Concepts In Context: Conceptual Frameworks, Evaluation and Exhibit Development

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Communication in an exhibit is more than the presentation or absorption of factual knowledge. It is a negotiation of meaning by people using similar or diverse conceptual frameworks to interpret the exhibit. When developer and visitor are using different conceptual frameworks misunderstanding can arise. The effectiveness of communication may be greatly increased when the conceptual framework used to select, organize and present information in the exhibit is compatible with the conceptual frameworks that visitors use to interpret the exhibit.

Impression 5 Science Museum is providing an interactive traveling exhibit about chemistry for the Exhibit Research Collaborative (a National Science Foundation project). In 1990 we requested matching funds from Dow Corning to create a chemistry exhibit which considers the importance of conceptual frameworks in helping "visitors understand the meaning of concepts, the relationships between them and their application to everyday experiences." Between December 1991 and June 1992 we interviewed 182 visitors as part of the front-end analysis and initial formative evaluation for the chemistry exhibit. Evaluation gave us insight into the conceptual frameworks which visitors spontaneously used to interpret information relating to our topic. Evaluation also helped us assess visitors' reactions to the organizing frameworks proposed for the exhibit.

What Are Conceptual Frameworks?

Conceptual frameworks are the relational assumptions that integrate a set of concepts and give them meaning. People use both logical propositions and metaphors to link and organize concepts. This offers rich possibilities for organizing information into arguments, categories, chronologies, scripts and many other structural forms (Lakoff, 1987). The organization of exhibit content reflects the conceptual frameworks utilized by the exhibit developers. For example, categorization is often used to organize and present exhibit content. This is occurring in an exhibit which

asks visitors to examine why a set of paintings form the genre known as *impressionism.* Alternatively, an exhibit which makes statements such as, "skin is the body's first line of defense against disease," is using a military metaphor to organize and interpret information about human physiology. Likewise, a history exhibit may use chronologies or script-like narratives to organize facts and events. In each case, a set of concepts is linked and given meaning by placing it in the context of an organizing framework.

To interpret an exhibit, a visitor must be able to place the content in a conceptual framework which is meaningful to them. This framework may be very similar to or very different from the framework offered by the developers. Exhibit content can have different meanings when interpreted by people with different conceptual frameworks. Developers need ways of learning about visitors' conceptual frameworks, examining and revising their own frameworks, and learning how the exhibit may help or hinder visitors' understanding of the exhibit. Evaluation can play an important role in providing this insight.

Evaluation and Conceptual Frameworks

The following is a brief summary of some of the methods which were used in this project to learn about visitors' conceptual frameworks and to assess potential organizing frameworks for the chemistry exhibit.

Open–Ended/Ambiguous Questions

Open-ended ambiguous questions require visitors to introduce their own concepts and relationships. Questions which impose context or limit responses are less likely to reveal unanticipated approaches to the subject matter. Visitors can be encouraged to elaborate on their responses to open–ended questions. This can be followed by questions which are more subject–specific or test a proposed framework.

In one application of this method, we showed visitors a set of familiar objects (steel wool, wood, a marble). We asked visitors, "How would you describe what these things are made of?". Compare this to the question, "Which of these items are made of atoms?". The latter question imposes a subject matter through terminology and it limits the possible responses. The first question also has limiting factors (the selection of materials, the nontechnical phrase "made of") but is more ambiguous and allows for a broad range of responses. In another interview visitors were asked to predict what would happen when two substances were combined and to describe what they observed afterwards. This gave information about visitors' stereotypes of chemical reactions and the physical cues which they saw, ignored, or thought they saw. Visitors were also asked what they thought made the substances change when combined.

Drawings

People's mental tools may include visual representations. Visitors' drawings and diagrams can be extremely helpful in clarifying and elaborating the mental models which the evaluator is trying to decipher. As a follow-up task in the wood–steel wool–marble interviews, we asked visitors to draw a picture of what they imagine when they think of an atom. Similarly, the chemical mixing interview included a follow–up request to "draw a picture of what you think is happening to the molecules when the substances were combined" (these requests were made of visitors who introduced or recognized the terms atom or molecule). Visitors were asked to explain their drawings. These explanations were often rich in propositions (e.g.. "molecules can move") and metaphors (e.g. "atoms are like little balls") (See Figures 1 and 2).

