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THE USE OF HYPERCARD IN DEVELOPING COMMON KNOWLEDGE: AN EXAMPLE IN CHEMISTRY

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INTRODUCTION

Current research on human learning and current knowledge about the processes that humans use to construct new knowledge have resulted in much "problem oriented" study of student conceptions (Driver & Erickson, 1983; Gilbert & Watts, 1983). The instructional strategies that have taken students' conceptions into consideration are known as "constructivist approaches to teaching," a translation of a constructivist perspective of learning to science education (Driver & Bell, 1986; Novak, 1988). These strategies aim at what is often called "conceptual change teaching," generally rooted in constructivist frameworks (West & Pines, 1985).

The related premises of a constructivist world view of learning are: (a) the child constructs personal knowledge of the physical world and this knowledge characterizes multiple meanings; (b) the child uses personal knowledge to construct the culturally-shaped and shared precepts and intentions; and (c) the child's personal knowledge acquires a social character via interpersonal negotiation of meanings. These principles of learning promote the view that in the science class we must attempt to achieve shared or common meanings by incorporating children's conceptions into science curriculum.

This paper will indicate a way of helping students to achieve "common knowledge" in solution chemistry using Hypercard. Common knowledge is the school science knowledge that becomes established as a part of the student's understanding through different instructional strategies. Common knowledge then becomes the contextual basis for further communication and learning of the discipline. This paper reveals the importance of establishing at first a common knowledge and understanding between the teacher and students for meaningful communication to take place. In order to develop an argument for fostering common knowledge through Hypercard (a possible teaching environment) in the area of solution chemistry, at the outset I will describe a collaborative study that I carried out with a chemistry teacher in my doctoral program at the University of British Columbia between 1987-1991. Next I will outline how Hypercard can be incorporated into a unit on solution chemistry that involves traditional "conceptual change" strategies as well.

TOWARDS HYPERCARD TEACHING ENVIRONMENT

My doctoral study, within a constructivist research genre, involved eliciting and categorizing students' conceptions of solubility, incorporating these into a teaching unit on solution chemistry, reflectively examining instructional procedures, analyzing students' conceptions after instruction, relating these to their prior knowledge of solution chemistry, and finally, assessing the influence of instruction.

Thirteen Grade 11 chemistry students participated in the pre- and post-instructional clinical interviews. The interviews consisted of gathering information on students' understanding of three chemical systems: System A: Sugar/Water; System B: Water/Alcohol/Paint Thinner; and System C: Salt/Water. The data were categorized using a phenomenographic research technique which provided a way to find, interpret, systematize, and describe the qualitatively different ways in which individuals experience and understand their reality (Marton, 1981). The study followed through a complete research cycle on constructivist science teaching. Consequently, the study presented a "phenomenography" (Marton, 1981) of solubility, narrated a story about classroom instruction which took students' conceptions into consideration, and reported four case studies on students' conceptual growth and changes (Ebenezer, 1991).

It was argued that the newly acquired conceptions of solubility reflected insufficient explanatory power and were merely overlaid with the chemical language. Learning the language of solution chemistry was reflected in the change between pre- and post-instructional conceptions. Hence it was argued that in order to help students to have a deeper understanding of the chemical concepts, to link microscopic explanations of chemical systems to their macroscopic observations, as well as to work in both these levels simultaneously and comfortably, appropriate teaching strategies have to be identified and assessed in the context of chemistry classrooms. This prompted me to survey the literature on using computers within a constructivist framework. Researchers such as DiSessa (1988), White and Horwitz (1988), and Zietsman and Hewson (1986) have developed "microworlds" to explore and incorporate children's ideas in science instruction. These authors see the computer as providing a context in which students can put to use what they already know in developing new ideas. The foregoing claims directed my attention to look at Hypercard as a way to develop common knowledge in the area of solution chemistry.

In the following sub-sections I will trace the roots for developing Hypercard stacks in solution chemistry. This will involve an interpretive account of students' conceptions of solubility in terms of System A (sugar in water); a brief account of solution chemistry instruction that attempted to incorporate students' conceptions of solubility; and a case study of how instruction influenced a student's preconceptions.

Students' Pre-Instructional Conceptions of Solubility

Considering the three systems together, the outcome space for solubility consisted of six qualitatively different conceptions. The outcome space for Systems A, B, and C was comprised of two, four, and five qualitatively different conceptions respectively. The frequency distribution for these conceptions of solubility for Systems A, B, and C are presented in Table 1.

