The Views of high school students' on the scientific modeling

Hilal Aktamis[1], Serap Çaliskan[2]
[1]*Faculty of Education Department of Science Education, Adnan Menderes University, Turkey.*
[2]*Buca Faculty of Education, Department of Science Education, Dokuz Eylul University, Turkey.*

E-mail: hilalaktamis@gmail.com

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Abstract

The general aim of modeling is to test an idea- represented as a system of related processes, events, or structures- against observations in the real world. The scientific modeling is different from the model space craft or the various models (clothes, cars, etc.) on the magazines. The model space crafts are done to reduce the size of the object that we can see to a smaller size which can be worked on better. The purpose of using such models is rather than explaining an event, to reproduce by copying as in the model space craft example or to advertise by the models on the magazines. Therefore, in this study, it was aimed to do validity and reliability study of "The Role of the Scientific Models Scale" according to the high school students' level and whose reliability study was done in order to determine the views of the high school students towards scientific modeling.

Keywords: Scientific modeling, high school students, students' views

Resumen

El objetivo general de la modernización es poner a prueba una idea- representada como un sistema de procesos relacionados, eventos, o estructuras- contra las observaciones del mundo real. La modernización científica es diferente del modelo de nave espacial o de varios modelos (ropa, coches, etc.) en las revistas. El modelo de nave espacial se hace para reducir el tamaño del objeto que podemos ver a un tamaño más pequeño que puede ser trabajado sobre la mejora. El propósito del uso de estos modelos en más que explicar un evento, para reproducir por copias como en el modelo nave espacial o de publicidad por los modelos en las revistas. Por lo tanto, en este estudio, que tenía por objeto hacer validez y fiabilidad el estudio de "El papel de la Escala en los Modelos Científicos" de acuerdo al nivel de los estudiantes de secundaria y cuya fiabilidad de estudio fue hecha con el fin de determinar los puntos de vista de los estudiantes de secundaria hacia modelos científicos.

Palabras clave: Modelado científico, estudiantes de secundaria, concepciones de estudiantes.

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I. INTRODUCTION

The general aim of modeling is to test an idea- represented as a system of related processes, events, or structures- against observations in the real world and to assess the adequacy of the representation against standards of evidence. The most important overall goal of scientists is the development of an understanding of how the natural world works. In all scientific disciplines, this understanding is most often accomplished through the conceptualization of models of various natural processes. The term "model" is often used to describe physical replicas of objects or systems. Models are important in science because they can be used as instruments to help in the construction of theories [1, 2]. The solar eclipse and the lunar eclipse models as the examples of the physical models, representational systems, such as maps or diagrams, and mathematical algorithms or formulae are also referred to as models. Students tend to think of physical objects that are constructed to convey an idea as models themselves. Rather than concentrating on the model itself, it should be concentrated on the correlations, similarities/differences of the structures represented by the models. The models are the comment of the investigated concept and correlation [3].

The scientific modeling is different from the model space craft or the various models (clothes, cars, etc.) on the magazines. The model space crafts are done to reduce the size of the object that we can see to a smaller size which can be worked on better. The purpose of using such models is rather than explaining an event, to reproduce by copying as in the model space craft example or to advertise by the models on the magazines [3]. A scientific model is a set of *ideas* that describes a natural *process* (For example meiosis model). A 'scientific' model so conceived can be mentally run, given certain constraints, to explain or predict natural phenomena (such as atomic model). It is in this way that scientific models are both desirable *products* of scientific research and useful as *guides* to future research (such as Rutherford atomic model, Bohr atomic model) [4].

The creative process of developing hypotheses from theories or models and testing these against evidence derived from observation and experiment. At the same time NRC [5] expresses the models as follows:

''Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists'' [5].

The abstract nature of the sciences broadens the usage area and the function of the models in the science classes. In science education, it can be very difficult to make certain concrete concepts as well as the abstract concepts achievable and understandable for the students. For example magnetic lines of force as an abstract concept is not a well-known concept for the students. When we think of the representation of the electrical and magnetic field forces as *line groups* in physics, or the chemical bonds as *stick*, and the atoms as *small balls* used to explain the atomic structures in chemistry, the significance of model and modeling in science education and learning can be seen [6].

Therefore, in this study, it was aimed to do validity and reliability study of "The Role of the Scientific Models Scale" according to the high school students' level and whose reliability study was done in order to determine the views of the high school students towards scientific modeling.

