A constructivist-based model for the teaching of dissolution of gas in a liquid

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Contents

Abstract

In this article we present details of a four-step constructivist-based teaching strategy, which helps students understand the dissolution of a gas in a liquid. The model derived from Ayas (1995) involves elicitation of pre-existing ideas, focusing on the target concept, challenging students' ideas, and applying newly constructed ideas to similar but related situations. Group work also is a feature of the model, and an appealing feature is that it uses simple, low-cost, material resources.

Introduction

Solution chemistry plays a key role for the understanding of other related topics such as solubility equilibrium, electrochemistry, and so on. Indeed, science education researchers and teachers alike are aware of the importance of solution chemistry and as a consequence a variety of studies have been conducted. Topics studied include: dissolution; the nature of solutions; solubility; energy in solution processes; effects of temperature and stirring on the dissolution of solids in liquid; conservation of mass during the dissolution process; types of solutions - unsaturated, saturated and supersaturated; vapor pressure lowering; solubility of a gas in water; the relationship between vapor pressure and boiling point; and, strategies to overcome students' alternative conceptions for dissolution chemistry (see Çalik, Ayas & Ebenezer, 2005 and references therein). Interestingly, studies of the dissolution of a gas into a liquid are rare, although Pinarbasi and Canpolat (2003) report a number of student alternative conceptions, suggesting that this is a problematic concept for students. According to theories of learning such as constructivism, determining students' conceptions – including their alternative conceptions, is the first step in devising teaching materials that might aid conceptual change towards the scientific conception. Clearly this on its own is not enough to overcome student alternative conceptions, since developing material resources to help overcome alternative conceptions requires understanding of more than students' lack of content knowledge. Necessary too are: a useful learning theory; a variety of teaching materials; and, an understanding of students' prior ideas. As might be expected, such processes take a long time, especially if teachers are unfamiliar with them. As a consequence, despite science curriculum content being replete with many problematic conceptions/topics, teachers often find it hard to justify modifying their teaching methods, particularly in light of the so-called ‘crowded-curriculum’. Given teachers’ busy schedules, any teaching methods thus need to be ‘productive’, and not take up significantly extra classroom time.

It is interesting to note that textbooks frequently contain alternative conceptions, and thus they may not necessarily help students to facilitate conceptual learning (see, e.g., Hawkes, 1996; Taber, 1995). In addition, textbooks seldom take account of students’ prior knowledge (Spilich, Vedonder, Chiesi, & Voss, 1979; Kim & Van Dusen, 1998), and are not generally prepared based on any learning theory or philosophy of teaching and learning (Niaz, 2001). However, some education researchers believe that using guide material based on sound learning theories enhances learning (see, e.g., Kurt & Akdeniz, 2002; Saka, 2001).

Why is understanding student alternative conceptions important? Two reasons are reported in the literature. First, alternative conceptions held by students interact with one another, so that these alternative conceptions bring about different new meanings for existing conceptions (Schmidt, 1997). As a consequence, when students try to learn new knowledge, this may occur in a fragmented manner if links are not made to their existing knowledge (Haidar, 1997). Second, there is ‘competition’ within student’s minds amongst scientific and alternative conceptions. Research suggests that the ‘strongest’ conception - often an alternative concept – frequently is more robust than the scientific conception (Stavy, 1991). By designing appropriate learning activities, teachers and researchers attempt to reinforce scientific conceptions at the expense of students’ alternative conceptions. However, how this is best achieved is still subject to debate (see Pfundt & Duit, 2000, and references therein).

The view of learning presented in this paper is based on constructivism (Wheatley, 1991), and sees learning as a result of the interaction between pre-existing knowledge and new knowledge. In this work we posit that alternative conceptions identified in the literature or by teachers in the classroom, need to be taken into account during the teaching-learning process. Hence, our stance is that if we can develop an activity that addresses student alternative conceptions, and that can be administered easily by teachers, we may able to encourage teachers to devise new activities for a variety of conceptions. For this reason, this paper reports on classroom use of an activity about the dissolution of a gas into liquid; based on a constructivist view of learning, and the authors classroom experiences. This activity works from the constructivist-based premise that learners' actively construct and transform their own meanings, rather than passively acquire and accumulate knowledge transmitted to them (Driver, Asoko, Leach, Mortimer & Scott, 1994; Rezai & Katz, 2002; Vosniadou & Brewer, 1987).

A Four-step Constructivist Teaching Model

There are a number of models of teaching based on constructivism reported in the literature. Here we utilize the four-step constructivist-teaching model, which builds on students' pre-existing ideas. The four-step constructivist-teaching model is as follows: eliciting students' pre-existing ideas, focusing, challenging and applying (fruitfulness) (Ayas, 1995). These strategies are now described in turn, using our example of the dissolution of a gas in a liquid. We begin by describing an activity, and follow this by explication of the four-step constructivist-teaching model.