Table 1: Frequency Distribution for Pre-Instructional Outcome Space of Solubility for Systems (n = 13)

Categories of Description	Frequency		
	A sugar/ water	B water/ alcohol/water paint thinner	C salt/
physical transformation from solid to liquid	10	-	4
chemical transformation of solute	5	-	1
density of solute	-	8	3
amount of space in solution	-	1	3
size of solute	-	1	-
property of solute	-	4	3

In this paper I will examine only the first two categories in an attempt to develop arguments for using Hypercard. For the first two categories of description, illustrative excerpt(s) of the interview dialogue are included. In the excerpts, "R" stands for the researcher and "S" stands for the student. The students are given pseudonyms. An outline of the descriptive categories for the concept of solubility of sugar in water follows:

1. <u>Physical Transformation from Solid to Liquid</u>

Many students viewed dissolving as a process of a solid transforming into a liquid form. Some students called this process "melting". Two sub-categories of this basic conception were identified as students spoke about the transformation of a substance from the solid state into its liquid state. These can be characterized by: (a) a continuous view of the "liquid state", and (b) a particle view of the "liquid state". Consider the following excerpt for the first sub-category, "a continuous view of the liquid state":

Shamila (1) [sugar/water]

> R:I am going to drop a cube of sugar. See what happens.
> S:Is it hot water?
> R:Yes, it is. Could you describe what might be happening?
> S:There are bubbles going up and sugar cube is melting. The sugar is going. It is melting practically. It is no longer a cube.
> R:What do you mean by melting?
> S:It dissolved. It was a cube. When you dropped it in the water and like you see it, it is falling apart. I think hot water is making it softer. It will be more stickier. Yeah, it will stick. Sugar melted somewhat like a syrup. That's what I think.

The foregoing excerpt is illustrative of students who had the notion that the solute (sugar or salt) when added to water melts and becomes a liquid. Students subscribing to this notion appear to have a "continuous liquid state" conceptualization. This view was not surprising because an analysis of the historical developments of matter reveals that the early scientists conceived matter to be "continuous" or "homogeneous".

Shamila found it logical to think of the process of dissolving in terms of melting--the solid becoming a liquid--because she did not see the solid sugar any more. She saw a liquid in the beaker. From experience, she knows that the water will taste sweet because of the dissolved sugar. To her it seemed reasonable to state that solid sugar had been converted into its liquid form. Shamila, also, talked about hot water making solid sugar soft and sugar turning into a syrup, a liquid state. What is interesting here is how Shamila brought her everyday talk to a chemical system. For example, when a piece of candy is sucked, often children say that it is melting in the mouth. The candy becomes syrupy and sticky inside the mouth. Similarly when sugar was put into hot water, several students stated that the sugar is melting.

When sugar dissolves in water, it is clear that the resulting solution is in liquid form. Often students seemed to be confused between the liquid-solution state and the liquid state, such as wax or ice melting. When a solid melts one can see the change in state by the resulting liquid. However, when solid sugar is added to water, the state change does not occur. But Shamila seemed to think that there is a change of state from a solid state to the liquid state.

Therefore, it can be argued that a confusion exists in Shamila's mind between a true liquid state and a liquid-solution state.

Some students stepped into the microscopic world in order to explain the process of dissolving as melting or a solid turning into a liquid. They used terms such as atoms, molecules, and particles. Nila's responses to the sugar/water and salt/water systems illustrate this conceptualization:

Nila (2) [sugar/water]

> R:I have hot water here. I am going to add a cube of sugar. Could you tell me what is happening?
>
> S:It's combining with water. It is mixing. It's not like it started out with the solid. But the molecules are tightly packed together and when you mix it with the water, it mixes with water. Then when they are moving freely but not really becoming like a gas, really spaced out, it is in a different state. ... They are all just mixing together in the liquid state.

Nila distinguished the molecular arrangement in solid, liquid, and gas. She noted that in a solid, molecules are tightly packed; in a liquid, molecules are moving freely, and in a gas the molecules are really spaced out. Nila considered that molecules of sugar are in movement when sugar is added to water. Therefore, she argued that sugar becomes a liquid.

2. <u>Chemical Transformation of Solute</u>

Some students had the notion that when sugar is added to water some type of chemical reaction or combination is taking place. At least half the class gave the idea that dissolving is a process of combining two or more substances. The task was to find out what these students meant by "combining." How do students picture this combination? Although, students gave slightly different versions for describing the nature of chemical transformation, this conceptualization will be presented with an example of how Gary pictured sugar "reacting" with water:

Gary (3) [sugar/water]

> R:This is hot water direct from the tap. I am

introducing a cube of sugar. Can you tell me what is happening to the sugar?

S:It is dissolving in the water. Eventually it will be all gone.

R:What do you mean by dissolving?

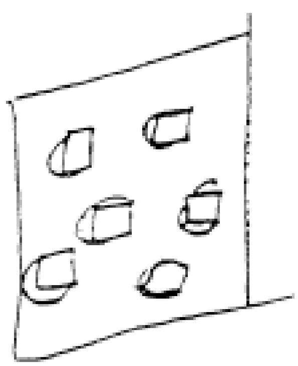
S:It will react with water and join with it. Going to the molecules of air that are empty.

R:Sugar reacts with water and it fills the air spaces. How do you picture that?

S:Because there is air in the water and sugar takes this place.

R:Could you draw that for me? I'd like to see it.

S:(Draws).



R:You think granules of sugar settle inside the air spaces in water?

S:Mmm.

R:What would you call this whole thing?

S:Solution.

R:Can you give me another example of solution?

S:Salt and water.

R:Same thing happens to salt and water?

S:Basically, yeah. I think.

R:Can you give other examples of solution?

S:Like water--oxygen and hydrogen.

Gary proposed the notion that there are small pockets in water which was once occupied by air and sugar drives these out and occupies these empty spaces. Using a diagram Gary showed how the combination takes place. Finally, Gary concluded that water is also a solution because oxygen and hydrogen are combined.

