Chapter 22

LEARNING SCIENTIFIC CONCEPTS IN SCIENCE CENTERS

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Introduction

It is important for teachers and students to realize that an understanding of the methods of scientific thought should not be considered as an end in itself. Students should develop skills in these methods in order to use them to discover and learn new things. In any effective science program it is necessary to clarify the understanding of a particular concept. Teachers, schools, as well as training colleges, have to be made aware of what methods, techniques and aids can be used to clarify the understanding of a particular concept.

Science centers have devised a new methodology in teaching science concepts. For students learning science they represent the ideas of science in a physical form that allows active experimentation and investigation parallel to that of science itself. Science museums have the unique ability to provide direct experience with real things, presenting possibilities that are difficult if not impossible to achieve in other forms of teaching. Museums can present broad overviews as well as detailed studies of concepts and ideas. The introduction of interactive exhibits has really captured the interest and imagination of today's youngsters who prefer to be actively involved rather than simply being passive observers. The interactive exhibits of science centers follow a pattern similar to that of science education. A hypothesis is offered in the form of a single exhibit, or series of exhibit units; the student (or a visitor) uses the exhibit in a variety of ways to test possible answers and, eventually, may discover a reasonable explanation. Pitman-Gelles (1981) argues that the concept of museums as learning environments has been the cornerstone of studies in teaching and learning in several disciplines. Sneider, Eason, and Friedman (1979) carried out a study on a participatory astronomy exhibit at Lawrence Hall of Science in California. They compared high school students randomly assigned to visit the Star Games exhibit to a control group on measures of cognitive learning, psychomotor skills in using telescopes and attitude towards astronomy materials. Their study revealed

that the exhibit was an effective learning tool, as assessed by both an astronomy quiz and a psychomotor measure, but they did not find the hypothesized increase in subjects' selection of astronomy books for later reading which was intended to demonstrate the motivational impact of the exhibit.

Wright (1980) investigated the effectiveness of a multisensory museum exhibit as a culminating activity following a sixth-grade biology unit. He found that the test performance of the experimental group surpassed that of students having an in-class review. Gennaro (1981), on the other hand, examined the effect of pre-visit instruction in the eighth-grade classroom on learning from a museum experience. His study provided evidence that students with such cueing show more cognitive gains than those who visit a museum without advance information regarding what they will be seeing. A study by Carlisle (1985) was concerned with "what a group of children actually did at Science Center". He found that the science center visit was both a solitary and a social experience. Borun, Flexer, Casey, and Baum (1983) carried out an experimental study of class visits to a science museum at the Franklin Institute in Philadelphia and at the Museum of Science in Boston. Cognitive and affective outcomes of a class visit to a participatory science museum were examined by comparing responses of 416 fifth and sixth graders randomly assigned to four conditions (control, exhibit only, lesson only, and exhibit followed by lesson) and two tests (verbal and visual). Students visiting a simple machines exhibit scored higher on a test of science content than the control group, but lower than the group attending a classroom lesson in the museum. The study did not demonstrate conclusively a cognitive advantage of having the exhibit experience prior to the lesson. Scores on the visual test were consistently higher than scores on the verbal test. Study findings indicated that the particular strength of the science museum exhibit lay in the affective domain. Students found the exhibit much more enjoyable, interesting, and motivational than a classroom lesson.

However, to date there has been partial and inadequate information about the effectiveness of exhibits for making children understand the scientific concepts. The present research conducted at Nehru Science Centre, Bombay (India), was designed to investigate the problem of evaluating the educational importance and impact of exhibits in Nehru Science Centre, Bombay.

The experiment was carried out into two phases: the pilot phase and the main study.

The following research hypothesis were tested:

- There will be no significant difference between the experimental and control group when they appear for a pretest, as no treatment is given to them prior to visit.
- There will be significant differences between the experimental and control group when they appear on a posttest of science concept.
- There would be a significant improvement in understanding scientific concepts among the students visiting the science center.

Method

The Pilot Phase

Fifty, seventh-grade students of Jamnabai Narsee School served as subjects for the pilot study. The seventh grade was chosen because it is a middle point in the secondary school years. Most children in this grade are still at the concrete operational stage in their intellectual development and enthusiastic towards the exploration of new environments. The subjects were assigned to one of the four conditions (i.e., blackboard method, blackboard + demonstration method, demonstration method, or no-treatment).

