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ABSTRACT

In science teaching insufficient emphasis is placed on the fact that models are simulations of reality based on a certain theory and that molecules are not miniatures of the models that represent them. The study reported in this paper investigated how chemistry teachers perceive the nature and functions of models. The research population included an experimental group of in-service teachers who attended a 56 hour training and a control group of pre- and in-service teachers. The training dealt with the model concept and ways to use various model types to illustrate chemical bonding and structure. Results indicate that: most of the participants thought of a model as a way to describe a process or a phenomena which we cannot see, they perceived models as a means to enlarge or reduce real processes or phenomena or to illustrate some theory, more teachers who took part in the training agreed that models can be used for prediction, and only teachers of the experimental group made a distinction between a mental image and a concrete model that can be seen and touched. It was concluded that the in-service training on models improved several aspects of the trainees' model perception. Contains four references. (Author/JRH)

Model Perception Among Pre- And In-Service Chemistry Teachers

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MODEL PERCEPTION AMONG PRE- AND IN-SERVICE CHEMISTRY TEACHERS

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Abstract

Insufficient emphasis is placed in science teaching, on the fact that models are simulations of reality based on a certain theory and that molecules are not miniatures of the models that represent them. We investigated how chemistry teachers perceive the nature and functions of models. The research population included two groups: an experimental group—in-service teachers who attended a 56 hour training, and a control group—pre- and in-service teachers who did not receive the treatment. The training dealt with the model concept and ways to use various model types to illustrate chemical bonding and structure.

Most of the participants from both groups thought of a model as a way to describe a process or a phenomenon which we cannot see. They perceived models as a means to enlarge or reduce real processes or phenomena, or to illustrate some theory. More teachers who took part in the training agreed that models can be used for prediction. Only the teachers of the experimental group made a distinction between a mental image and a concrete model that can be seen and touched. Overall, the in-service training on models has improved several aspects of the trainees' model perception.

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Introduction

The use of molecular models to illustrate phenomena in chemistry teaching is widespread. The choice of the type of model has an impact on the image the student creats concerning the ways in which things are shaped and how they function in the "real" world from a scientific viewpoint.

One of the problems that arises while using models is that insufficient emphasis is placed on the fact that models are theory-based simulations of reality. Applied to chemistry, models are not merely enlargements of the molecules they are intended to represent. This explains the multiplicity of models that can be used to represent the same molecule. Teachers frequently use just one type of model, limiting students' experience with models and causing their model perceptions to be partialiy or completely unadequate.

The aim ot this study is to investigate how chemistry teachers perceive the nature and functions of models. Their perceptions are important, since if teachers do not have the necessary understanding of the nature of models, how they have evolved, and the role they play in the development of a discipline, they probably will not be able to incorporate them properly in their teaching (Gilbert, 1991; Smit and Finegold,1994). Students need more experience with models as intellectual tools that provide contrasting conceptual views of phenomena, and more discussion of the roles of models in the service of scientific enquiry (Gabel and Sherwood, 1980; Grosslight, Unger, Jay and Smith, 1991).

Research Methodology

We examined the perception of the model concept among pre- and in-service chemistry teachers. The research tool was a questionnaire on models in general and on models in chemical bonding and structure in particular. The first part includes 15 statements used in a questionnaire developed and implemented by Finegold and Smith (1994). In this part, responders are asked to mark and explain if they agree, disagree or are unsure about each statement.

The statements in the first part are as follows.

1. All models are creations of the human intellect.
2. All models are representations. (Some are purely visual, some can be seen and felt).
3. Any representation of an object, of a structure, or of a process is called a model.
4. Models exist in nature.
5. All models are mental images, i.e. exist only in the human mind.
6. Models are aids that are used to obtain knowledge of nature.
7. A model always provides a complete description of the object, structure or process in nature that it models.
8. A model is formulated using facts obtained by experiment and/or observation.
9. The terms model and theory are synonymous.
10. The only function of models in science is in teaching.
11. Models are of a temporary nature. With the increase of knowledge a model becomes obsolete or useless and is either adapted or replaced by another model.
12. A scientist always has more knowledge of an object, process or structure than is represented by the model itself.
13. An important function of any model is to describe an object, a structure, or a process in nature.
14. Models play an important role in the explanation of phenomena.
15. Models can be used to predict phenomena, structures or processes that have not previously been observed.

The second part relates to the use of models in chemistry and contains open questions related to bonding and structure. Responders are asked to define model in their own words, give three examples for the use of models in chemistry, and specify the model type(s) which are used to explain some examples of visible phenomena. The examples are:

1. Copper in the solid state conducts electricity .
2. Gaseous chlorine does not dissolve in water, whereas, hydrogen chloride gase dissoves excellently in water.

3. Solid graphite conducts electricity, while diamond dose not.

4. Sodium chloride does not conduct electricity in solid state, but has conducrivity in aqueous solution.

Research Population

The two groups of the research population were as follows:

1. Experimental group (N=22): Pre- and In-service teachers who participated in a training course on teaching strategies for chemical bonding and structure and the use of various types of models.