In some of my earlier work I have observed that other students also consider water to be a solution. When one of these students was asked to explain which is the solvent and which is the solute in water, he suggested that hydrogen is the solvent because water has two parts of hydrogen and oxygen is the solute because water has one part of oxygen, which suggests the view that the solvent must be present in greater quantity.

Solution Chemistry Instruction: Teacher-Researcher Collaboration

The teacher/researcher collaboration journey on teaching and learning of solution chemistry began when Jane (the teacher) invited the researcher to "model" a constructivist approach by teaching solution chemistry in her class. In response to Jane's invitation, an attempt was made to try out some of the constructivist strategies to teach solution chemistry. At the outset it must be mentioned that the researcher makes no claim in being an expert constructivist practitioner. Although she has had the opportunity to examine extensively the literature on constructivist teaching and learning, this is the first time she has had a chance to put that knowledge into practice in a secondary chemistry class.

The first three lessons were taught by the researcher. The rest of solution chemistry was taught by the teacher. On the first day of the solution chemistry unit, in accordance with the first two components of Driver's instructional model, that is, "orientation, and elicitation," two learning experiences were provided to orient and elicit students' prior knowledge of solution chemistry. The first activity consisted of students drinking Orange Crush to orient them to solution chemistry (a motivational activity). The second activity consisted of adding a cube of sugar to hot water, which focused on the solution process. With the second activity, the students worked in groups of five students. The students were expected to describe what might be happening to the sugar when it was added to water. The students were given plenty of time to share their ideas about solutions in small groups. Then the students shared their ideas in the large group. In lesson two, students' alternative conceptions formed the content of teaching rather than what was outlined in the curriculum guide. One of the alternate conceptions that we examined was: "chemical transformation of solute" which will be referred to in the section under "the problems posed by the discipline of chemistry in chemistry teaching. The third lesson was a review lesson and it consisted of representing students' understandings of solutions on a heuristic tool called a "Vee diagram" (Ebenezer, 1992; Novak and Gowin, 1984).

Jane taught five lessons: (a) incorporating students' ideas about melting and dissolving using a diagrammatic representation of sodium chloride dissolving in water; (b) preparation for a laboratory session on polar and non-polar solutes and solvents; (c) students doing the lab in groups of two or three; (d) post-lab discussion, and "concept attainment" (Joyce and Weil, 1986) on polar or non-polar, in a large group format; (e) review--teams, games and tournament (Joyce and Weil, 1986) in groups of four; and (f) final test.

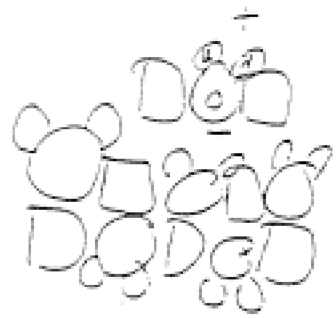
Gary's Post-Instructional Conception of Solubility: A Case Study

At the end of the unit, soon after the exam, the same thirteen students participated in the interview. The same demonstrations were used. Each interview took about 30-45 minutes. Questions were asked for in-depth learning. Have the students' conceptions changed, and if so, in what ways? Links were also made in terms of pre- and post-conceptions. Four case studies were done. In this paper I will use Gary's (fictitious name) case study to examine what sorts of conceptual change has taken place.

<u>Combination of solute and solvent</u>: Viewing the sugar/water system, Gary said that sugar and water are combining. Consider the following excerpt from the post-instructional interview:

Gary (4) [sugar/water]

R: What do you mean by dissolving?
S: The sugar is combining.
R: With what does sugar combine? How does it combine?
S: They come together.
R: Would you draw a picture to show how they combine?
S: I don't know how sugar looks like. (Draws)



R: Does each of the grains of sugar looks like one of these (pointing to the above diagram) in the microscopic view?

S: Sure.

Gary probably tried to represent each grain of sugar in the cubic form, but he drew squares. This may be because of the big cube of sugar that was immersed in water. Each sugar grain is magnified and drawn separately. Gary's diagram indicated the invasion of the sugar molecules by the water molecules. For the same system, in the pre-instructional interview, Gary argued, ``sugar goes to the molecules of air that are empty and then reacts with water.'' Compare Gary's post-instructional interview diagrams (above) with the pre-instructional interview diagrams in pre-instructional excerpt 3. However, after instruction, as indicated by the diagram, sugar ``combining'' or ``joining'' with water took a different meaning--sugar in solvated form--for Gary.

From Gary's post-instructional interview, it is evident that instruction has provided him new ways of thinking about solubility. It is also clear that instruction has mainly helped him in developing the language of solution chemistry. For Gary, learning the language of solution chemistry and acquiring some theoretical understanding of it reflect the change as evolutionary from pre-to post-instructional conceptions. This was the case with those students who participated in the study. The students' evolutionary conceptions were mixed with confusions. Why might this be the case? We will explore this issue further in terms of dissolution of sugar in water.

The dissolution of sugar in water or salt in water do not indicate any outward appearance of an ordinary chemical change. In the ordinary sense solutions of sugar and salt in water is said to be a physical change because the components can be separated by simple physical means such as evaporation.

