Chapter 14

Virtual Laboratory Work for Discovering Gas Solubility in Water: Effects of Altered Guiding Structures

Göran Karlsson
Halmstad University, Sweden

ABSTRACT

Compared to hands-on experiments, virtual laboratory work has the advantage of being both more cost- and time-effective, but also invokes questions about its explorative capacities. The aim of this chapter is to study how students’ scientific reasoning was contingent on altered guiding structures within a virtual laboratory experiment. The virtual laboratory was developed through a design experiment involving three successive versions with altered guiding structures. Analysis of 12 dyads’ reasoning about gas solubility in water revealed that the problem was not primarily for the students to realize how the volume of gas changed, but rather to understand the concept of solubility of gases. It was also observed how the guiding structures within each version influenced the students’ reasoning about the studied phenomenon in certain trajectories.

INTRODUCTION

Digital technologies are widespread and constitute an essential part of the media world, permeating almost all of our activities; these technologies are now available in most educational practices. Models of unobservable scientific phenomena for educational purposes can be shaped in different ways. Educators have traditionally sought to conceptualise processes that involve invisible structures and dynamic characters; for example, by representing molecular reactions with pictorial models supplied with arrows (Lantz-Andersson, Linderoth, & Säljö, 2009). For example, teachers draw such sketches on whiteboards and textbooks are equipped with pictures illustrating dynamic phenomena. Digital technologies offer enhanced opportunities to create representations of scientific phenomena that can otherwise only be demonstrated with, for example, hands-on experiments.

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The prospect of using animated multimedia presentations for learning purposes has aroused growing interest among educators and has generated a substantial amount of research results in this field. Especially in the area of science education, researchers’ attention has been attracted by the potential to visualise phenomena that illustrate unobservable scientific concepts. By visualising dynamic characteristics of the depicted phenomena, animated pictures in contrast to static illustrations render it possible to convey information about both spatial and temporal structures and to endow objects with characters, such as locomotive power, shifting colour, shape, and so on.

With the rapid growth of websites that provide animated learning technologies, and with the technical achievements in this area, we can anticipate even more refined simulations for use in science education. However, we must also consider that regardless of how sophisticated these representations become, there is always an individual interpreting the depicted phenomenon based on her/his own experiences, so there will always be grounds for unintended interpretations. In consideration of several studies of animations as representational tools, Säljö (2004) concluded that:

*The modelling provided by the dynamic animation is so rich in information that it becomes difficult to discern what is to be attended to. So, the technology probably, like all other tools, is sometimes productive but sometimes not so efficient. Technology is but one element in the equation, there are many other factors such as the context, content, etc.* (p. 491)

Active online learning – defined as methods by which learners actively participate in the learning process and where technology is used effectively – has attracted growing interest from the educational system and has been shown to promote learners’ growth and development (Sharma & Mishra, 2007; Wang & Hitch, 2017). Digital technology has the potential to make complex relationships available, thereby providing ‘access points’ that make otherwise obscure or unobtainable events easily accessible to the learners (Edstrand, 2016). Thus, from an educational point of view, there could be benefits from dynamic visualisation of scientific concepts education. However, like all educational tools, digital learning materials involve certain problems, and educational gains from technical innovations cannot be taken for granted. Analysing students’ scientific reasoning in their work with discovering scientific concepts might be a way of unravelling the learning process engendered by digital technologies. It is in the study of what students actually say and do, in their collaborative work with online learning materials, that we can get an in-sight in the meaning making processes governing the outcomes (e.g., Lemke, 1990; Roth, 1995).

Interactivity has been a major feature in the debate on how to advance multimedia learning technologies. The degree of interactivity ranges from low to high depending on the type of control available to the users. There is a general assumption – often referred to as the interactivity effect – that the higher the interactive level, the greater the degree to which learning should increase when students engage in multimedia technologies (e.g. Evans & Gibbons, 2007). In line with the proposed interactivity effect – that is, that interactivity can help learners overcome difficulties of perception and comprehension during the learning process – Wang, Vaughn and Liu (2011) examined the impact of animation interactivity on students’ learning of statistics and found that increased interactivity significantly improves student achievement. A variety of interactive multimedia software packages for instructional purposes in science education are accessible on the Internet, both free and paid for. However, free or commercial, there is a demand for research results explaining how they function in classroom practice.
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