DOCUMENT RESUME

ED 370 781 SE 054 394

AUTHOR	Zuckerman, June Trop
TITLE	Attributes Heeded When Representing an Osmosis Problem.
PUB DATE	Apr 94
NOTE	18p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 1994).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Classroom Research; *Concept Formation; Constructivism (Learning); Diffusion (Physics); High Schools; High School Students; *Problem Solving; *Schemata (Cognition); *Science Instruction; Scientific Concepts; Secondary School Science
IDENTIFIERS	*Osmosis

ABSTRACT

Eighteen high school science students were involved in a study to determine what attributes in the problem statement they need when representing a typical osmosis problem. In order to realize this goal students were asked to solve problems aloud and to explain their answers. Included as a part of the results are the attributes that the students used to solve osmosis problems. The author hopes that this information can be used by teachers to guide students to construct more appropriate osmotic schemas. (ZWH)

Attributes Heeded When Representing an Osmosis Problem

June Trop Zuckerman

Department of Secondary Education

The State University of New York at New Paltz

Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, April, 1994

ATTRIBUTES HEEDED WHEN REPRESENTING AN OSMOSIS PROBLEM

How do high school science students represent an osmosis problem? To represent a problem is to construct an understanding of what that problem is about. The representation then drives the rest of the solving process. I wanted to know what attributes in the problem statement high school science students heeded when representing a typical osmosis problem.

Solvers begin by making a gross analysis of a problem statement. Then they classify the problem to access a schema, i.e., their own knowledge structure for that type of problem. The schema enables them to heed and make inferences about the information in the problem statement and thereby to represent the problem (Chi, Feltovich, & Glaser, 1981). This paper is about the attributes 18 high school science students heeded when representing a problem about a typical osmometer-like system (see Figure 1).

Insert Figure 1 about here

Many biology texts display an osmometer to exemplify the essential attributes of an osmotic system: the concentration gradient, selectively permeable membrane, and net movement of water (Friedler, Amir, & Tamir, 1987). Students, however, may heed other attributes. By identifying the attributes they heeded, I hoped to shed light on their osmotic schemas.

The Data

To ensure that the solvers had studied osmosis, I selected students who had already completed several science courses, including biology. In individual interviews, I asked 18 solvers to think aloud as they solved the problem. Immediately afterward, I asked them to explain their solvings.

I used records of their solvings and retrospective reports to note the attributes they heeded when rationalizing the movement of water. Accordingly, I classified their representations as either osmotic or nonosmotic. A representation was osmotic if the solver (a) predicted that water would move into the funnel and (b) attributed that movement to either the concentration gradient or membrane permeability. Otherwise it was nonosmotic.

The Representations

Each of the 18 solvers constructed a representation of the problem. Eleven of the representations were osmotic; 7, nonosmotic.

The Osmotic Representations

Of the 11 solvers who constructed an osmotic representation, 7 heeded just the concentration gradient and/or membrane permeability when rationalizing the movement of water. (See Table 1.)

Insert Table 1 about here

The other four, however, seemed to heed some inappropriate attributes as well. For example, Suzie and Dana seemed to heed differences in the amounts as well as the concentrations of water across the membrane. From Suzie's solving:

> There is less uhm water molecules in the sugar solution and more water molecules in the pure water tank. So water will want to move from high pressure grad-- uh from the high concentration, which is in the pure water, to the low concentration, which is in the sugar solution.... At equilibrium... uhm you're getting quite close to uh the num-- the number of water molecules in the pure water equalling the number of water molecules in the solution.

Likewise Gil seemed to heed the air pressure as well as the concentration gradient and membrane permeability:

> It [the solution level] would only go up a certain amount because there's air pressure in the top of the tube pushing down on the solution in the tube and as well as the air pressure pushing down on the water in the beaker.

Gil apparently saw the air pressure as limiting the extent of osmosis.

The Nonosmotic Representations

Seven of the 18 solvers, however, ignored both the concentration gradient and membrane permeability entirely. Instead they heeded either an air pressure "difference," the difference in the levels of the two liquids, the membrane as a "filter," or the "displacement" of the water in the beaker. (See Table 2.)