In another sense, salt dissolving in water is also characterized as a chemical phenomenon. For example, the behaviour of salt solution is different from the way crystalline salt behaves. Unlike salt in the solid form, salt solution conducts electricity because salt separates into two new electro-chemical species. Thus the concept of dissolving poses difficulty for students because of its dual behaviour--a chemical process as well as one which does not show any outward appearance of chemical changes. In order to understand the chemical process of dissolution, students must operate in the microscopic and the symbolic worlds and these might induce complex learning difficulties.

Chemical concepts, chemical knowledge and understanding can be elaborated, differentiated, and articulated precisely only if the student becomes conversant with the chemists' language which characterizes microscopic and the symbolic worlds. Only when students are shown how to perceive chemical phenomena in the appropriate manner (based upon the structure of the discipline and the related language) does the meaning become clear (Brauner, 1985). For these two reasons, I think teaching chemistry in Hypercard environment will be useful. However, Hypercard should be introduced appropriately. While the students interact with a Hypercard activity, the teacher must interact with students in developing their ideas about chemical concepts that are presented in the Hypercard. In the next section I will present how chemistry teachers can develop common knowledge starting from students' point of view.

DEVELOPING COMMON KNOWLEDGE IN SOLUTION CHEMISTRY

Instructional Objectives based on Students' Conceptions

An examination of Table 1 reveals that most of the students had the notion that sugar in the water environment undergoes a process of melting. Some of the students also expressed the idea that dissolving involved a process of chemical change in the ordinary sense. Therefore, students' conceptions of solubility of sugar in water gave rise to two key questions that must be addressed in a unit on solution chemistry:

1. What does the solution process involve?
   °melting and/or dissolving?
2. Is dissolving a physical change, a chemical change, or chemical phenomenon?

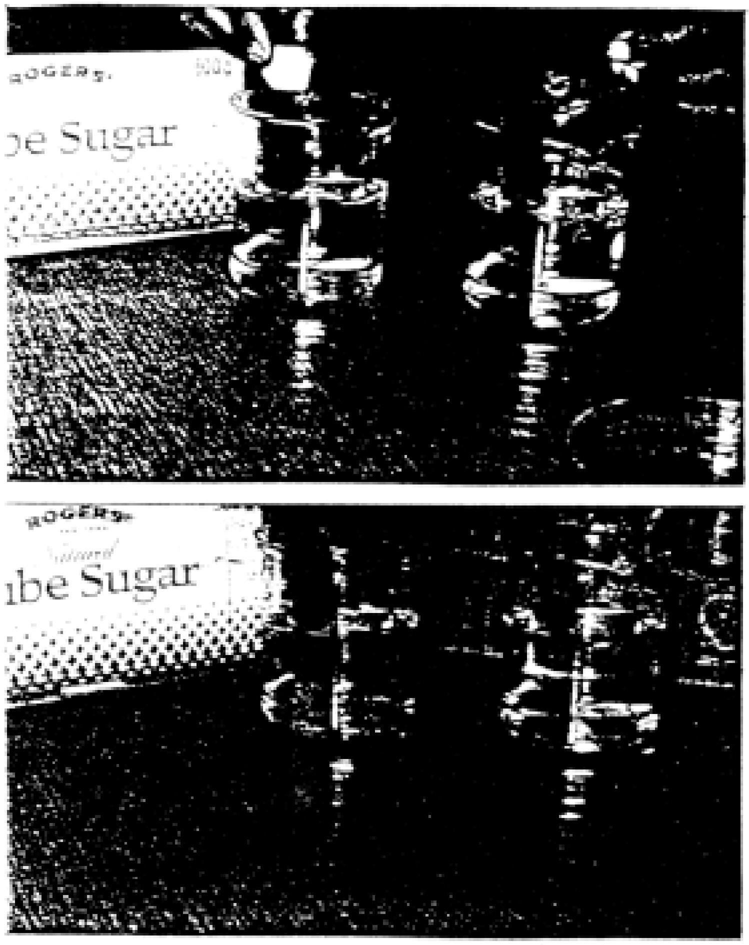
Based on students' conceptions of solubility of sugar in water, the objectives for a unit on solution chemistry are:

1. to help students distinguish between the processes of melting and dissolving
2. to help students understand the types of changes that occur in the process of dissolution

What Does the Solution Process Involve: Melting or Dissolving?

Because we used sugar and salt to elicit students' conceptions of solubility, it is only reasonable to heat these substances to explain the process of melting. Unfortunately, the process of melting cannot be adequately shown with sugar or salt. The melting point of sugar is not readily observable--When sugar is heated; instantaneously it changes from a solid state to a liquid state, forming new substances. Therefore the process that sugar undergoes when heated cannot be called melting because the school chemistry definition for melting is: "the change of a solid to a liquid without the formation of any new kind of matter." The melting of table salt cannot be shown in the laboratory because its melting point is 800^{o}C. Therefore, instead of simply defining what melting is the students may be asked to propose a working theory for melting by heating the following substances: ice, snow, wax, moth flakes, sugar, and salt (Activity 1). At the end of Activity 1, the students may have some ideas about melting. Now if sugar is added to water, the students may conclude that something else is happening to the sugar. This process may be used to cause dissatisfaction with the existing conception that sugar melts in water.

