The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2016

Volume 4, Pages 424-428

ICEMST 2016: International Conference on Education in Mathematics, Science & Technology

ANALYSIS OF PROSPECTIVE CHEMISTRY TEACHERS' VIEWS ON MODELS ACCORDING TO SOLO (STRUCTURE OF OBSERVED LEARNING OUTCOMES) TAXONOMY

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ABSTRACT: In this study it was investigated prospective chemistry teachers' views on the nature of models and the use of models and modeling in chemistry teaching by using Structure of Observed Learning Outcomes (SOLO) taxonomy. A qualitative study was performed on 16 prospective chemistry teachers who attended the fifth grade. Three open-ended questions were used as the data collection tool. The assessment scale, prepared by the researchers, was employed to make the descriptive analysis of what understanding levels on the SOLO prospective teachers' answers corresponded to. The views of the prospective teachers about the model definition were usually found to be in the pre-structural level, which is the lowest level and no view was identified to be at the highest level, which is the extended abstract. The prospective teachers' views regarding the use of models were generally in the pre-structural and untistructural levels and no view in the extended abstract level could be identified.

Key words: Models, prospective chemistry teachers, SOLO taxonomy

INTRODUCTION

Chemistry is not an easy subject to understand because of abstract nature of chemistry concepts. For this reason, many students have difficulties in learning chemistry. Models play a vital role in teaching and learning chemistry concepts and help students to form concrete ideas about abstract concepts. It is essential that the prospective chemistry teachers have an appreciation of what 'a model' is and that definition should be congruent with the one that is accepted by scientists. Besides, they have to learn that why and how models are used in chemistry teaching. On the other hand, several studies revealed that students and teachers generally do not clearly distinguish the ideas and/or purposes underlying models and the content of the models. Students usually view models as toys or miniatures of real-life objects, and few students understand why models are used in science (Ingham & Gilbert, 1991). Students generally do not give meaning to the process of modeling. Teachers' understanding of the nature of models and modeling were also investigated in the different contexts.

Van Driel and Verloop (1999) carried out a study concerning experienced secondary science teachers' understanding of the nature of models in The Netherlands. The subjects in this study were teachers of biology, chemistry and physics preparing for the curriculum innovation. They used two instruments which one was a questionnaire with seven open items on models and modeling and second one was a Likert-type questionnaire. They found that, in general, experienced teachers subscribed to the view that 'a model is a simplified or schematic representation of reality'. In the Likert-type questionnaire study, they identified three scales that confirmed first results. The first concerned the relation between a model and the target it represents: the extent to which models are seen as a simplified representation of reality. The second concerned the physical appearance of models: whether they could be met in a range of modes of representation. The third concerned the social context of model construction: whether models are the product of human creativity and communication. Harrison (2001) interviewed ten experienced science teachers about their understandings of the analogical models they use to explain science to their students in Australia. Justi ve Gilbert (2003), a semi-structured interview was used in Brazil to enquire into the 'notion of model' held by a total sample of 39 science teachers. Seven 'aspects' of their

- Selection and peer-review under responsibility of the Organizing Committee of the conference

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notions of a model were identified in this study. It was found that teachers with degrees in chemistry or physics had different views about the notion of 'model' to those with degrees in biology or with teacher training certificates. It was seen that the teachers who participated in the aforementioned studies had problems about the definition of a model and using in science classrooms. For this reason to understand how prospective chemistry teachers' knowledge about models is important.

The Structure of Observed Learning Outcomes (SOLO) taxonomy, developed by Biggs and Collis (1982), is one of the significant tools to comprehend cognitive development among students. It provides educators and researchers with a systematic way of classifying and describing the range of performances produced by learners in attempting a particular academic activity such as writing an essay or answering an open-ended question. Biggs and Collis constructed their model on the notion that in any 'learning episode, both qualitative and quantitative learning outcomes are determined by a complex interaction between teaching procedures and student characteristics' (1982, p. 15). The SOLO taxonomy describes non-linearity of students' cognitive development and level of increasing complexity in a student's understanding of a subject through in five stages: Prestructural, Unistructural, Multistructural, Relational, and Extended Abstract. These levels are ordered in terms of various characteristics, including the movement from the concrete to the abstract, the use of an increasing number of organizing aspects, increasing consistency, and the relating and extending of key principles (Biggs, 1999; Biggs & Collis, 1982). The aim of this study is to examine the utility of Biggs' and Collis' (1982) Structure of Observed Learning Outcomes (SOLO) taxonomy as a means to assess prospective chemistry teachers' understanding about models and using models in chemistry lessons.

