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Analysis of Pre-Service Teachers' Views toward Models and Modeling in Science Education

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Abstract

The purpose of this study is to analyze views of pre-service science teachers (PST) towards concepts of model and modeling. The sample of the study was included 40 PST. All participants were senior students from the department of science education in a State University. The research was conducted during the spring semester of 2012-2013 academic years. A questionnaire was prepared in order to collect data. The questionnaire was composed of open-ended questions and true-false statements. Content analysis and descriptive analysis methods were used to analyze data. From the findings of the study, it can be inferred that PSTs had adequate knowledge about models and modeling. On the other hand, it was seen that PSTs were unaware that representatives they use in their daily lives were models and there were some gaps and mistakes in their knowledge about which examples could be models, and model types.

Key Words: model, modeling, technology, models in science education, views of pre-service teachers, science education

Introduction

One of the most important aims of science education is to enable students to understand concepts about natural events and relationships between these concepts. Within this process, while some of the concepts are possible to experience in daily life, some are not. When these kinds of concepts are encountered, it is considerably important to make an effort on teaching and learning by building a relationship between these concepts and an experienced event or daily life. For this reason, it is essential

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to concretize subjects and visualize them, and design and use related materials. For an abstract, unobservable event, and even if it is possible to observe the event, scaling can be needed. For those situations, materials that are used are called models. (Ünal & Ergin, 2006). Models are not real, and approved models can be changed with new information (Harrison, 2001). Models are scientific and mental applications that are used in order to ease the comprehension of complex events (Gobert & Buckley, 2000). Models, as an integral part of science education, are materials used in order to test hypothesis in scientific researches, to comprehend and to describe scientific facts, to predict and to relate them. In addition, models are guide materials for us to see the development of our ideas, and to carry our knowledge to a higher level (Yıldız, 2006). A good model must have certain characteristics. Models must be easy to use and understand, economical, interesting, comprehensive, and scientific, they must explain the important things about a subject and should represent reality at the highest level. (McKean & Gibson, 1989; Mickle, 1990; Soderberg, 1992; Oakley, 1994; Stencel, 1995; Lock, 1997). When science literature is analyzed generally, it is seen that while modeling is defined as the process of transforming an unknown target into a clear and understandable concept moving from existing sources, models are defined as products after this procedure (Koçak, 2006). Using models in science education ease concept comprehension and learning. Models draw students' attention, activate the class (Aslan & Doğdu, 1993), and by promoting learning by doing, models make learning permanent, make unreachable events, objects, facts relatively reachable in class environment. Students particularly like technological materials such as; videos, simulations, 3D computer animations which demonstrate molecules (Byers, 1997). Such technological materials increase student-teacher and student-student interaction (Burke & Greenbowe, 1998; Sutherland, 2004), develop students' cognitive skills such as; thinking, producing and researching (Wasson, 1997), increase students' interest and curiosity to learn. According to National Science Education Standards, while constructing a scientific model, models give students the opportunity to test their conceptual frames' directions and to reveal their thoughts by attending the hypothesis testing, and reviewing stages (National Resource Council, 1996).