During summer 1994, this group attended a 56 hour in-service training course on the model concept and on ways of using plastic, metal and computerized models to illustrate chemical bonding and structure.

2. Control group (N=19): Pre- and in-service teachers who took part in one of the following two activities:

i) A training course on the use of computers in chemistry teaching, or

ii) A pre-service course on chemistry teaching methodologies.

Results

Statements (1) and (5), that models are creations of the human intellect and that they are mental images, are similar. Therefore, similar responses were expected. Results, depicted in Figure 1, show that in the experimental group (E), 95% and 68% respectively agreed to statements 1 and 5. In the control group (C), the corresponding numbers are 86% and 23%, indicating some confusion. It was also expected that negative responses to (4) — models exist in nature — would be reflected in positive responses to (5) — all models are mental images. This indeed occurred with the experimental group, in which 31% agreed to (4) and 68% agreed to (5). This was not the case with the control group, where 27% and 23% respectively agreed to statements (4) and (5).

Statements (2) and (3) both describe models as representations. Indeed, about 68% of the teachers from both groups confirmed these two statements.

A large majority of both groups agreed with statements (13), (14) and (15) which refer to the descriptive, explanatory and predictive functions of models. Whereas almost all the teachers (100%-E and 95%-C) agreed that models play an important role in the explanation of phenomena (14), only 79% (E) and 73% (C) agreed that an important function of any model is the description of something in nature. This may indicate that more teachers consider the model as a tool for explaining things rather than as a tool for describing them. A more noticeable gap exists between the two groups when prediction is involved; 95% of the teachers in the experimental group agreed that models can be used for prediction while only 72% of the teachers in the control group thought this way.

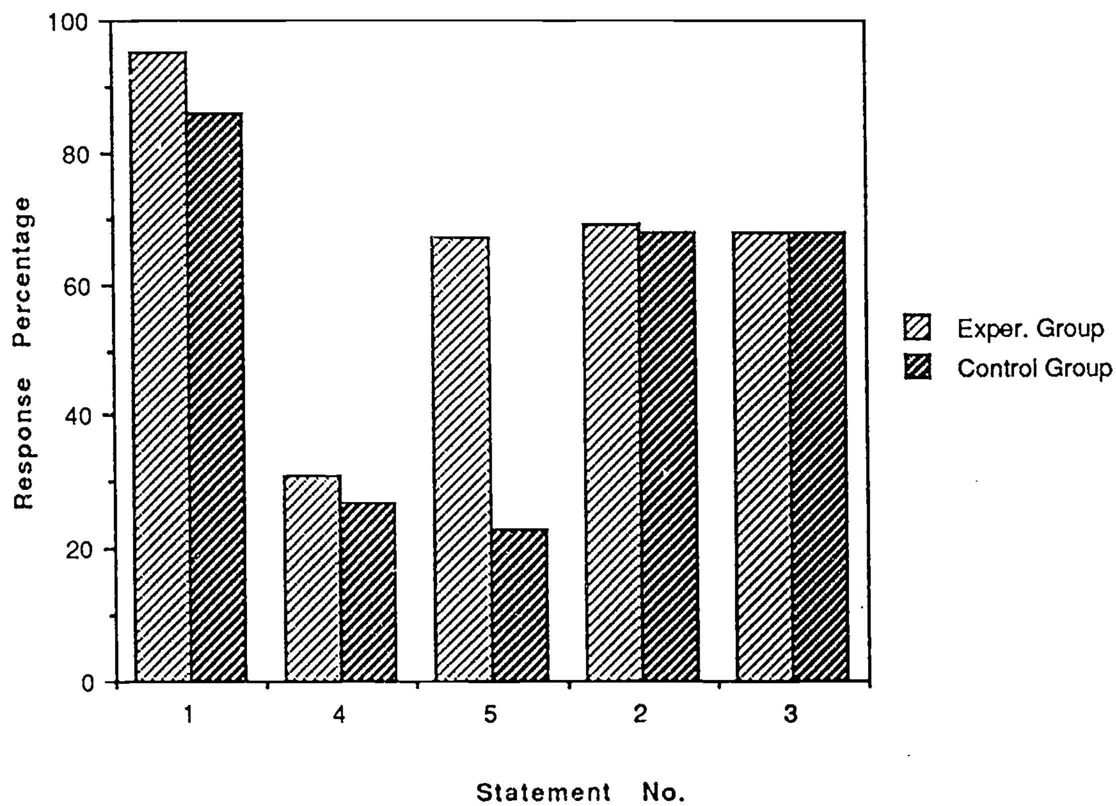

Figure 1. Responses by experimental and control groups to statements 1-5

Statement (6) relates to the function of models as aids in obtaining knowledge while (10) suggests that their only function is in teaching . Only 37% of the experimental group and 36% of the control group agreed to statement (6). In contrast, none of the control group agreed, and 15% of the experimental group agreed to statement (10), (see Figure 2).