The Main Study

A pretest-posttest control group design was selected for the main study. Students were assigned randomly into two groups. One group was chosen for experimental treatment (learning scientific concepts from exhibits in the science center) and the other group was selected for control treatment (i.e., blackboard + demonstration). In the main study the experimental and control groups were treated as nearly alike as possible except for the treatment variable. Both groups were given the same pretest and posttest and were tested during the same period. Data were collected from 190 seventh-grade students from two schools: Maratha High School, Worli, Bombay; and Municipal School, Worli, Bombay.

The following measurement tools were used in the study:

- The pretest-posttest questionnaire based on the cognitive aspects of the exhibits.
- Observation and evaluation about the appropriateness of the exhibits from the point of view of location of label, number of words in label, length of label, nature of exhibit, etc.
- A structured interview inventory for teachers and students.

All three schools visited Nehru Science Centre on Saturdays. Students were expected to study a particular gallery for at least 3 hours on a visiting day. The lessons for the three treatment groups in the pilot

study and for the control group in the main study were conducted in the respective school classrooms by the investigator. The investigator made use of a few small, common demonstration materials which would be available to any science teacher.

The pretest-posttest questionnaire was used as the basic mode for the data collection. Since the intent of the exhibit is to teach basic science facts and concepts it was considered appropriate to use tests of science content to assess cognitive outcomes of a visit to the exhibits. The test was conducted to serve three purposes:

- To test the entering behavior of the learners.
- To diagnose their weakness in understanding of concepts.
- To measure the impact of the experiment on the students' understanding of concepts.

While designing the cognitive test, three dimensional objects were taken into consideration: knowledge level, understanding level, and application level.

The questions were of multiple choice. A maximum of three questions were asked per exhibit. Where appropriate, diagrams of individual exhibits were included to obviate any reading difficulties or confusion which may have arisen. The questionnaire was in cyclostyled form. The questionnaire was designed to be self-administered immediately after the visit. Students responded to each item by putting a check mark against the right answer. The score for each student was the number of items answered correctly. The internal consistency reliability coefficient (K-R Formula 20) computed from data for the pilot posttest was found to be 0.74; whereas for main study it was found to be 0.62. The content validity was confirmed by the following:

- Consulting standard and authentic books on the subject.
- Collecting and conducting opinionaire by the following experts:
  - Five science teachers
  - Two eminent scientists
  - Three educators
  - The members of the evaluation team in Nehru Science Centre.

Results of the Pilot Study

Means and Standard Deviations of Posttest For Students in the Pilot Study

Results of the pilot study (see Table 1) showed that control group students had scored significantly higher on a test of science content than students in the demonstration group, whereas no significant difference was observed between blackboard vs. control group and blackboard + demonstration vs. control group. It was concluded that the control group had done equally well in comparison with the other three groups. Pilot

study results showed that Science Center was successful in teaching scientific concepts.

Results of The Main Study

Significance of the Difference Between Means & Standard Deviations

The analysis of the data of total pretest scores revealed the fact that there was no significant difference between the experimental and control group. It was found that the groups were matched for mean and standard deviations (see Table 2).

Significance of the Difference Between Means

The analysis of the difference between two independent means showed that students who had visited the exhibits in Nehru Science Centre scored significantly higher on a test of science content than students in the control group (see Table 3). This was a strongly positive finding. It showed that school children were absorbing a significant amount of exhibit content during a museum visit. This study supported the notion that museums can serve as adjunct learning institutions which supplement the classroom and other educational media.

As far as children's growth in scientific observation and inferential thinking is concerned, the visit to the Nehru Science Centre was obviously influential.

The Amount of Increase From Pretest to Posttest on the Three Dimensional Objects

At all three levels, increases in scores from pretest to posttest were seen. It is interesting that the highest increase was in the understanding level (see Table 4). This perhaps indicates that the particular strength of participatory displays is their effectiveness in making children understand the scientific concepts. Even though there was a slight increase in the application level, it is noteworthy that seventh graders have shown that they can apply the gained knowledge to other examples of the same process.