Many studies have been carried out related to models and modeling in science education. (McKean and Gibson, 1989; Vosniadou, 1994; Lock, 1997; Jilbert ve Boulter, 1998; Driel ve Verloop, 1999; Gobert & Buckley, 2000; Harrison & Treagust, 2000; Harrison, 2001; Cullin & Crawford, 2002; Justi & Gilbert, 2002; Gülçiçek & Bağcı, 2003; Gülçiçek & Güneş, 2003; Güneş, Gülçiçek ve Bağcı, 2004; Gödek, 2004; Sarıkaya, Selvi & Bora Doğan, 2004; Koçak, 2006; Ünal & Ergin, 2006; Taylan Yıldız, 2006; Zeynelgiller, 2006; Güneş, Gümüş, Demir, Koçak, Kaya & Kırıcı, 2008; Örnek, 2008; Berber & Güzel, 2009; Stocklmayer, 2010; Ergin, Özcan & Sarı, 2012; Harman, 2012). Some of these studies are about teachers' views on models and modelling in science education (Van Driel & Verloop, 1999; Güneş, Gülçiçek & Bağcı, 2004; Justi & Gilbert, 2002; Ergin, Özcan & Sarı, 2012; Justi & Gilbert, 2002), some of them are about academicians' views (Güneş, Gülçiçek & Bağcı, 2004; Driel & Verloop, 2002), and some are about pre-service teachers' views about the subject(Berber & Güzel, 2009; Harman, 2012). Because basic philosophy of science education is to provide students with scientific thinking and studying skills, it is essential to create a class environment in which students can understand the nature of models and modeling process, and apply these individually or in groups. In addition, National Science Education Standards (National Resource Council, 1996), request Science and Technology teachers to be knowledgeable about the nature of science and scientific researches, including roles of models and modeling in science education. In this respect, for today's pre-service teachers, it is essential and important to have adequate knowledge about models and modeling as future science and technology teachers (Sevim, 2002; Çepni, Küçük & Bacanak, 2004; Gödek, 2004; Sevim & Pekbay 2012). Studies about pre-service teachers' views towards models and modeling in science education are very few in Turkey, and most of these studies are about what they know as models rather than their perceptions about models and modeling. Thus, it was aimed to investigate perceptions of pre-service science and technology

teachers on models and modeling through revealing their views about the relationship among models, modeling, and technology.

Method

Research Design

This research, which is aimed to analyze pre-service teachers' perceptions about models and modeling, and relationship between models, modeling and technology is a descriptive study in order to describe an existing situation. For this reason, special case method was used in this research (Çepni, 2007).

Sample

Sample of the study is composed of 40 pre-service teachers who received education in 4th grade in Black Sea Technical University Fatih Education Faculty Science Teaching Department during 2012-2013 academic years. All of the pre-service teachers have passed their pedagogical and field education courses. Thus, they must have adequate knowledge about models and modeling. Names of participants are not given due to research ethics. Instead, they are coded as PT1, PT2, PT3, ……..PT40

Data Collection Tool

To collect data, a questionnaire composed of open-ended questions and true-false statements were used in this study. Questionnaire method is an instrument which is used for obtaining data from the answers of the members of a sample group, which is decided in advance, to the questions, which were posed in a certain structure. A test that included models, modeling, aims of using models and modeling in science education, characteristics that models must have, relationship between modeling and technology, and sample models was prepared and applied to the pre-service science teachers. Professionals' advices were taken into account while forming test questions.

Data Analysis

Pre-service teachers' answers were analyzed by using descriptive analysis and content analysis methods. With the help of descriptive analysis, data can be organized according to the themes of research questions or they can be presented considering the questions asked during observations and interviews (Yıldırım & Şimşek, 2008). In this kind of analysis, the aim is to present sequenced and interpreted data to the reader. Content analysis is a systematical technique of summarizing a text in smaller content categories by using codes that are based on specific rules (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2008). In addition, frequencies and percentages of pre-service teachers' answers are also presented in this study.

Findings

In this chapter, first questions, and then findings are presented.

Question 1. *What does the concept of model mean to you? Describe.*

Pre-service teachers' views about the concept of model are given in Table1.

Table 1
Views of pre-service teachers on model as a concept

Views on model as a concept	**N**	**%**
Concretizing concepts and objects	13	32,5
Simplifying education and teaching	2	5
Maximized, minimized or same-scaled copies of the original objects	15	37,5
Material that reflects the original object perfectly.	1	2,5
2 or 3 dimensional instrument or visual aid	12	30
Affective teaching material	2	5
Introduction Method	6	15