II. METHOD

At the research, survey model was used. Totally 409 students 234 of whom are female, and 175 of whom are male who are reading at 9th, 10th, 11th and 12th grades at high school in İzmir and Aydın provinces in Turkey participated into the research. In the research, the modeling questionnaire which is translated by Gunes, Gulcicek & Bagci [6], and where some items are added by the researchers again was used. At the research, the reliability of the scale was obtained by Cronbach's alpha reliability coefficient, and the validity of it was obtained by factor analysis.

A. Reliability and Validity Analysis of Modeling Scale

In order to investigate the construct validity of the scale, the factor analysis was performed. At the factor analysis, the items giving high load values with a factor are called as the items measuring the structure defined by that factor, and generally, it is preferred to have an item factor load value equals to or greater than 0.45. However, it is seen that the factor load value up to 0.30 can also be accepted for few numbers of items at the applications [7]. And in this research as well, the accepted limit value for the factor load value in item selection was reduced up to 0.30 for few numbers of items. In order to define the factor structures of the scale, first unrotated principal component analysis (PCA), and then Varimax orthogonal rotation technique in terms of principal components were used.

Gunes and his colleagues [6] in their researches done used a questionnaire to receive the views towards modeling. 26 of 30 items of the questionnaire used by the researchers are taken from Treagust's [8] study called as "*Students'Understanding of the Role of Scientific Models in Learning Science"*. And the last 4 test items are developed and added by the researchers in order to determine the science and mathematics instructors' views about the scientific model samples. As a result of these operations, the five-choice Likert type questionnaire consisting of 30 items was prepared by the researchers.

And in this research, in addition to these operations, the validity and reliability studies of the questionnaire prepared by Gunes and his colleagues [6] were done, and the questionnaire was transformed into the scale. Therefore, in the study it is called as scale instead of questionnaire, and herein after it will be called as The Role of the Scientific Models Scale. The students were wanted to mark any of the best applicable choice for themselves from the degrees of acceptance listed as "strongly disagree", "disagree", "undecided", "agree", and "strongly agree" for each item of the scale.

As a result of the reliability and validity studies done in the research, new names were given to the items categorized under the factors determined as different from the names existing in the original form of the scale. The findings obtained as a result of the validity and reliability studies of the Role of the Scientific Models Scale (RSMS) are presented below:

1. It is convenient to use the Alpha coefficient developed by Cronbach which is a criterion of inner consistency in order to determine the reliability level in a Likert-type scale [9]. At the end of the reliability analysis, the Cronbach Alpha reliability coefficient was calculated as $\alpha = 0.86$.

2. One of two methods to obtain the structure validity of the scale is the item analysis; and the other one is the factor analysis [7]. Below, the item analysis and factor analysis processes belonging to this scale were explained in detail.

a) Item Analysis: When the total item scale correlations belonging to the RSMS were calculated, it was seen that all items measured the same behavior where the minimum correlation was 0.21, and the maximum correlation was 0.57. At the first step, an item having a total item-scale correlation lower than .20 is removed from the scale.

b) Factor Analysis: The Kaiser-Meyer-Olkin (KMO) Sampling Adequacy coefficient which displays the convenience of performing factor analysis for the scale (KMO>0.70) was calculated as 0.88; and then, the Varimax rotation technique was applied to the scale, and seven factors whose eigenvalues greater than 1 were created.

At the second step, 3 overlapping items whose difference between their factor loads were smaller than 0.10 were removed from the scale. At the end of the fifth factor analysis process performed after these items were removed, it was seen that 21 items were collected under five factors.

The eigenvalues, percent of variance, and total percent of variance related to these five factors were given in Table I.

TABLE I. Findings Related to the Factors Obtained at the End of the Factor Analysis.

Factor	*Eigenvalue*	*Percent of Variance*	*Total Percent of Variance*
1	2.34	11.15	11.15
2	2.19	10.42	21.57
3	2.17	10.35	31.92
4	2.16	10.28	42.20
5	2.15	10.26	52.46

When the values in Table I were examined, it was seen that each eigenvalue was greater than 1,0; and all five factors represented the 52.46% of total variance. Distribution of items existing at scale into factors, and factor loads at the end of the factor analysis were given in Table II.

TABLE II. Distribution of Items Existing at Scale Into Factors, and Factor Loads at the End of the Factor Analysis.