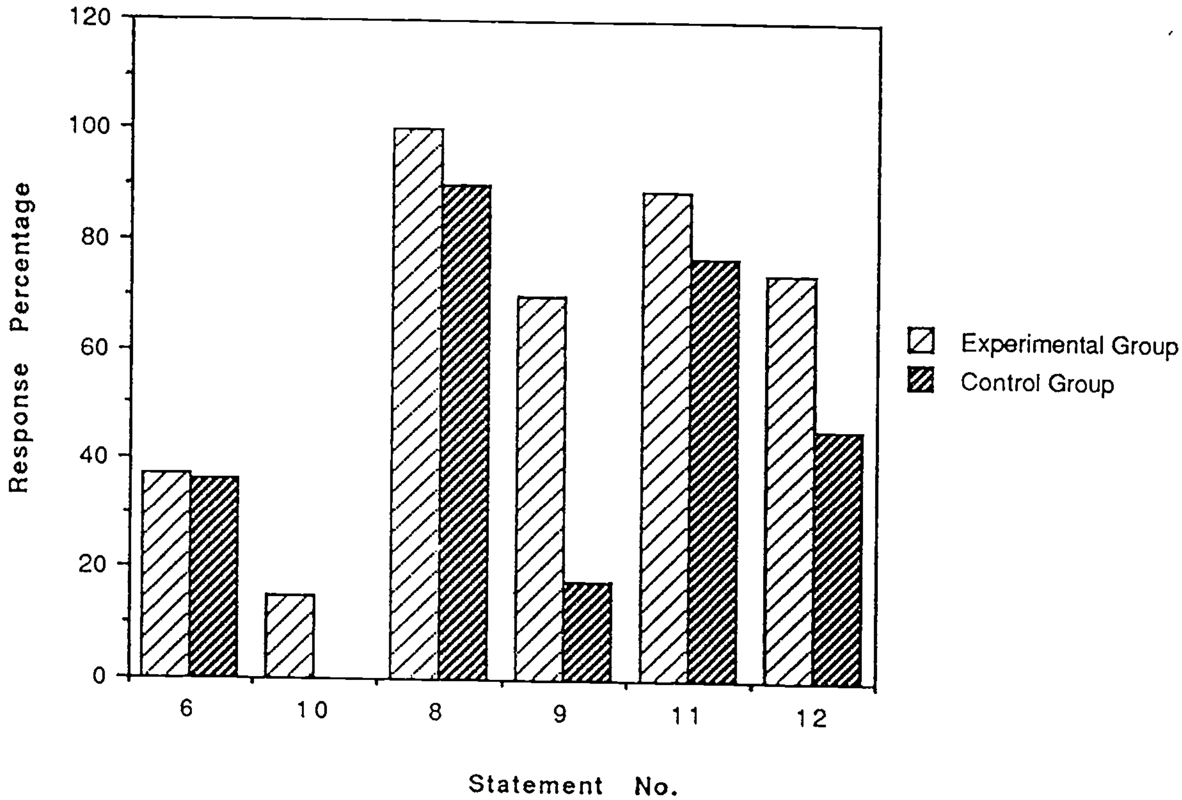

Figure 2. Responses by experimental and control groups to statements 6, 8-12

Comparison of responses to statements (6) and (10) points a possible problem in training, which may have over-emphasized the instructive role of models and somewhat suppressed their role in knowledge acquisition. 100% (E) and 90% (C) agreed that models are formulated using facts obtained by experiment and/or observation (8). However, in response to statement (9) that the terms model and theory are synonymous, a significant difference - 70% (E) vs. 18% (C) - exists between the two groups, indicating that the experimental group teachers learned to relate the terms model and theory to a much greater extent than did those in the control group.

Statement (11) presents an important view of the transient nature of models. Responses indicate that 89% of the experimental group and 77% of the control group were aware of this fact. 74% (E) and 46% (C) agreed that a scientist always has more knowledge of an object, process or structure than is represented by the model itself (12). In both statements (11) and (12) the experimental group has evidently gained a more sophisticated insight into certain aspects of models and their meaning.

Analysis the answers to the second, open part of the questionnaire, we found that most of the participants from both groups thought of a model as a way of describing a process or a phenomenon which cannot be seen. A distinction between a mental image and a concrete model that can be seen and touched was made only by the participants of the experimental group. There was agreement among all responders that models help explain and understand phenomena through simplification and visualization.

The examples given for the use of models in chemistry were all in the domain of atomic and molecular structure. Most teachers perceive models as a means to enlarge or reduce the real process or phenomena, or to illustrate some theory. Only few teachers thought of models as mental images.

Conclusion and Future Research

The results indicate that overall the in-service training program on models has improved many aspects of the trainees' model perception. Hence, more time should be invested to introduce pre- and in-service teachers to the model concept and to its use in science in general and in chemistry in particular. More research is needed to determine the long-term effect of such training on the classroom students of the trainees.

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