When pre-service teachers' views about the concept of model are analyzed, it was seen as in Table 1 that 32,5% of pre-service teachers defined models as instruments which are used for concretizing objects and concepts. PT34 stated, " *Models are instruments that are used for transforming subjects, which are difficult to explain during teaching and education process, from abstract to concrete.*", PT24 mentioned, *" It is a very good concept that is used for concretizing abstract thoughts."* 5% of pre-service teachers mentioned that models were the materials that simplify teaching. PT1 stated *" It is concretizing an object or a subject for a better explanation. In addition, there are some teaching models to make teaching more affective.".* About same subject, PT25 indicated, *" these are the methods developed for making teaching and education easier.". 3*7,5% of pre-service teachers are agreed that models are enlarged, minimized or they are same-scaled of original objects. PT29 mentioned that *" it is enlarged or minimized object. It can be identical either."* %2.5 of PT agreed that materials were the objects that reflect the original object perfectly. PT3 explained his/her views as: *" model is a material that reflects the original object identically or provide a person with adequate information about the object." 3*0% of pre-service teachers' views were that models are two-dimensional or three-dimensional visual materials. About this, PT38's view was such: *"models are two dimensional or three dimensional maquettes that are brought to class to explain complex concepts.".*5% of pre-service teachers were thinking that models are used for better teaching. About the subject, PT9 stated*" it is about explaining abstract concepts that are difficult for students to acquire, with concretizing them. For example, explaining kidney with beans. Secondly, these are the things that are structured in levels in order to teach subjects more effectively.".* About the same subject, PT19 stated his/her views as *" Model is a way to explain. Like cooperative learning.", PT*32 stated:*" Models explain which applications to be applied, and the sequence of them in the lesson. In addition, materials to be used, can be presented as models"*

Question 2. *What is modeling, and which path do you think scientists follow while designing a model?*

Views of pre-service teachers about the concept of modeling are given in Table 2.

Table 2
Views of pre-service teachers about modeling

Views of Pre-service Teachers	**N**	**%**
Constructing a model	6	15
Emerging different points of view in teaching concepts	4	10
Transforming a concept from abstract to concrete	8	20
Teaching method	3	7,5
Enlarging or minimizing a structure	9	22,5

When views about the concept of model are analyzed, as indicated in Table2, 15% of pre-service teachers stated modeling as constructing models. PT37's answer to this question was "Designing something suitable for the topic and forming a model", PT34's answer was " Modeling: Constructing a model." 10% of pre-service teachers stated that modeling was about different perspectives of teaching a concept. PT2 expressed his/her idea as "it is bringing up different perspectives on teaching a concept or an event." 20% of pre-service teachers described modeling as transforming an abstract concept into concrete. PT21 described modeling as "concretizing a concept which is difficult to explain, with the help of models." 7,5% of pre-service teachers claimed that models were teaching methods. PT29 stated "About an invisible subject (DNA) making a three dimensional structure or it could be a teaching model like 5E". 22,5% of pre-service teachers agreed that modeling was constructing an object by enlarging or minimizing the original one. PT31 stated, ''Modeling is constructing objects by minimizing or enlarging their original size since we cannot produce an identical one."

50% of pre-service teachers claimed that they did not know the answer to the question *"which path do you think scientists follow while designing a model?"* Four pre-service teachers agreed that scientists should take aims and objectives into account. One pre-service teacher claimed that scientists should report their studies, two of them said that object's real features should be considered, one of them claimed that practical features should be emphasized while constructing a model, and two of them mentioned that advantages of models should be more than their disadvantages.

Question 3. *What are the aims for using models in science (physics, chemistry, biology) education?*

Views of pre-service teachers about aims of using models in science (physics, chemistry, biology) lessons are given in Table 3.

Table 3
Views of pre-service teachers about aims of using models in science lessons

Views of pre-service teachers	**N**	**%**
To provide meaningful and permanent learning	23	57,5
To concretize abstract concepts	15	37,5
To visualize	10	25
Enable students to relate concepts to everyday life	3	7,5
To increase students' motivations	3	7,5