METHODS

Research Design

This is qualitative study and in the qualitative research, it is important that the data collected should be detailed and in-depth and views and experiences of the individuals studied should be presented as directly as possible so that a descriptive and realistic picture can be presented to the readers who show interest in the matter in question (Yıldırım and Şimşek, 2005, p. 48).

Participants

The present study was situated in the context of the ten semester of a five-year pre-service chemistry teacher education program. The study's sample consists of 16 prospective chemistry teachers (7 male and 9 female) who attend the 4th class of the Chemistry Teaching Department. All of the prospective chemistry teachers have completed their chemistry-related courses. As prospective chemistry teachers encounter many models both at their field courses and field training courses, the participants were selected using criterion sampling, which is one of the purposive sampling methods (Yıldırım and Şimşek, 2005, p. 112).

Data Collection Tool

In the study, a test consisting of three open-ended questions was used as the data collection tool to obtain the views of prospective chemistry teachers about models. During the development of the test, the measuring tools used in the studies conducted about models were examined (Grosslight et al., 1991, Justi & Gilbert, 2003) and questions were formulated based on this assessment.

Data Analysis

For data analysis, the SOLO taxonomy levels and criteria, developed by Biggs and Collis (1982), were taken into account in developing assessment scales for prospective teachers' views about the definition of a model and about the intended uses of models. Descriptive analysis was performed using the assessment scales prepared. Explanation of each level of the SOLO taxonomy, used in the analysis, was given in Table 1. In the descriptive analysis, the data obtained can be summarized and interpreted based on the predetermined themes and direct quotes can be given with a view to reflecting individuals' views in a striking manner (Yıldırım and Şimşek, 2006, p. 224).

Table 1. SOLO Taxonomy Used in the Analysis of Student Responses (Minogue ve Jones, 2009)

	Level	Description
1	Prestructural	The task is not attacked appropriately, the student has no understood the point, or question is reworded.
2	Unistructural	One aspect of the task is picked up and used (understanding as nominal).
3	Multistructural	Several (two or more) aspects of the task are learned but are treated separately (understanding as knowing about).

4	Relational	The components are integrated into a coherent whole, with each part contributing to the overall meaning (understanding as appreciating relationships).
5	Extended Abstract	The integrated whole at the relational level is reconceptualised at a higher level of abstraction, which enables generalization to a new topic or area, or is turned reflexively on oneself (understanding as far transfer and as involving metacognition).

To ensure reliability, the responses by prospective teachers were analyzed by a researcher and a field training specialist according to the SOLO taxonomy to identify Agreement and Disagreement situations. Using the reliability formula, proposed by Miles and Huberman (1994), the reliability of the study was calculated to be 94%. Thus, the findings obtained through the analysis of the data were readied for description. Also, direct quotes were occasionally made for the better portrayal of the views of prospective teachers during the presentation of the findings. Teachers were given the letter codes "PCT" and numbers "PCT1, PCT2, PCT3)

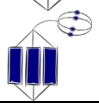
RESULTS and FINDINGS

In this section of the study, the findings from the analysis of prospective teachers' views concerning models according to the SOLO taxonomy were given in two parts. The first part includes the findings obtained from the analysis based on the SOLO taxonomy of the prospective teachers' views about the definition of a model while the second part is about that the findings related to the views about the intended use of models.

Findings from the Analysis of Prospective Teachers' Views on the Definition of a Model according to the SOLO Taxonomy

In this section, the answers the prospective teacher gave to the question, "How do you define a model?" were analyzed according to the SOLO taxonomy and the findings were given in Table 2.