Activity

To carry out this activity, students conduct the following steps:

1. Suck up 10 mL of a carbonate drink such as 'cola' using an injector (ensure that there is no air space between the cola and injector).
2. Pull the pump of the injector from I to II as indicated in Figure 1.
3. During this step, make sure to move the pump of the injector from II to I as indicated in Figure 1.
4. Repeat step 2.

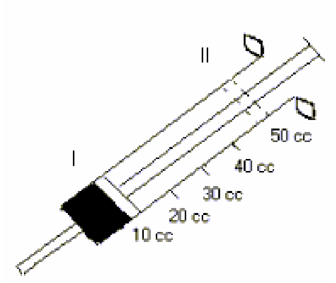

Figure 1

As students conduct Step 2, they should observe that there are many bubbles in the injector. From this exercise, they should conclude that as the pressure decreases (as the injector moves from I to II), the bubbles can then be seen by the naked eye. When carrying out Step 3, the student's should observe that the bubbles, which emerged in the previous step, disappear; in other words, the bubbles cannot be seen easily by the naked eye. From this, they should deduce that the more the external pressure increases, the more gas molecules dissolve in the liquid. By repeating the process in Step 2, the students should again see the effect of the external pressure, and this should help confirm their previous observation and subsequent conclusion.

We now consider how we can adopt this activity based on the four-step 4E constructivist-teaching model (engage, explore, explain, evaluate, see Bodzin, Cates & Price, 2003; Bodzin, Cates, Price & Pratt, 2003), and show how teachers are able to use the activity to enhance student understanding.

Eliciting students' pre-existing ideas

Before the enactment of the activity, all students are divided into groups of four students. The teacher then asks students about their pre-existing ideas in an attempt to *engage* them with the task; using prompt questions such as: "How does the dissolution of gas change with pressure? Please explain your reasons".

Focusing

In the next step, the activity is explained to each student so that the students can gain experience in following the directions. The teacher observes students' activities and encourages them to discuss the topics within their group, helping them to explore their understanding of the topic. Also, at this point the teacher tries to help students clarify points, but does not give any clues. After the activity, the teacher asks the students to answer questions that are presented in activity paper, and defend their answers within their groups; in other words they are asked to explain their answers and reasoning to their peers. The questions provided used are: "After doing the second step, what did you observe? Please explain", "After doing the third step, what did you observe? Please explain", "Please compare the results of the fourth step with that of the second step?", "Taking into account the experiences you acquired as a result of activity, please explain the effect of pressure to the dissolution of a gas into water?"

Challenging

In this evaluation step, the students should by now understand the target concept. However, if students do not, teachers should verify the knowledge domain the students acquire. In this case, for the concept under investigation, the teacher needs to point out that there is a steady increase between dissolution of a gas into liquid and external pressure, that is, if pressure increases, the dissolution of a gas into water also will increase; if it decreases, its dissolution decreases as well.

Applying (Fruitfulness)

In this step, it is intended that the students try to apply their experience learned to another different situation, in order to reinforce their new knowledge. Likewise, they also may be able to make relationships between these rather contrived examples, and their daily life. In case of the above concept, students are asked to respond to the following questions: “When a diver dives into the sea, if he or she tries to reach the surface too rapidly, he or she is exposed to a kind of paralysis. Please explain this process by looking at the dissolution of N_2 gas in blood”, “When you open a bottle of cola, what happens?” Finally here, in order to explore students’ understanding more deeply the teacher requires them to prepare a composition as to what they felt they learned during these activities. As a result, students can engage in some self-assessment, in order to aid their conceptual understanding. However, in our experience with this sort of self-assessment exercise, students are often reluctant to write down a composition. Therefore, we devised a kind of self-assessment form drawing on the worm of Çepni (2006). When we exploit this, students tend to fill the form easily and seem to enhance their enthusiasm. The form is in the following:

Please select the choice that reflects your self-assessment and write down the concepts you think you have learned and/or the concepts you think you have not learned:

(a) I learned the concepts involved in this activity
(b) I did not learn the concepts involved in this activity
(c) I need to revise them
The concepts I learned: ....
....
The concepts I did not learn: ....
....

Teaching science in many developing countries, or in poorly resourced schools in more developed countries, is often problematic because of lack of teaching facilities or equipment, such as laboratory equipment and technological support such as computer networks (Ayas, Çepni & Akdeniz, 1993). The activity presented here, based on recommendations from the science education literature, and the authors own classroom experiences does not require advanced equipment, and may prove a useful tool and teaching approach for the teaching and learning of the dissolution of a gas into liquid. The present study shows how to use this activity step by step, and is designed based on students' preconceptions. Teachers are often aware of student alternative conceptions, but not sure how to tackle them. Likewise, administering similar activities may foster better learning. These activities have the benefit of being simple to design and implement, and also help address problems associated with a 'crowded-curriculum'. Hence, the activity presented here is not only time-efficient but also can be administered easily.

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