Insert Table 2 about here

Air pressure "difference". Ron and Cal thought the problem was about air pressure. Unlike Gil, they believed that the air pressure difference would actually force water into the funnel. From Cal's solving: "Air pressure on top of the water pushes it down. So that's going to cause a force to push water back up through the tube."

Later Cal explained: "Because the surface area of the water in the beaker is greater than the surface area of the water [solution] through the tube, there's more air providing pressure on the surface of the water than inside the tube."

Levels of the two liquids. On the other hand, Jay, Rich, and Ted thought the problem was about equalizing the levels of the water and sugar solution. Jay, however, predicted no change despite the different levels. He imagined the sugar solution as a single substance that could not permeate the membrane. "[Since] the membrane is only water soluble [permeable], that sugar solution... will not be released from it unless there's a leak."

On the other hand, Rich and Ted predicted that water from the solution would flow into the beaker. Rich explained that gravity would force the flow:

> Since the water level is lower than the level of the solution, the gravity would probably, to make the two reach equilibrium, the water in the

solution would come out the membrane, and therefore, the level of the solution would decrease, and the water level would increase up to a certain point.

The "filtration" of the solution. Vic also predicted that water would flow into the beaker. He, however, confused osmosis with filtration. He thought the membrane would filter the solution:

> I remember seeing a James Bond movie where they took cocaine that was in the gasoline, and they strained it, and you couldn't even see it, and once you strained it, there was the cocaine. That's not osmosis though; that's straining. That's not... it can't be-- it HAS to [be] osmosis. It has to osmose out.... All right. I believe that it [water in the solution] will. Yeah, because I remember studying that osmosis stuff.

"Displacement" of the water. Finally, Tom, thinking the problem was about water displacement, predicted that the solution level would rise. He reasoned that gravity would force water into the funnel so as to return the level in the beaker to its height before the funnel had been inserted:

When the uh funnel was put into the water, it most likely caused a level increase in the water in the uh beaker. So that means that the water's been displaced more because of the insertion of the, of the funnel.... So the water, uh due to the pressure that'd be put on by gravity, would be forcing itself up into the diluted sugar solution.

Implications

Eighteen high school science students constructed a representation of a typical osmosis problem. Eleven of the 18 seemed to understand that the problem was about osmosis. That is, they used a schema that included essential attributes of an osmotic system. Four of the 11, however, also seemed to include inappropriate attributes. Specifically, they seemed to confuse the amount with the concentration of water or the air pressure with the osmotic pressure.

The other seven solvers, however, did not even realize what the problem was about. They were, in effect, solving a different problem. Although (a) the problem under study featured a typical osmotic system and (b) the word osmosis appeared in both the title and problem statement, they did not use an osmotic schema. These seven students, notwithstanding several years of high school science, did not seem to have an osmotic schema.

This study is significant because it shows teachers the attributes their students may be heeding when solving a typical osmosis problem. In fact, their students may be heeding attributes that have nothing to do with osmosis. Instead of the concentration gradient and/or membrane permeability, they may be heeding relative differences in the amounts of water, the levels of the liquids, or the air pressure. They may be imagining that the membrane acts like a filter or that the water, after having been displaced, must recede. Perhaps teachers can use the results of this study to guide their students to construct more appropriate osmotic schemas.

Conclusion

Problem solving is a useful instructional strategy (Pizzini, Shepardson, & Abell, 1989). In fact, it may be especially useful for the complex phenomena that students ordinarily fail to recognize in their everyday experience. Osmosis is such a phenomenon.

In particular, I recommend the problem under study because students construct such varied representations of it. By providing opportunities for students to present and defend their representations, teachers may generate the conceptual dissonance that can promote conceptual change (Strike & Posner, 1992).

Acknowledgment

I am grateful to Andrew J. Mackie for collecting and transforming some of the data for this study.

References

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. Cognitive Science, 5, 121-152.

Friedler, Y., Amir, R., & Tamir, P. (1987). High school students' difficulties in understanding osmosis. International Journal of Science Education, 9(5), 541-551.