Table 2. Findings from the Analysis of Prospective Teachers' Views on the Definition of a Model according to the SOLO Taxonomy

SOLO Understanding Level		f	Sample Answers
Prestructural		8	A model is a person who is taken as an example. (PCT6, PCT8, PCT9, PCT16) A model is the whole of a concept or a limited system. (PCT1) Visualization of the topic to be explained is called a model. (PCT2) Model is the form of narration that threads topics like a chain and it is the way of dominating the class. (PCT7). A model is the form of a topic shown using graphs, charts or slides. (PCT15).
Unistructural		4	A model is what can form visuality. (PCT10, PCT11, PCT12) Models are more concrete things. (PCT13)
Multistructural		3	Models are the tools, materials and activities that facilitate comprehension. (PCT3, PCT5) A model is a material which exemplifies and represents the situation. (PCT14)
Relational		1	A model is a set of graphs, figures and materials used to clarify a topic or theory. (PCT4)
Extended Abstract		0	---

Examining the date in Table 2, it was found that regarding the model definition, 8 of the prospective teachers are on the "Prestructural" level which contains insufficient, disconnected, irrelevant or false information about models. At this level, the leading model definition is "the model in daily life." 4 prospective teachers are in the "Unistructural" level which includes an approach to models from a single perspective as well as a small bit of knowledge about models while 3 prospective teachers are on the "Multistructural" level as they adopt multiple perspectives in their approaches. Only 1 prospective teacher gave answers on the "Relational" level by approaching to models from several angles and associating them in a logical way.

Findings from the Analysis of Prospective Teachers' Views on the Intended Use of a Model according to the SOLO Taxonomy

In this section, the answers the prospective teacher gave to the questions, "Why are models used in secondary education chemistry classes?" and "How are models used in the secondary education chemistry classes?" were found to be similar and related to the intended uses of models, and therefore, they were merged for analysis. The findings from the analysis of prospective teachers' views on the intended use of a model according to the SOLO taxonomy are given in Table 3.

Table 3. Findings from the Analysis of Prospective Teachers' Views on the Intended Use of a Model according to the SOLO Taxonomy

SOLO Understanding Level		F	Sample Answers
Prestructural		3	They are used to summarize a topic.(PCT1) They are used to develop a certain standard across the country. (PCT7) They are used to gain experience from experienced people. (PCT16)
Unistructural		7	They are used to add a visual aspect. (PCT6, PCT10, PCT11) They are used to make abstract concepts more abstract. (PCT3, PCT4, PCT13, PCT15)
Multistructural		2	They are used to arouse students' attention in the lesson and express what will be done and how. (PCT9) They are used to facilitate and reinforce comprehension. (PCT8)
Relational		2	They are used to ensure that student can visualize the concepts that can hardly be understood without seeing, such as the concept of atoms. (PCT14) They are used to make sure that information in committed to the long-lasting memory for effective learning. (PCT2)
Extended Abstract		2	They are used to help students visualize theoretical information such as atoms and envisage them with dummies. (PCT5) They are used to describe the concepts like atoms and bonds, which we cannot see with our eyes in daily life, but which are scientifically proven, and facilitate their comprehension by making them more concrete. (PCT12)

Examining the date in Table 3, it was found that regarding the intended use of models, 3 of the prospective teachers are on the "Prestructural" level which contains insufficient, disconnected, irrelevant or false information about the intended uses of models. 7 prospective teachers are in the "Unistructural" level which includes an approach to the intended use of models from a single perspective as well as a small bit of knowledge about the intended use while 2 prospective teachers are on the "Multistructural" level as they adopt multiple perspectives in their approaches to the intended use of models. 2 prospective teacher are on the "Relational" level as they approach the intended use of models from several angles and associate them in a logical way, and 2 prospective teachers are on the "Extended Abstract" level in which the knowledge about the intended use of models is transferred to different situations and generalizations are made.

CONCLUSION

In this study which measures the levels of prospective teachers' views about models using the SOLO taxonomy, the following conclusions were obtained: The views of the prospective teachers about the definition of a model were found be generally on the Prestructural level of the SOLO taxonomy and the number of prospective teachers declined toward the higher levels, with no teacher making into the highest level, i.e., Extended Abstract. As for their views on the intended use of models, the prospective teachers were generally on the Prestructural level of the SOLO taxonomy and they exhibited an equal distribution of the higher levels.