To help students restructure their understanding about the solution process, Activity 2 (see Figure 1) may be carried out: Label two identical beakers A, and B. Pour an equivalent amount of warm water to each of the beakers. To beaker A, add a cube of sugar, to Beaker B, add an ice cube. After 10 minutes each of the stuff would have disappeared in water. Have students answer the following question: Which beaker contains a solution? Have students justify their answer. This problem is sensory-based and it exposes the students to conflict situations. Thus the difference between melting and dissolving may become intelligible to the students.



A cube of sugar in water   A cube of ice in water

Figure 1: Sugar cube in water and ice cube in water--To examine the conceptions "sugar is becoming a liquid or sugar is melting.

The difference between melting and dissolving may become <u>plausible</u> to the students when this difference can be established at the atomic/ionic/molecular level. At this point, a hypercard stack illustrating the macroscopic and microscopic views of the processes of melting and dissolving (see Appendix). This might help students (a) to understand the difference between melting and dissolving of solutes; and (b) to understand the solution process of sugar and salt. Card 1 shows the macroscopic view and molecular structure of ice. A description of the microscopic view of ice is as follows:

Each water molecule is surrounded by a tetrahedral arrangement of four other water molecules to which it is bound by hydrogen bonds. Each oxygen atom forms covalent bonds to two hydrogen atoms and two hydrogen bonds with hydrogen atoms of neighbouring water molecules. The structure is a three-dimensional network. It is very open structure. When ice melts, the structure collapses because the hydrogen bonds in ice are broken. The molecules of water pack more closely together and so the density of water is greater than that of ice. Thus the heat energy forces the molecules of water part to form a puddle of water.

Card 2 represents the macroscopic view of ice (solid water) forming into liquid water. Cards 3-9 represent the molecular (microscopic) views of ice melting to form a fluid (liquid water). Although the solid water and liquid water are physically different, chemically they are alike as shown in Card 1 and Cards 3-9. Similarly, the process of melting of any other solid can be explained (see Cards 10-21).

How does a solution of sugar appear to be at the molecular level? A microscopic model of sugar in water can be better understood by initially examining the macroscopic and microscopic models of the dissolution of salt in water. A sensory-based type of knowledge can be constructed by observing table salt dissolving in water to form salt-water solution (see Cards 22-36).

Macroscopically salt appears to disappear in water. To test whether or not the salt is in the "liquid state" as suggested by most of the grade eleven students, introduce a conductivity probe into the salt solution (Activity 3--see Figure 2). The students should be asked why the light bulb glows. The students usually come up with the idea of <u>charges</u>. The teacher can expand on this understanding by having students construct atomic models of sodium and chlorine with clay and wire. The teacher must carry out an interpretive discussion with the students to illustrate the formation of sodium and chloride ions.

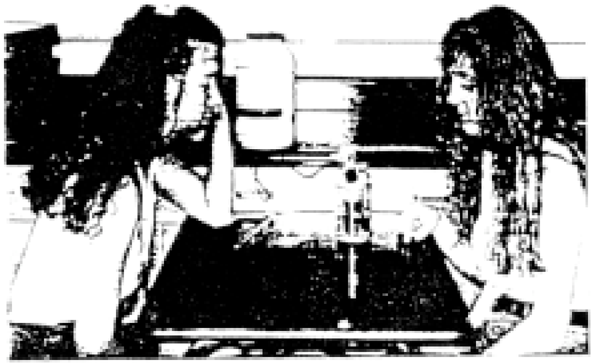


Figure 2: Salt solution conducts an electric charge.

Then the teacher should explain how salt dissociates into sodium ions and chloride ions when salt is introduced into water and how these ions become hydrated (see Cards 37-44).

At this point, solutions of other solids such as copper sulphate, lead nitrate and sodium hydroxide in water can be tested for the presence of ions by means of a conductivity probe to show students that there are many ionic compounds (Activity 4).

In summary, the process of an ionic crystal dissolving in water may be illustrated with Hypercard that indicated the following steps: (a) A small sodium chloride crystal before it dissolves in the surrounding water. (b) Ions are pulled away from the crystal by the attraction of the polar water molecules. (c) Hydrated chloride ions are formed. (d) The sodium crystal has dissolved, giving a solution of hydrated positive sodium ion and negative chloride ion.

Although the dissolution process of ionic compounds such as table salt might become fairly clear to students, this knowledge would conflict with the solution process of compounds consisting of polar covalent bonds such as sugar because sugar solution does not make the light bulb glow. To account for this discrepancy, the students should be taught that sugar is a polar covalent compound and that solids or liquids of this type do not conduct electric charge. These compounds break up into molecules rather into ions (see Cards 70-78 that indicate a possible mechanism of the solution process of sugar).

To reinforce the difference between the solution processes of ionic compounds and polar covalent compounds the following Hypercard activity may be used:

Twenty sodium chloride particles produce forty sub electro-chemical species when dissolved in water (see Card 79). Cards 80 and 81 consists of more problems of the foregoing type.

Sixteen sugar particles produce only sixteen molecules in solution (see Card 82). Similarly Card 83 indicates that five particles of sugar yields five molecules of sugar.