When pre-service teachers' views about aims of using models in science lessons (physics, chemistry, biology) are analyzed, as in Table3, 57,5% of pre-service teachers agreed on the view that models were used for meaningful and permanent learning. PT29 explained his/her view as: " the purpose of this is to make learning meaningful and permanent by experiencing" 37.5% of pre-service teachers were agreed that in science models were used for concretizing abstract concepts. Answer of PT2 to this question was "It should concretize abstract situations". 25% of pre-service teachers agreed that models were used for visualizing things in science courses. PT28 explained his/her view as " for example, while explaining organs, we cannot make students fully understand organs' forms and their places. When models are used, we achieve permanent learning since we visualize them." 7,5% of pre-service teachers agreed that while using models in science education, the aim is to enable students to relate concepts with daily life. PT13 stated, "Because science courses are related to daily life, modeling provides students with the ability to relate these with daily life and to interpret the events around him/her." 7,5% of pre-service teachers agreed that models were used in order to motivate students and promote their will to learn. Explanation of PT39 was: "it is used in order to provide students with better understanding of the subject draw their attention and help them develop positive attitudes toward science courses."

Question 4. *Which features do you think models should have?*

Views of pre-service teachers about the features models should have are given in Table 4.

Table 4
Pre-service teachers' views about the characteristics models should have

Views of Pre-service Teachers	**N**	**%**
They should reflect the features of the original object.	15	37,5
They should perfectly reflect the features of the original one	3	7,5
They should give information about the subject	1	2,5
They should be demountable and mountable /reusable	5	12,5
Hey should fit the subject and the aim	10	25
They should be concrete	1	2,5
They should be two or three dimensional	5	12,5
They should be economical	2	5
They should be practical	11	27,5
They should be interesting	2	5
They should be prepared according to dimensions and proportions of the original one	5	12,5
They should be related to contemporary topics	2	5
They should be appropriate with students' levels.	6	15
They should be simple and easy to comprehend.	6	15
They shouldn't take too much time	1	2,5

When Table 4 was analyzed, it was seen that about the features that models should have, 37,5% of pre-service teachers agreed that models should reflect the features of the original object or event, 7,5% of them mentioned that it should perfectly reflect the features of the original object or event. 2,5% of them stated that it should give information about the subject, 12,5% of them expressed that it should be demountable and mountable. 25% of pre-service teachers claimed that it should be suitable with the subject and the aim, 2,5% mentioned that it should be concrete. 12,5% of them claimed that it should be two or three dimensional, 5% mentioned that it should be economical, 27,5% claimed that it should be practical, 5% claimed that it should be interesting, 12,5% mentioned that it should be prepared by taking the scale and the proportions of the original one into account, 5% claimed that it should be related to contemporary topics, 15% of them claimed that it should be simple and easy to comprehend, and 2,5% of them agreed that it shouldn't take too much time.

Question 5. *What is the relationship between modeling and technology? Give examples.*

Views of pre-service teachers about the relationship between modeling and technology are given in Table 5.

Table 5
Views of pre-service teachers about the relationship between modeling and technology

Views of Pre-service Teachers	**N**	**%**
Technology brings models	7	17,5
Models bring technology	21	52,5
Modeling and technology are interwoven	12	30

When Table 5 was analyzed, it was seen that about the relationship between modelling and technology, 17,5% of pre-service teachers agreed that models were developed by using technology, 52,5 % of them agreed that technology was developed with the help of models, 30% mentioned that modelling and technology are interwoven and they affect each other. PT9's view about the relationship between modelling and technology was *" Modelling is demonstrating an innovation or an invention. Having a concrete structure. The question of its advantages and benefits to technology by considering this structure's features. Moving from this model, with innovations and inventions, technology can be developed. For example, assume that we would by a new car. We may draw the car we want to buy, and then model it. We can develop a new material or a new instrument that has never been used before. What would happen if we used each material by using computers? Technology would be developed by using a model."* PT13 expressed his/her view as *" While modelling, we use technology. Power point presentations, animations, simulations help us visualizing our models."* PT11 mentioned *" Modelling and technology are interwoven. Demonstrating an event or an object as it is in real life is possible with the help of technology. When modelling and technology are used together, events or objects in real life become less dangerous and easier to demonstrate than they are in reality, and we can observe the consequences better. Thus, experiments become easier and cheaper."*

Question 6: *Write (T) for true, write (F) for false propositions given below.*

Pre-service Teachers' views about the propositions are given in Table 7.