In literature, Likert-type scales (Treagust, 2002; Güneş, Gülçiçek and Bağcı, 2004) and open-ended questions (Grosslight et al., 1991; Güneş, Gülçiçek and Bağcı, 2004; Justi & Gilbert, 2003) were used to identify the views (of primary and secondary school students, lecturers and experts) on models and modeling. Unlike the literature, this study used the SOLO taxonomy to identify the views of students about models. If we compare the findings of this study to the three levels developed by Grosslight et al. (1991) to study the views on models and their use in sciences, we can say that 1st level in which "models are seen as toys or simple copies of reality" corresponds to the SOLO taxonomy's "Unistructural" level, and the 2nd level in which "models need not to overlap with the real-world objects they model after" corresponds to the SOLO taxonomy's "Multistructural" level. The first two factors of the 3rd level which consists of three factors are “perception of a model not as a replica of reality, but

as a service for developing ideas and testing them" and "the person making the model should take an active role in modeling" and they correspond to the SOLO taxonomy's "Relational" level while the third factor, which is "models are changeable and can be subject to tests and they provide information in a cyclical constructivist process" correspond to the SOLO taxonomy's "Extended Abstract" level.

The study's findings imply that there are prospective teachers who have wrong information about the definition and intended uses of models and the number of prospective teachers who nurture views at higher levels is considerably small. The views of prospective teachers about the definition and intended use of models are similar to those Justi and Gilbert (2003) found in studying the views of primary school science teachers and secondary school physics, chemistry and biology teachers about the nature of models. Justi and Gilbert (2003) came up with a classification which categorized the teachers' views about the nature of models from 7 perspectives (Nature, Use, Entities, Uniqueness, Time, Prediction and Accreditation). This study's findings were found to be similar to the classifications "Nature" and "Use." The "Nature" classification consists of 4 categories (i. A reproduction of something, ii. A representation of the whole of something, iii. A representation of part of something, iv. A mental image) while the "Use" classification has 4 factories (i. A standard or reference to be followed, ii. A visualization, enabling a person to 'see' a phenomenon, iii. A way of supporting creativity, the imagining of new contexts and the creation of new ideas, iv. A way of understanding or explaining something).
The views of some prospective teachers about the definition of a model were found to be similar to the category "A representation of the whole of something" in the "Nature" classification while their view about the intended use of models were similar to the categories "A visualization, enabling a person to 'see' a phenomenon" and "A way of understanding or explaining something" in the "Use" classification.

RECOMMENDATIONS

The elimination of the errors and deficiencies in the views of prospective teachers about the definition and intended use of a model is of critical importance for them to use the models correctly and properly in future. Therefore, their views should be analyzed in a way to take into consideration their cognitive levels, when possible. Therefore, in line with the findings of this study, the SOLO taxonomy can be recommended as an alternative tool that can be used to analyze the views of prospective teachers about models.

REFERENCES

Biggs, J. B. and Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy.* New York: Academic Press.

Biggs, J. (1999). What the student does: Teaching for quality learning at university. Buckingham: Open University Press.

Grosslight, L., Unger, C., Jay, E. & Smith, C. (1991). Understanding Models and Their Use in Science: Conceptions of Middle and High School Students and Experts. *Journal of Research in Science Teaching, 28*(9), 799-822.

Güneş, B., Gülçiçek, Ç. ve Bağcı N. (2004). Eğitim fakültelerindeki fen ve matematik öğretim elemanlarının model ve modelleme hakkındaki görüşlerinin incelenmesi. *Türk Fen Eğitimi Dergisi,* 1(1), 35-48.

Ingham, A.M., Gilbert, J.K. (1991). The use of analogue models by students of chemistry at higher education level. *International Journal of Science Education*, 13, 193-202.

Justi, R. & Gilbert, J. (2003). Teachers' views on the nature of models. *International Journal of Science Education, 25*(11), 1369-1386.

Miles, M. B., and Huberman, A. M. (1994). *Qualitative data analysis.* Thousand Oaks, CA: Sage

Minogue and Jones (2009). Measuring the Impact of Haptic Feedback Using the SOLO Taxonomy. *International Journal of Science Education, 31*(10), 1359–1378.

Treagust, F.D. (2002). Students' understanding of the role of scientific models in learning science, *International Journal of Science Education, 21*(11), 1141-1153.

Van Driel, H. J. ve Verloop, N. (1999). Teachers' Knowledge of Models and Modelling in Science. *International Journal of Science Education, 21*(11), 1141-1153.

Yıldırım, A. ve Şimşek H. (2005). *Sosyal bilimlerde nitel araştırma yöntemleri.* Ankara: Seçkin Yayınevi.

The images in table 2 and table 3 were taken from http://www.pamhook.com/