In summary then, at the particle level, melting may be visualized as in Figure 3 and dissolving may be visualized as Figure 4

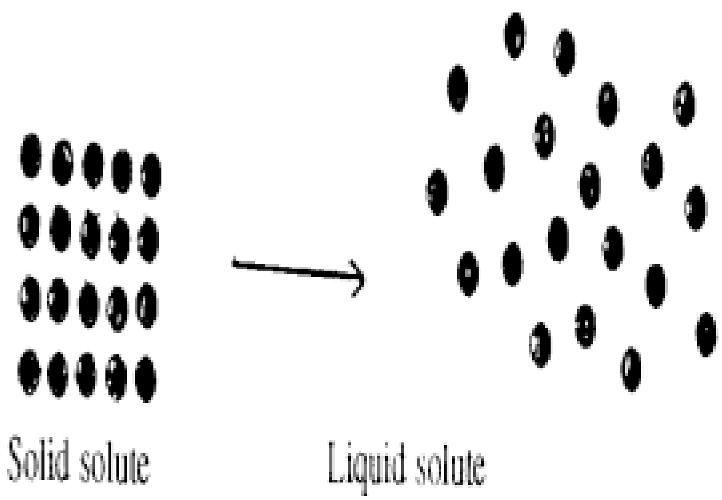
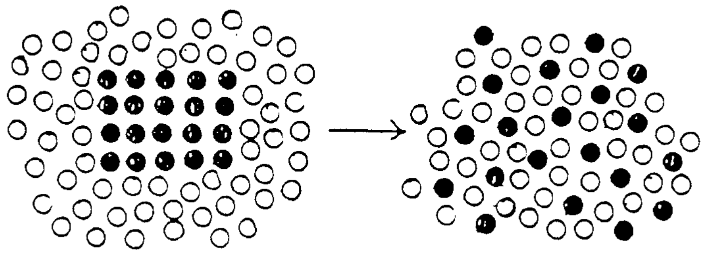


Figure 3: Solid solute transforming into liquid solute.

Solid solute Liquid solute
Figure 3: Solid solute transforming into liquid solute.



Solid solute in liquid solvent A solution

Figure 4: Solid solute in liquid solvent becoming a solution.

Solid solute in liquid solvent A solution

Figure 4: Solid solute in liquid solvent becoming a solution.

How do we symbolically represent the difference between melting and dissolving? The distinction between melting and dissolving becomes a fruitful event when the dissolving of salt is represented at the symbolic level. We may represent the dissociation of sodium chloride crystals in water by use of an ionic equation (Equation 1):

$$\mathbf{Na^{+}Cl^{-}(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)}$$

Equation 1: Dissociation of sodium chloride

Is Dissolving A Physical Change, A Chemical Change Or Chemical Phenomenon?

Some of the grade eleven students looked upon dissolving of sugar/salt in water as ordinary chemical changes. Is dissolving a physical change, a chemical change or a chemical phenomenon? How do we resolve this? Many ordinary chemical changes that take place in a solution environment may be shown. It is also important to draw students' attention to dissociation of ionic compounds as a chemical phenomenon and distinguish between an ordinary chemical change and a chemical phenomenon.

Dissolving is considered to be a physical change because upon evaporating a salt solution, salt can be regained (Activity 5--see Figure 5). The regained salt may be different from the original salt in physical appearance. However, chemically, it is still salt.

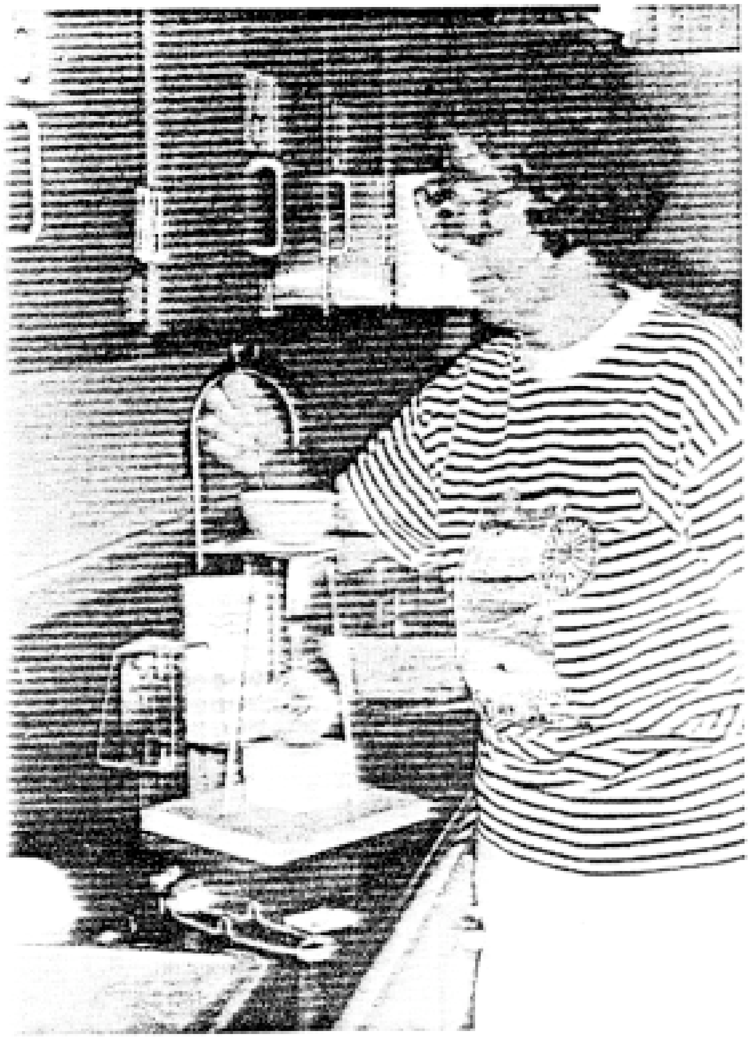


Figure 5: Evaporation of salt solution.