Table 6
Views of pre-service teachers about the propositions

Propositions	**T**		**F**	
	N	**%**	**N**	**%**
Pictures, Computer animations, human body maquettes used in Science education are models. (T)	28	70	11	27,5
Models can be used for making predictions and testing predictions about a scientific event. (T)	22	55	17	42,5
Stick and ball figures used in science or chemistry lessons to show molecules and atoms that form molecules are models. (T)	38	95	1	2,5
Models are not real and they do not represent real objects' characteristics perfectly.(T)	39	97,5	1	2,5
Darwin's Evolution Theory, is not a model.(F)	3	7,5	36	90
Models cannot be changed or they cannot be modified even if necessary. (F)	37	92,5	2	5
Correlations or equations that show equivalence of two quantities are models. (T)	14	35	25	62,5
Periodical Table, which contains all the elements in the world according to a specific order, is a model (T)	25	62,5	14	35
An event or an object can have only one model.(F)	30	75	9	22,5
F=m. a , known as dynamics law, which is one of Newton's movement rules, is not a model (F)	6	15	33	82,5

Only scientists can construct models. (F)	37	92,5	2	5
Models are representatives of ideas about an object or an event, not the object or the event itself. (T)	17	42,5	22	55
Describing chemical bonds, formed by two or more elements, with formula is an example for modelling. (T)	21	52,5	17	42,5
Models must be concrete.(F)	9	22,5	30	75
5E learning cycle, based on constructivist learning theory, is a model.(T)	34	85	5	12,5
Models must be copies of real objects or events. (F)	28	70	11	27,5
Proportions and size of the original object and model must be equal. (F)	28	70	11	27,5
Analogies formed and presented in order to explain a new concept that is not known by students, are models. (T)	25	62,5	14	35
Food Chain, in which species in order according to their order of consumptions of each other, is not a model.. (F)	26	65	13	32,5
Models are approved according to the reality, that supports the theory or the model, instead of scientists' feelings.(F)	20	50	19	47,5
Charles Law, which indicates that volume of a gas is in proportion to absolute temperature under constant pressure, is a model. (T)	17	42,5	22	55
Forms in students' minds about a subject are not a model because they are not concrete. (F)	17	42,5	22	55
When we go to buy an apartment, the maquette we see in there, is not a model. (F)	28	70	11	27,5
Plastic human body skeleton, which is shown to explain the structure of bones, bone types and properties within the muscular and skeletal system unit, is a model. (T)	34	85	5	12,5
Factorization of a quadratic equation, is not related to modelling (F)	15	37,5	24	60
Acid-base, reduction-oxidation reactions, electric current, electrical ignition are not models, but they are concepts. (F)	11	27,5	28	70
A model does not interact with the target it represents. Therefore, photographs or spectrums are not models. (T)	17	42,5	22	55
We cannot design a model of an object or an event, which we cannot observe.(F)	27	67,5	12	30
Everything about a model must explain the event it represents.(F)	2	5	37	92,5
Pictures in our minds about a scientific event are also models.(T)	25	62,5	14	35
Toy cars we had when we were children, were not models since they did not reflect all the features of a car. (F)	28	70	11	27,5

When Table 6 was analyzed it was seen that 95% of pre-service teachers' answers to the proposition ''Sticks and balls that are used in order to show molecules and atoms in science and chemistry lessons are models'' were correct. 97,5% of pre-service teachers gave correct answer to the proposition ''Models are not real and they do not reflect the original objects' characteristics perfectly'', 90% of them gave incorrect answers to the proposition '' Darwin's evolution theory is not a model''. 92,5% of them gave correct answers to the proposition ''Models cannot be changed or modified even if necessary'' , 82,5% of them gave correct answers to the proposition ''F=m.a, known as dynamics law, which is one of Newton's movement rules, is not a model''. When the table was analyzed, it was also seen that 92,5% of pre-service teachers answered the proposition "only scientists can construct models.'' correctly, 75% of them gave in correct answer to the proposition that indicates that models must be concrete. 85% of pre-service teachers answered this proposition correctly: " 5E learning cycle, based on constructivist learning theory, is a model." 85% of them gave correct answer to the proposition that indicates "Plastic human body skeleton, which is shown to explain the structure of bones, bone types and properties within the muscular and skeletal system unit, is a model.", 92,5% of pre-service teachers answered the proposition "Everything about a model must explain the event it represents" correctly.