Pizzini, E. L., Shepardson, D. P., & Abell, S. K. (1989). A rationale for and the development of a problem solving model of instruction in science education. Science Education, 73(5), 523-534.

Strike, K. A. & Posner, G. J. (1992). A revisionist theory of conceptual change. In R. A. Duschl & R. J. Hamilton (Eds.), Philosophy of science, cognitive psychology, and educational theory and practice (pp. 147-176), Albany, NY: SUNY.

Appendix

Insert Figure 2 about here

Table 1

Attributes Heeded by Solvers with an Osmotic Representation

	Attributes			
	Appropriate		Inappropriate	
Solvers	conc grad	memb perm	water amts	air press
Robert	X	X		
Joe	X	X		
Mike	X			
Eric	X			
Rachel	X			
Wendy	X			
Carl	X			
Suzie	X		X	
Dana	X	X	X	
Niki		X	X	
Gil	X	X		X

Note. The four attributes are the concentration gradient, membrane permeability, amounts of water across the membrane, and air pressures across the membrane.

Table 2

Attributes Heeded by Solvers with a Nonosmotic Representation

	Attributes			
Solvers	air press	liquid levels	memb filter	water displacement
Ron	X			
Cal	X			
Jay		X		
Rich		X		
Ted		X		
Vic			X	
Tom				X

Note. The four attributes are the air pressure, levels of the liquids, membrane as a filter, and displacement of the water.

Figure Captions

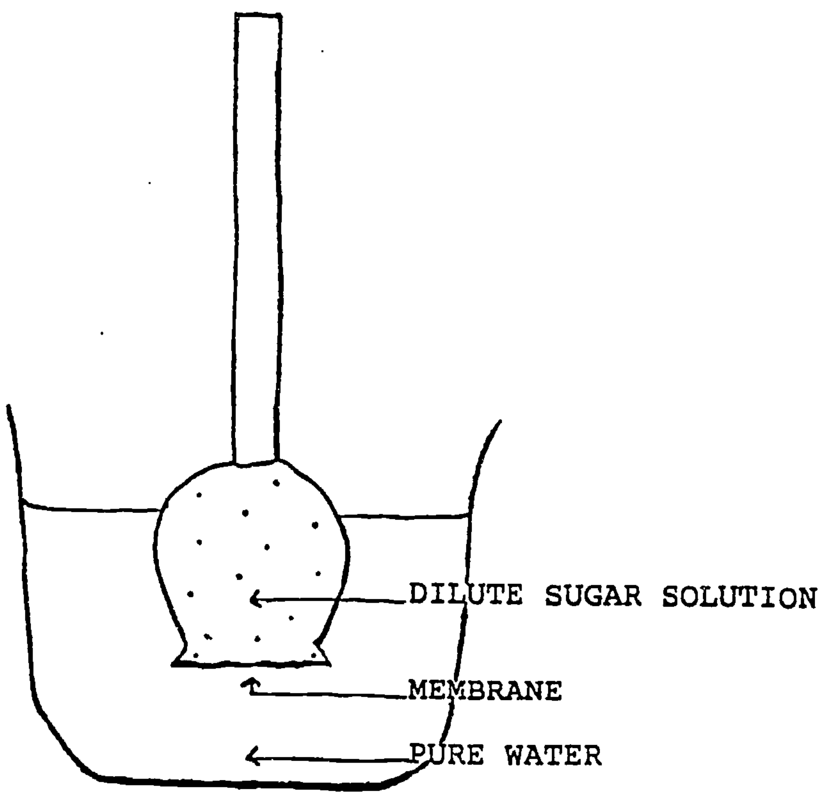
Figure 1. Statement of the problem.