In an ordinary chemical change, the resulting product becomes a new substance and one cannot get the original substance back. At this point, students should be shown some chemical reactions such as sodium metal reacting with water and chemical reactions in solutions such as lead nitrate reacting with potassium iodide (teacher demonstrations).

In the case of sodium metal reacting with water, because of the hissing noise, and the accompanying flame when sodium disappears in water, the students are able to recognize that some (a tiny amount of) matter has been changed into at least two forms of energy (sound and light) as illustrated in Activity 6 (see Figure 6).

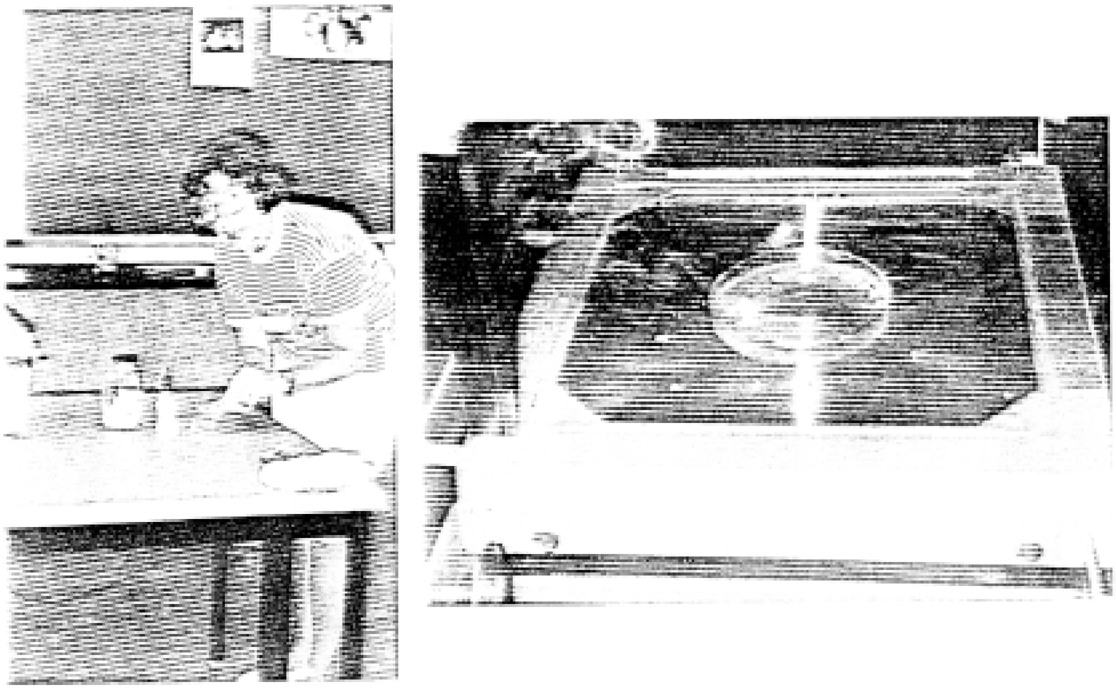


Figure 6: Sodium disappearing in water.

Figure 6: Sodium disappearing in water.

The students also figure out that bubble formation is due to the evolution of a gas. When a drop of phenolphthalein indicator is added to the resulting solution, the indicator turns pink showing that the solution is now alkaline. For these reasons, the students are able to identify that sodium entering into water environment produces a chemical reaction. This reaction can be represented by Equation 2:

$$\mathbf{2Na_{(s)} + 2H_20_{(1)} \;->\; 2NaOH + H_2}$$

Equation 2: Sodium reacting with water.

In the case of lead nitrate and potassium iodide, chemical reaction is evident because of the formation of yellow-coloured precipitate (Activity 7--see Figure 7). Only lead and iodide ions undergo a change as they join to form when they are mixed. Potassium and nitrate ions
remain exactly the same - they are spectator ions.