Discussion and Conclusion

As a result of the study, it is seen that while describing models, pre-service teachers emphasized on enlarged or minimized form of objects, two or three dimensional visual materials, and instruction method. Although their definitions of models were not false, it can be indicated that pre-service teachers' definitions were inadequate. At this point, it can be inferred that about models, the first think they thought of was scaling models or they were unaware that models could be not only concrete, but also abstract, or they had no knowledge about abstract models.

It was seen that pre-service teachers described modelling as structuring a model, using a model, enlarging, or minimizing a real structure, visualizing concepts, using models as teaching materials, expressing different points of view in teaching. From their descriptions, it was understood that great majority of pre-service teachers thought of modelling as a way of concretizing concepts and they did not have any idea about the path scientists should follow while designing models, and some pre-service teachers emphasized that objectives and the original object should be taken into account while designing models. It has also been found that the studies in the literature have resulted (Van Driel & Verloop, 1999; Güneş, Gülçiçek & Bağcı, 2004; Justi & Gilbert, 2002; Berber & Güzel, 2009; Harman, 2012). Harman detected that pre-service teachers described modelling as a three dimensional sample object, a visual material that represents reality, a way of concretizing abstract concepts, a thing that enables meaningful learning, simplifies explaining, enables permanent learning, visualizes concepts in mind, and it is used for stimulus.

Pre-service teachers agreed that models are used in science lessons (physics, chemistry, biology) in order to concretize abstract concepts, permanent learning, facilitate learning, picture things mentally by visualizing concepts, meaningful learning, relate new information with daily life and practice them, to enable learning by doing, to motivate and to draw attention. Particularly it is concluded that pre-service teachers were agreed that models are used for enabling meaningful, permanent and affective learning, and concretizing abstract concepts(Güneş, Gülçiçek & Bağcı, 2004; Driel & Verloop, 2002; Justi & Gilbert, 2002). Berber and Guzel (2009) detected in their studies that science pre-service teachers see models as representations of reality and aware of the roles of models in science education.

It was seen that pre-service teachers generally agreed that models should be economical, practical, simple, and easy to comprehend, informative, perfectly represent the features of the original object or event, identical with the object. Also they agreed that models should be prepared by taking the original scale and proportions into consideration, suitable with aims, concrete, about contemporary topics, suitable with students' level, mountable and demountable, interesting, and shouldn't take too much time. Pre-service teachers accepted the view of models should represent the features of the real object more than the view of models should reflect features of the real object. At this point, it is observed that only three pre-service teachers had incorrect views about the question of models should represent all features of original objects. It has also been found that the studies in the literature have resulted (Van Driel & Verloop, 1999; Güneş, Gülçiçek & Bağcı, 2004; Justi & Gilbert, 2002). Ornek(2008) detected that about the items which should be taken into consideration while designing a model, pre-service teachers expressed their opinions as it should be economical, practical, suitable with the aim, suitable with students' level, should be three or two dimensional. It was concluded that pre-service teachers mostly agreed that a model should be economical, practical, should be two or three dimensional, suitable with the aim, suitable with students' level.

While relating models with technology, most of the pre-service teachers claimed that technology is developed with the help of models. It is concluded from the examples given by pre-service teachers that they thought that models could only be concrete and pre-service teachers were only aware of physical models.30% of pre-service teachers agreed that models were structured with the help of technology,

animations and simulations were models which were formed thanks to technology, and these support science education visually.