Categorization

Evaluation can be used to gather information about visitors' formation of and reaction to categories. We provided visitors with a set of white cards bearing words such as water, salt, glass, hydrogen, sodium, etc. Visitors were asked to arrange the cards in groups that made sense to them. They could use as many or as few cards as they wished. Visitors were then asked to label and explain their choices. After recording this arrangement, the cards were unsorted and visitors were given a set of blue cards representing key categories often used by chemists (atoms, molecules, compounds, elements). Visitors were asked to repeat the task above. If they thought a blue card would be useful to them they could use it as a category heading. Again, visitors explained their choices. All results (including cards which were ignored) were recorded. The first grouping of concepts provided information about the frameworks which visitors spontaneously use to organize the concepts. The second grouping helped us gauge visitors' responses to a molecular-level framework (See Figures 3 and 4). We also conducted interviews in which visitors categorized images.

Think-Aloud Problem Solving

Conceptual frameworks are thinking tools. When visitors think aloud as they they work through a task, evaluators can learn about the mental tools which visitor use. It becomes easier to discern which questions/topics are of particular interest to visitors and to see how visitors ignore, introduce, pursue, rework, drop and revisit themes.

We arranged a simple mock-up that included a variety of chemicals to mix and a brief set of how-to instructions (no explanations or technical terms). The chemicals and instruction produced color changes which the visitors could induce by recognizing a pattern of mixtures. We also conducted this activity with an additional chart that allowed visitors to use color to identify when acids were present. In both cases, visitors were asked to describe what they were thinking as they used the exhibit. The evaluator

only intervened when necessary for safety or to help the visitor remember to think aloud. After the visitor had ceased exploring the exhibit the evaluator asked follow-up questions.

Concept Mapping

Novak and Gowin (1984) developed concept maps as tools for evaluating students' knowledge and helping them learn how to learn. Concept maps are diagrams which express a student's view of how a set of concepts are linked together and hierarchically arranged. Concept maps are powerful tools for exploring visitors' conceptual frameworks.

We initially used a simplified (non-hierarchical) version of Novak and Gowin's concept mapping technique with visitors (see Figure 5). This approach allows visitors to spontaneously introduce their own concepts and links. However it was time-consuming to explain the technique to visitors. As an alternative, visitors were given a set of five white cards with the words people, rocks, cells, molecules, and atoms on them. We then introduced a set of blue cards with the linking words "are made of" and "are the same as." After a brief neutral example, visitors were told they could use the cards to make any sentences that made sense to them. Concept cards could be used in more than one sentence, in a crossword puzzle format (See Figure 6). This adapted approach is easy to use and very helpful for assessing visitors' responses to a proposed framework.

Exhibit Development

Since our objective is to produce an effective, appealing exhibit, evaluation must translate into development. Here are some of the ways we did this in the chemistry exhibit.

The Organizing Framework for the Exhibit

Initially we proposed to organize the exhibit around the themes of Change, Balance and Order. Evaluation helped us realize that the organizing themes which we found so intellectually attractive might not meet our visitors' needs. We had to compare multiple frameworks and construct a mutually workable approach.

Our visitors do share with chemists a propensity for building block metaphors—the view that big things are made of smaller things and that observable events are influenced by more basic properties or events. Visitors often repeated chemistry terms (e.g.. "molecule"), propositions (e.g.. "everything is made of atoms"), and metaphors (e.g.. "atoms look like solar systems"). Naturally they were very interested in the familiar materials and phenomena of their everyday lives. However, unlike chemists they found it very difficult to actually use molecular-level concepts to explain their familiar macro-realm. They knew that these two worlds are intimately connected but were mystified and often fascinated by those

connections. Our visitors needed help commuting from the familiar macro-realm to the molecular realm. This would be far more useful to them than the addition of big abstract themes such as *Balance* and *Order*. Consequently we let go of our original approach and switched to a framework that emphasizes building block metaphors and the formation of explicit bridges between the macro- and molecular realms.

Creating and Integrating Specific Components

We used several techniques to infuse the exhibit components with the conceptual framework. The following is a description of some of the components, to provide specific examples.

• Showing the "big picture":

Our visitors needed a "big picture" that would help them orient novel concepts in mental and physical space. The concept mapping interview which involved working out links between people, rocks, cells, molecules and atoms helped visitors place chemistry concepts in a broader context. Visitors responded very well to this activity, exclaiming, "You should make this into an exhibit," "These are all the pieces I couldn't fit together!," and "I wish someone would have showed me it this way." The exhibit includes a large, sculptural dome with three entries representing a familiar natural living, natural nonliving, and synthetic entity. The *people* passage progresses through body systems, organs, groups of cells, a cell, groups of molecules, and a molecule before finally reaching an atom. Each passage has an appropriate progression ending with an atom. Portions (and adaptations) of this "map" appear in many forms throughout the exhibit.