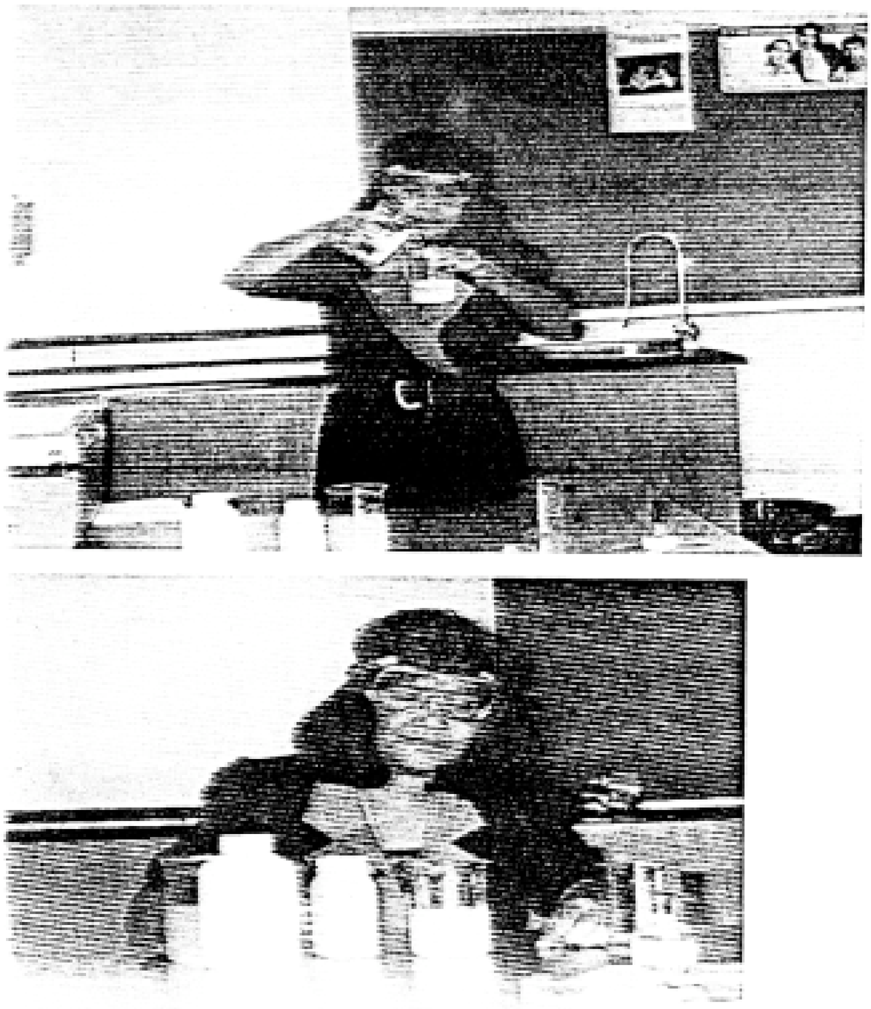


Figure 7: Chemical reaction between lead nitrate and potassium iodide.

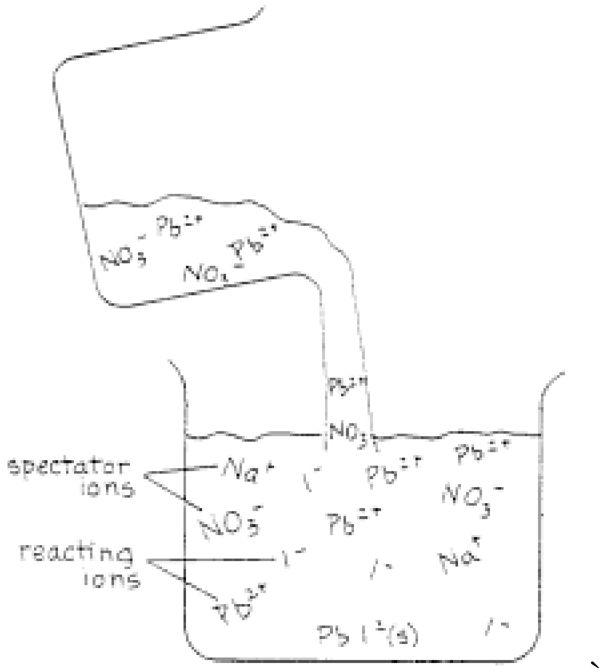


Figure 7: Chemical reaction between lead nitrate and potassium iodide. The net reaction is represented in Equation 3.

$$\mathbf{Pb^{2+}{}_{(aq)} + 2I^{-}{}_{(aq)} \rightarrow PbI_{2(s)}}$$

Equation 3: Precipitation of lead iodide

With the chemical reactions that have been described above, it might be possible to show that sugar or salt dissolving in water is not what we might call a chemical change. However, it has been argued that dissolving an ionic compound in water is a chemical process because of the formation of two new electro chemical species. In the case of sodium chloride, the two electro chemical species are sodium ion and chloride ion and is a chemical phenomenon. The ionic equation (Equation 1) for salt dissolving in water clearly shows this. In addition, the solution process involves energy changes. For instance energy changes are evident in the formation of some solutions: The beaker is felt warm when pellets of sodium hydroxide are dissolved in water. When sodium acetate or sodium thiosulphate crystals are dissolved in water, the beaker feels cold.

The foregoing discussion suggests that dissolving can be considered a physical change as well as a chemical phenomenon.

SUMMARY

In this paper, I have attempted to show how students' conceptions can be explored and incorporated into a unit on solution chemistry. More specifically, I have indicated how Hypercard can be used in chemistry to foster common knowledge.

A grade eleven chemistry curriculum may include topics such as concentration, molarity, depression of freezing point, and elevation of boiling point in a unit on solution chemistry. These theoretical topics and related problems will become more meaningful when the students have a better understanding of the solution process of different substances. Hypercard is a computer software that can be used to develop meaningful mini-lessons in chemistry in order to help students' develop common knowledge.

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