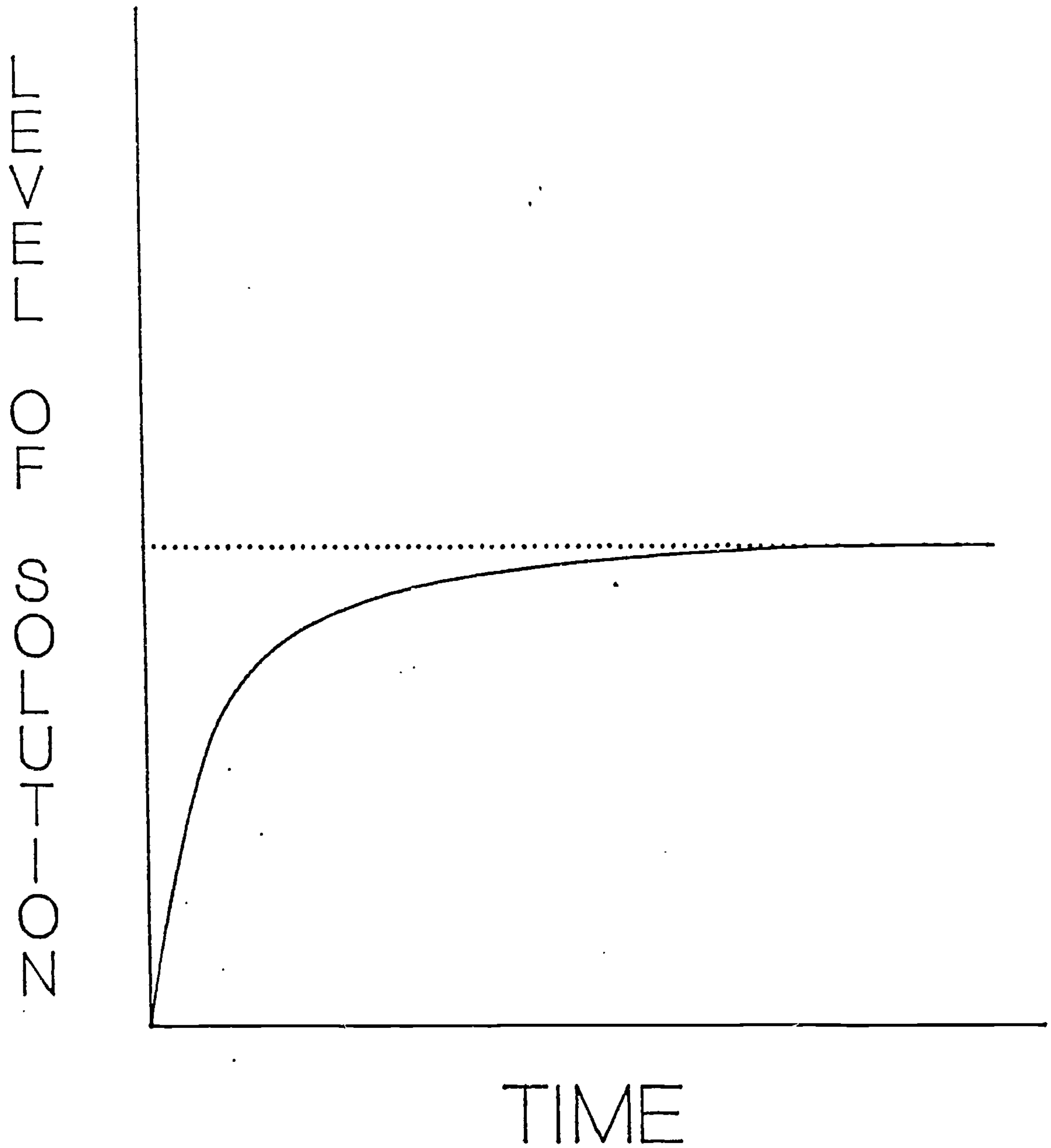
Figure 2. Answer to the problem.

A Problem about Osmosis

The figure below is a diagram of an inverted thistle top funnel which can be used to demonstrate osmosis. At the beginning of an experiment there is a dilute solution of sugar and water inside the funnel. An inelastic membrane permeable only to water has been fitted across the immersed funnel opening. The funnel is surrounded by pure water.

Make a graph to show how the solution level in the stem of the funnel changes with time.




LEVEL OF SOLUTION
TIME