The General Effects of Socio-Economic Background of Children in Learning Through Museum

It is evident that a child belonging to any socio-economic group does learn scientific concepts in the museum environment (see Table 5). There was negligible change for lower income group children. The low percentage of change from pretest to posttest may be due to the following facts:

- Lack of motivation at home background.
- Lack of exposure to learning sources like mass media and social agencies.
- Shy or introverted attitude towards strange atmosphere, etc.

Conceptual analysis revealed the fact that 61% of the concepts were effectively understood by the students, whereas 39% of the concepts have not shown any clearly significant difference at the 0.01 level. While evaluating the failure of 39% of the concepts, the following points were noticed:

- In some cases, no specific educational claims were made; it was hoped that students will have an aesthetically pleasing and rewarding experience (e.g., Fairyland; Laughing Mirrors, etc.).
- Some exhibits were found beyond the level of understanding of children of Std. VII (e.g., Ultrasonic Sound, Optical Illusion).
- Difficulty in identifying the objects (e.g., Viz. Polyhedron, Pyramid Exhibit: Sliding and Rolling).
- Some exhibits might not have attracted students of Std.VII and communicated with them. (e.g., Vibrating Lips).
- In the case of some exhibits, labels were not uniformly effective in conveying information to seventh graders. (e.g., Muscular Power).

The instructional effectiveness of an exhibit is measured from the point of view of the amount of increase in learning. "Effectiveness" is based here on the amount of increase from pretest scores to posttest scores of the experimental group exposed to the exhibits in Nehru Science Centre. The average post-visit score (52.4%) shows an increase of 15.2% points, which represents a 41% increase over the pre-visit score (37.2%). It is likely that there is a limit to the amount of exhibit-based learning in a free-access, unprogrammed situation. The highest instructional power is found in case of interactive exhibits Viz, Harmonograph, Lazy Tube, The Ecliptic Motion, etc. "Participatory devices" are generally thought to be more effective than static exhibits in attracting and holding visitors' attention and communicating content (Thier & Linn, 1976). The present research work strongly supports the view of Thier and Linn.

Discussion

These findings suggest that the strength of participatory displays lies in their effectiveness in conveying scientific concepts. As hypothesized, the experimental group students who visited the exhibits in Nehru Science Centre achieved significantly higher scores on a test of science content than students in a control group, regardless of the socio-economic background. This shows that the educational forte of participatory

museum exhibits lies in the enhancement and reinforcement of science concepts.

Results of the pilot study indicated that the control group had done equally well in comparison with the other three groups. The results of the pilot study were verified by the main study and it was found that the exhibits in science centers are successful from the point of view of their inclusion in presenting the scientific concepts in the school science program. The inclusion in the research design (main study) of a control group that had only a classroom lesson permitted a comparison of the relative educational effectiveness of a participatory museum exhibit and a classroom lesson. Even though the classroom lesson was concise and well-delivered by the investigator using a few small, common demonstration materials, the methodology used in the Nehru Science Centre was found to be more effective due to its success in creating an effective learning environment.

It was also noticed that there is a limit to the amount of exhibit based learning possible in a free-access, unprogrammed situation. Minda Borun (1977) and Harris Shettel (1968) similarly found that an average of 50-75% of the information content of an exhibit is communicated to the casual visitor. It is important to note that Shettel had used a control group of paid subjects who were instructed to learn as much of the exhibit content as they could before they were tested, whereas in the present study, learning was allowed to occur under free conditions. The results of conceptual analysis yielded a higher value of CR for interactive exhibits and also the instructional power of interactive exhibits was found to be higher than for the inactive exhibits. Similar findings were also observed for those exhibits which appeal for social interaction. The most appreciable outcome of the present investigation is to show how museum visits can be treated as ancillary to the regular curriculum. In selecting the exhibits, only those exhibits which were relevant to seventh grade standard curriculum were selected. The study had shown evidence in the growth of comprehension power of seventh graders. Students have understood 61% of the concepts very effectively.

The majority of the children indicated that they had thoroughly enjoyed their visit to the Nehru Science Centre. Active participation with exhibits constituted the primary reason given for their enjoyment. Students have emphasized that they were delighted by the opportunity for physical interaction provided by the museum exhibits. In the beginning of the experiment, in the first two visits, they were observed to "rush" from one exhibit to another in a seemingly haphazard manner, often returning to specific items for "another go", but in the later part of the visits they were found to move more systematically.