• Linking familiar concepts, abstract concepts, and real experiences:

A trio of components addresses the water cycle. One of the components allows visitors to construct a large puzzle-like model which uses familiar phenomena (ocean, rain, animals) to discuss evaporation and condensation in the water cycle. Another component explains that water is made of molecules. The activity enables visitors to explore how the movement of the molecules causes water to change from a gas to a liquid. A third component allows visitors to use a video microscope to explore Brownian motion. There is an attempt throughout the exhibit to connect concepts and place them in a meaningful context.

• Building visitors' visual and kinesthetic imagery:

Visitors have a vast repertoire of experiences and images relating to phenomena in the macro-realm. This makes it easier for them to construct conceptual frameworks involving these things. In contrast they lack mental images of abstract molecular-level phenomena. The exhibit provides many opportunities for visitors to see and manipulate two- and three-dimensional models representing atoms and molecules. This may make it easier for

visitors to use such concepts as explanatory tools or to link those concepts with the macro-realm.

Conclusions

It is important to consider the ways in which visitors' conceptual frameworks bear upon their interpretation of an exhibit and may be altered through interaction with an exhibit. It is equally important that developers see a subject matter from an array of unexpected viewpoints and be able to explore and revise their own framework through interaction with visitors. Evaluation can be a process by which visitors and developers "negotiate" a mutually-meaningful conceptual framework that can be translated into an effective organizing framework for an exhibit's content.

References

Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind.* Chicago: University of Chicago Press.

Novak, J.D., & Gowin, D. B. (1984). *Learning how to learn.* New York: Cambridge University Press.

Additional Reading

McManus, P. (1988). Do you get my meaning? Perception, ambiguity and the museum visitor. *ILVS Review: A Journal of Visitor Behavior, 1*(1).

Resnick, L. B., & Klopfer, L. E. (1989). Toward the thinking curriculum: An overview. *Toward the thinking curriculum: Current cognitive research.* Association for Supervision and Curriculum Development.

Figure 1
Visitors' Drawing of an Atom

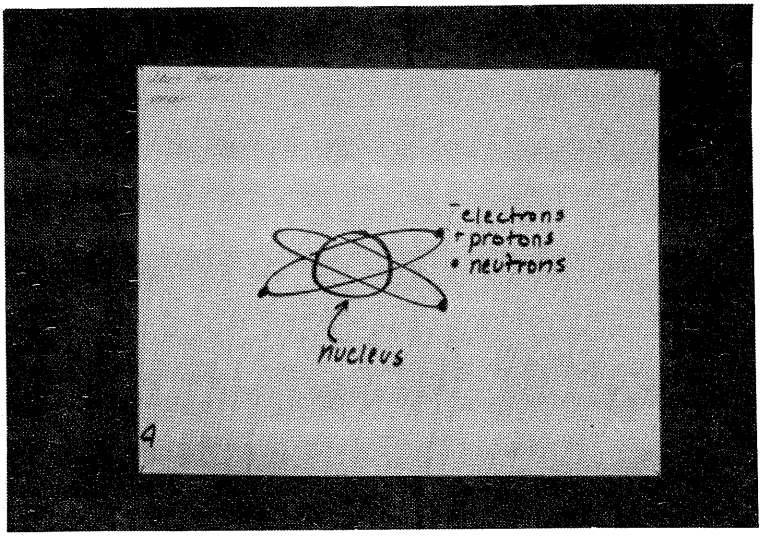

Figure 2
Visitors' Drawing of Molecules in Chemical Reaction

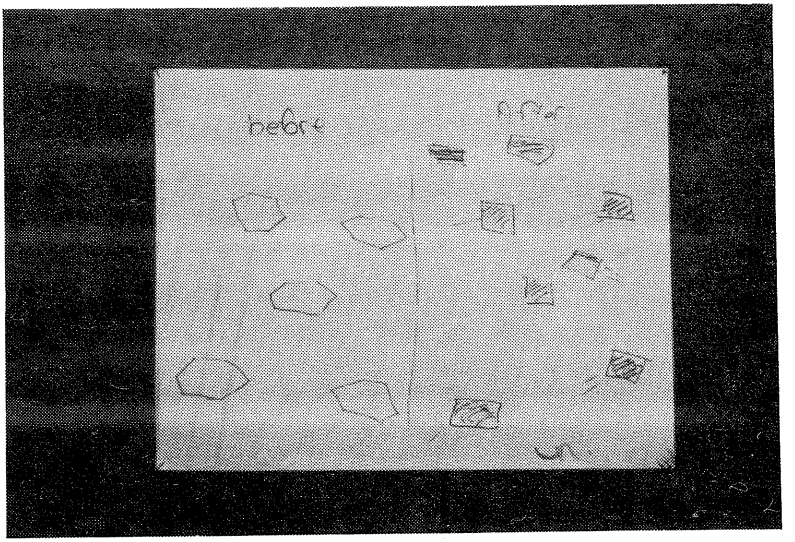

Figure 3
Visitors' Categorization
(Visitors' Headings)

