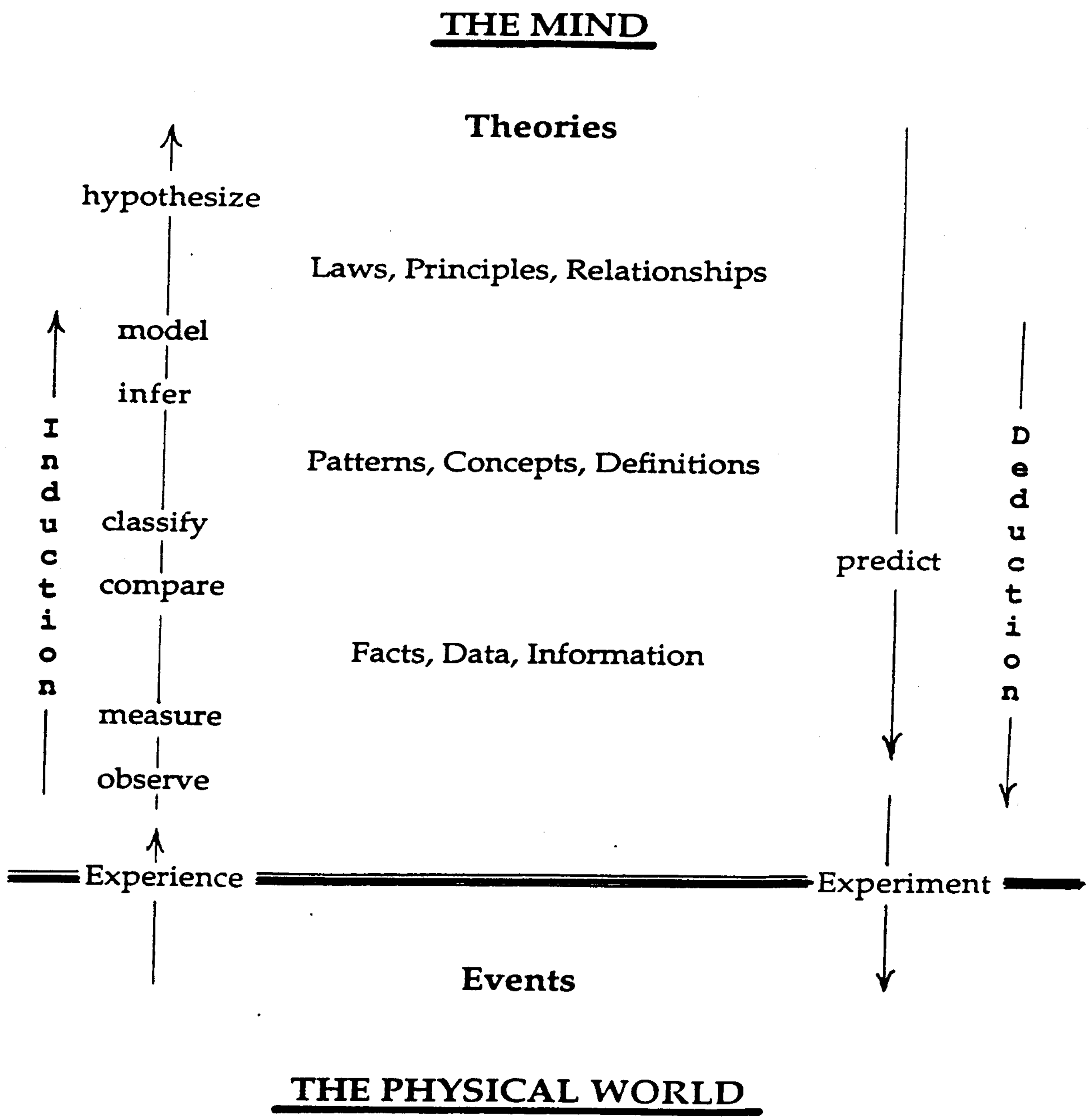

Fig. 1: The Cycle of Science

2. There is both a hands-on component--observation and experiment--and a minds-on component--the inductive and deductive reasoning ladders--to science. But there is no direct path between the "real world" and the concepts of science. Thus, for example, there is no way that anyone can see Newton's laws, kinetic or potential energy, rays of light forming an image, etc. Yet many texts and so-called "hands-on" science materials (not to mention some science museums) imply that this is indeed what people can and should be seeing. This mistake of not clearly distinguishing the mental constructs from the actual observations--of not following the path of the cycle--is a great disservice to students. The result is almost certain to be the rote learning of the words of science without any accompanying understanding.
3. The processes a person uses to move around the cycle of science require skills, both intellectual and physical. It is critical to recognize that having skills means actually being able to do something, and the only way to learn to do something is by actual practice, with the teacher taking the role of coach.

Identifying Needs for Learning Science

With the entire cycle of science in mind as the learning goal, teachers and exhibit developers can identify three attributes a person needs to have in order to become an active participant.