Teachers from the three schools were of the opinion that the project work was well organized. They have stressed that similar types of project work should be organized by each and every school in order to foster

positive attitudes towards science amongst children and to give them a better learning experience. Teachers were of the opinion that the visit had contributed towards the acquisition of some basic scientific facts by pupils, towards the development or practice of some skills, such as hand-eye-coordination, and to their understanding of some science concepts.

Implications of This Study

The findings of the present study have important implications for science education. Teachers who turn to a participatory science museum as a resource to supplement classroom learning will no doubt find that learning does take place on the school trip. But more importantly, they can be assured that the museum experience will stimulate an interest in learning science concepts by presenting them in a manner that students find exciting.

School visits to museums are not organized by the school authority as a compulsory part of the school curriculum but are left to individual teachers to decide for themselves. The present study has shown that museum visits should be designed to compliment school education. A particular theme, a small section of the museum, or a special exhibit should usually be the object of a visit. The exhibit should be graded age-wise by the museum staff so the teacher visiting the museum with his/her students would be made aware of concepts that he/she should expose his/her students to during the field trip. Otherwise the teacher should make a pre-visit to the museum and select only those exhibits which can become a resource to supplement classroom learning. Teachers should plan the museum visit in such a way that it can be integrated with classroom experiences for children's science education.

The material used for the cognitive test in the present study was teacher-made test material. In order to standardize this test material, the content of the present cognitive test should be tested over a large sample of seventh graders visiting Nehru Science Centre. After analyzing the maximum effectiveness of such material, a researcher can make standardized test material. This will be the unique contribution for school teachers, which would help them to evaluate their students and also will encourage them to think of possible feedback. The standardized test material will help school teachers to judge to what extent their museum visit was successful. A study should also be undertaken to judge the effectiveness of exhibits in fostering scientific inquiry among school children.

It is appropriate to conclude, then, that science centers have the unique ability to provide direct experience with real things, presenting possibilities that are difficult to achieve in other forms of teaching. Science centers present detailed studies of concepts and ideas in a novel manner. Science centers can be considered as an important source of

learning. Once again it can be emphatically concluded that this new methodology, "Learning Scientific Concepts in Science Centers", can serve as a valuable adjunct to formal science education.

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Table 1

Means and Standard Deviations of Posttest for Students in the Pilot Study

Group	N	Mean	SD	Comparison	CR	Signif.
Blackboard Group	11	101.3	13.5	1 vs 4	0.77	N.S.
Blackboard + Demo Gp	12	101.7	15.4	2 vs 4	1.40	N.S.
Demonstration Group	11	95.4	8.3	3 vs 4	5.70	$p < .01$
Control Group	11	105.0	10.9			

Table 2

Significance of the Difference Between Means and Standard Deviations

	Exp. Group		Control Group		Significance of the Difference between Means	SD	Significance
	M	SD	M	SD	CR.	CR.	CR.
1.	66.8	8.7	63.4	7.8	1.72	0.64	N.S.
2.	56.6	7.9	56.9	8.1	0.19	0.14	N.S.

1. Maratha High School 2. Municipal School

Table 3

Significance of the Difference Between Means

Experimental Group M	SD	Control Group M	SD	CR	Signif.
		Maratha High School			
95.6	10.5	75.4	8.5	8.8	$p < .01$
		Municipal School			
78.32	10.5	70.5	13.7	2.62	$p < .01$
		Combined results of the two schools:			
86.98	13.5	73.1	11.4	6.6	$p < .01$

Table 4

The Amount of Increase from Pretest to Posttest on the Three Dimensional Objects

[Experimental Group: Maratha High School ≠ Municpal School]

	Knowledge Level No. of Questions 47		Understanding No. of Questions 47		Application Level No. of Questions 46	
	Total Score	%	Total Score	%	Total Score	%
Pretest	1,090.0	32.3	1,229	36.3	1,417	42.8
Posttest	1,581.5	46.7	1,849	54.6	1,685	50.9
Change	491.5	14.5	620	18.3	268	8.1

Table 5

The General Effects of Socio-Economic Background of Children in Learning Through Museum

Experimental Group	Pretest % Score	Posttest % Score	Change
Higher income group	54.3	74.0	19.7
Middle income group	51.9	73.3	21.4
Lower income group	48.4	56.0	7.6