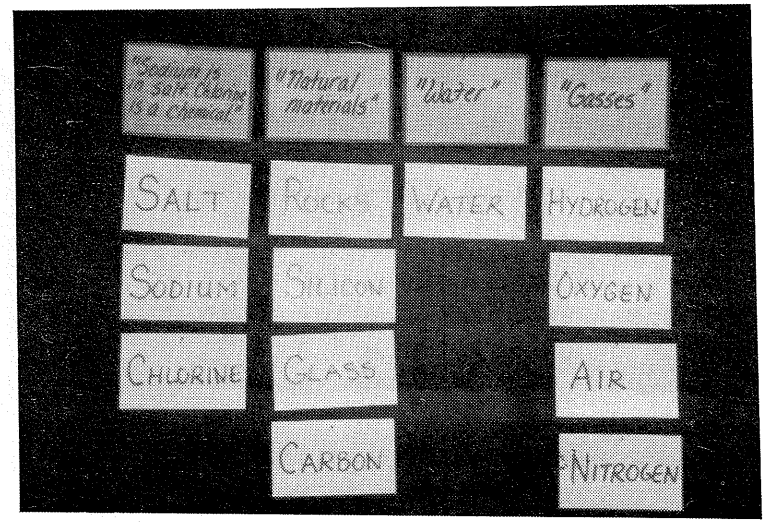

Figure 4
Visitors' Categorization
(Headings Provided)

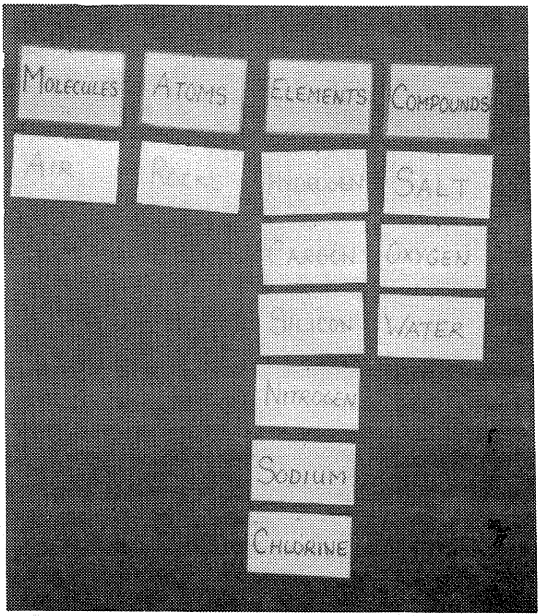

Figure 5
Visitors' Concept Map

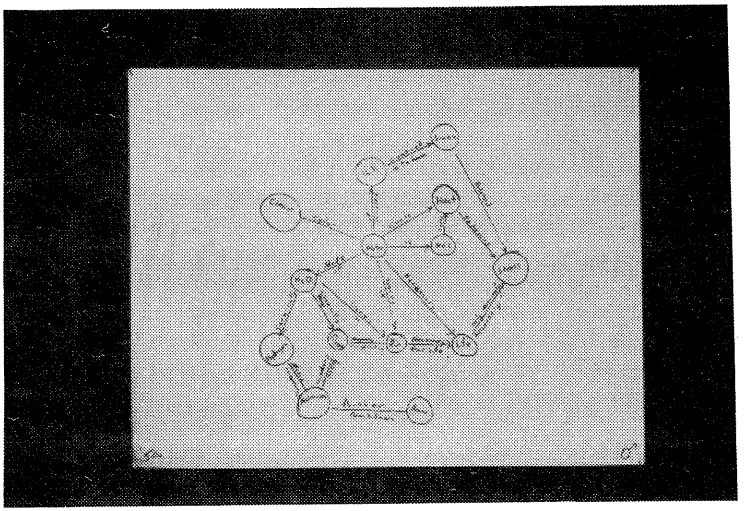

Figure 6
Visitors' Concept Map