1. Curiosity. This is the personal characteristic that drives the whole enterprise. Without it there is little observation and questioning, and the whole process never gets started.
2. Experience. The direct result of our interaction with the real world we call our experience. Without a foundation of experience, which may also be called "physical knowledge," there can be no development of the conceptual knowledge of science. There would be no specifics on which to base the generalizations; "science" would be the answers to questions that had never been asked.

3. Reasoning and experimental skills. These skills are what enable a person to move around the cycle, and it is the level of these skills that determines how extensively he or she will be able to engage in the cycle. Recognizing skill level as the critical factor allows us then to set up appropriate science for preschoolers.

All three of these elements are necessary for engaging in science. They reinforce and build on each other. For example, curiosity will lead to experience which will facilitate skill development; and higher skills will yield satisfied curiosity which in turn creates more curiosity. The three are completely intertwined and the development of these need to be the principal focus of teaching or exhibit efforts.

Science for Preschoolers

To decide what would be appropriate to emphasize in science for preschoolers, one can just examine the three areas of need and inquire at what stage the preschooler is and what his or her capabilities are.

Curiosity is something that all children start out with in abundance. All that is needed here is to encourage it--or at least not to discourage it.

Physical knowledge is being acquired by children from the day they are born as the natural result of their curiosity. Extending the possibilities for exploration, and thus the extent of their physical knowledge, is the main focus of science for preschoolers.

Some development of skills will come as a by-product of the physical exploration, and it can be aided by properly designed experiences, but that is really not the main focus for preschoolers. Skill development becomes more important at the elementary level.

Science Museums and Exhibits

Science for preschoolers, therefore, is mainly encouraging their innate curiosity and extending their physical experience. Museums and science centers, with their interactive exhibits and informal environment, turn out to be excellent places for this.

At the Museum of Science and Industry in Chicago we have created an exhibit area especially for preschoolers, called "The Curiosity Place," and I will describe the characteristics which we believe make it effective in reaching the above goals.

· First, and perhaps of greatest importance, is the room itself. It is a separate area, with a limited capacity, and always staffed. The importance of this is that it forms a safe, friendly environment within which the children are completely free to explore on their own--without the need for adult assistance or intervention. (Slides 1-7)

· The exhibits should pose a "problem" for the child, and they should allow for a progression of activities that can eventually lead to success in finding a "solution." (Slides 9-13)

· The exhibits need to be physically involving; and the more senses used, the better, (Slides 14, 15)

· Unexpected, novel results will continue to pique interest and curiosity. But the opportunity to explore the familiar in new ways can be just as exciting. (Slides 16, 17)

· The effects of the child's actions at the exhibit should be both clear and quickly apparent. (Slides 18, 19)

· A variety of interactions at different levels of understanding will keep a child involved at an exhibit and is the best way of developing new physical knowledge. (Slides 20,21)

The combined effect of these factors is to keep the curiosity of young children very much alive while they are happily and busily engaged in developing physical knowledge of the world around them.

The Role of Adults

The role of the adults present in the exhibit, either parents or staff, is critical to the success of the exhibit in reaching its goals. They are there to encourage the child in his or her exploration; but not to teach in the usual sense. True encouragement stems from an attitude of respect--respect for the child as a human being and for his or her capability to learn. Some specific "dos and don'ts" that come from this are:

· Do be accepting and non-judgmental of the child.

- Do reinforce positive actions and build on them; don't correct what the child is doing "wrong."
- Don't do for children what they can do for themselves.
- Don't answer "why . . .?" questions with "because. . . ." answers. Since this shuts off exploration and denies the satisfaction of discovery, it is ultimately discouraging.

Adults have a tendency to want to teach the child, lead the child, or help the child too much and too quickly. We therefore suggest that adults stay in the background at first and simply observe their child playing with the exhibits. Surprisingly, many may never have done this before and will be interested to see how productively involved the child can become without their assistance.

Conclusion

I would like to conclude by summarizing the answers to the three questions which were posed at the start of the talk.

- There is such a thing as science for preschoolers, but it is participating in the "cycle of science," not learning the isolated concepts of science. In this sense science for preschoolers is the same as science for anyone else--just less sophisticated in the level of experience that is presupposed and in the skills that are used.
- Science for preschoolers, which is mostly encouraging curiosity and extending physical knowledge, is highly appropriate. It is what children of that age are doing naturally and the thing that is shared most equally by all children, regardless of the richness of poverty their social environment.
- Science for preschoolers can be furthered through well-designed, manipulative exhibits set in a safe, friendly environment and by providing encouraging interaction with adults.

If this approach to science were available to all preschoolers, and continued up through elementary grades, we might see students arriving at high school and college with active curiosity and a wealth of physical knowledge. Think what a pleasure it would be to work with these students to develop the more conceptual levels of knowledge in our formal science courses.