When pre-service teachers' answers to the propositions are analyzed, it is seen that 97,5% of them were aware that models are not real and they do not reflect every feature of the real object. 90% of them were unaware that evolution theory, F=m.a formula, and formulizing a quadratic equation were examples of modelling, uncertain about formulating chemical compounds, and Charles Law were models. In addition, 92,5% of them agreed that everything about a model must represent the event it represents. It was also seen that pre-service teachers were indecisive about this subject since they thought that a model must represent every feature of an original object although they were aware that a model was not real and it does not reflect all the features of the original object or event. It has also been found that the studies in the literature have resulted (Berber & Güzel, 2009; Stocklmayer, 2010; Ergin, Özcan & Sarı, 2012; Harman, 2012). In addition, when answers given to propositions were analyzed it was concluded that they thought that only scale models were models, they have general knowledge of physical models but they didn't have adequate information about mental and analogical models. Harman (2012) found in his study in 2012 that science pre-service teachers had adequate knowledge about models and modelling, they had inadequate knowledge about model types and which examples could be models or not, and they were unaware that the representatives they used in their daily life were models.

Suggestions

Science pre-service teachers must be provided with adequate education about models and modeling by taking models and modeling subject into education program in science departments in education faculties.

In order to increase pre-service teachers' awareness, their information should be extended and they should be provided with adequate information about qualifying some examples as models by giving them extensive theoretical information in teaching principles and methods, education technologies and material design, and teaching methods course, and with various applications..

Science pre-service teachers' wrong perceptions such as models can only be concrete, should be remedied. In addition to physical models, pre-service teachers should comprehend different model types such as: mathematical models, computer models, analogical models and mental models and they should apply these models. Science pre-service teachers should be encouraged and informed about producing and using computer models such as animation and simulation.

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Appendix. Views On Modeling In Science Education Questionnaire (VoMSEQ)

A. Please, read each question carefully and write down your sincere responses.

1. What does the concept of model mean to you? Please, describe.
2. What is modeling and which pathway do you think scientists follow while designing a model?
3. What do you think models are used for? Please, explain.
4. What are the aims of using models in science courses (physics, biology, chemistry)?
5. Which features do you think models should have?
6. Do you think that the modeling interacts with technology? (If no) Why is that the case? (If yes) What is the nature of this interaction?

B. Please, read each statement carefully and put (T) for the propositions that you think are true, put (F) for the propositions that you think are false.

( ) Pictures, computer animations, and plastic human bodies are the models available for education.
( ) Models can be used to make or test predictions about a scientific phenomenon.
( ) Stick and ball figures to show bonds and atoms are the models drawn in science books.
( ) Models are not real and they do not represent real objects as they really are.
( ) Darwin's theory of evolution is not a model.
( ) Models cannot be changed or modified even if it is necessary.
( ) Correlations or equations are the models to show relation among quantities.
( ) Periodical table is a model.
( ) There can be only one model for an event or an object.
( ) Second law of Newton that can be formulated as “F = ma” is not a model.
( ) Only scientists are able to construct models.
( ) Models are representatives of ideas about an object or an event, not the object or the event itself.
( ) Describing chemical bonds with a formula is an example for modeling.
( ) Models should be in concrete form.
( ) 5E learning cycle is a model based on constructivist learning theory.
( ) Models should be copies of real objects or events.
( ) Size of the original object should be equal in proportion of models.
( ) Analogies are the models which used to explain new concepts over already known concepts.
( ) Food chains are not a model which displays the species in order of consumptions of each other.
( ) Models are approved according to the reality that supports the theory or the model, instead of feelings of scientists.
( ) Charles’s law is a model which shows that the volume of the gas also increases in proportion as absolute temperature increases.
( ) Subject patterns shaped in student minds are not a model since they are not concrete.
( ) The cartoon imitation of the buildings exhibited in house management offices are not a model.
( ) Plastic human skeleton is a model used to explain the structure and function of skeletal system.
( ) Factorization of a quadratic equation is not related in modeling.
( ) Acid-base, reduction-oxidation reactions, electric current, electrical ignition are not models, but they are concepts.
( ) Photographs or spectrums are not models, since a model does not interact with presented target.
( ) We cannot design a model of an object or an event, which cannot be observed.
( ) Everything about a model should explain the event it represents.
( ) Pictures about a scientific event in our minds are also models.
( ) Toy cars are not models since they did not reflect to all features of a car