Item No	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*	*Factor 5*
23	0.66				
27	0.65				
21	0.64				
30	0.62				
19	0.51				
16		0.69			
20		0.66			
17		0.57			
14		0.52			
13		0.45			
6			0.77		
3			0.71		
4			0.50		
5			0.49		
24				0.80	
26				0.76	
25				0.75	
10					0.79
12					0.67
9					0.65
15					0.46

According to the values obtained at the end of the factor analysis performed by Varimax rotation technique, the principles of being the factor load of each item existing at the scale at least 0,30; and not having any overlapping factor load (the difference between the factor loads < 0.10) had been taken into consideration. As seen from Table II, the factor loads belonging to 21 items constituting the (RSMS) range between 0.45 and 0.80. By taking into consideration the items which were contained in five dimensions, the names given to these dimensions, number of items within each dimension, Cronbach Alpha Reliability Coefficient belonging to each dimension, and sample items were given in Table III.

TABLE III. Names Given to the Factors Related to RSMS, Number of Items, Results of Reliability Study, and Sample Items.

Sub Dimensions	*Number of Items*	*Cronbach Alpha*	*Sample Items*
Abstractness of the models	5	0.69	The Newton's Laws; Archimedes' principle, Evolutionary theory, and Pythagoras' theorem are the samples of the model.
Content of the models	4	0.66	A model can be a diagram, a figure, a map, a graphics or a picture.
Structure of the models	4	0.68	The models can explicitly display the correlation between the opinions.
Changeability of the models	3	0.77	A model can change if new theories or phenomena verify the different facts.
Being realistic of the models	5	0.66	A model should exactly resemble the real object except for its size.

The Role of the Scientific Models Scale (RSMS) consisting of 21 items and five factors was obtained after performing the reliability and validity studies of modeling questionnaire the original form of which is developed by Gunes and his colleagues [6].

B. Analysis

In order to investigate the construct validity of the scale, factor analysis was done. At factor analysis, the items giving high load value by one factor are called as the items measuring the structure defined by the factor, and generally it is preferred to have an item factor load value of 0.45 or higher. However, at the applications, it is seen that the item factor load value is accepted up to 0.30 for few items [7]. And also in this research, at item selection, the accepted limit value for the factor load value is reduced up to 0.30 for few items. To define the factor structures of the scale, first, unrotated principal component analysis (PCA) was used, and then, Varimax orthogonally rotated technique was used according to principal components.

Moreover, the students' views according to their scores taken from each sub-factor of RSMS were calculated as low, middle, and high by percentage and frequency values (n) by SPSS 11.5 statistical analysis.

III. FINDINGS AND COMMENTS

The students' views were given in percentages for each sub-factor of the scale of views towards modeling.

A. Students' Views about the Abstractness of Models

Totally five expressions exist in this factor. The maximum score which can be gotten from this factor is 25, and the minimum score is 5. According to this, it is thought that the students' views are in high level if the total score of them taken from this factor is between 25 and 18; in middle level if it is between 18 and 12; and in low level if it is between 12 and 5. The views of the students existing in these levels were given in percentages and frequencies (Table IV).

TABLE IV. The Percentage and Frequency Values Related to The Students' Views About the Abstractness of Models.

Views	*Frequency (n)*	*Percentage (%)*
Low Level	22	5.4
Middle Level	159	38.9
High Level	228	55.7

It is seen that more than half of the students (55.7%) delivered views about that the models can also be abstract. 38.9% of the students consider in middle level that the models can be abstract. And it is seen that a few numbers of students (5.4%) think that the models are not abstract.

B. Students' Views about the Content of Models

Totally five expressions exist in this factor. The maximum score which can be gotten from this factor is 25, and the minimum score is 5. According to this, it is thought that the students' views are in high level if the total score of them taken from this factor is between 25 and 18; in middle level if it is between 18 and 12; and in low level if it is between 12 and 5. The views of the students existing in these levels were given in percentages and frequencies (Table V).

TABLE V. The Percentage and Frequency Values Related to The Students' Views About the Content of Models.

Views	*Frequency (n)*	*Percentage (%)*
Low Level	13	3.2
Middle Level	127	31.1
High Level	269	65.8

It is seen that most of the students (65.8%) had information about the content of the models. It is seen that 31.1% of the students had information about the content of the models in middle level. And it is seen that a few numbers of students (3.2%) had no information about the content of the models.

C. Students' Views about the Structure of Models:

Totally four expressions exist in this factor. The maximum score which can be gotten from this factor is 20, and the minimum score is 5. According to this, it is thought that the students' views are in high level if the total score of them taken from this factor is between 20 and 15; in middle level if it is between 15 and 10; and in low level if it is between 10 and 5. The views of the students existing in these levels were given in percentages and frequencies (Table VI).

TABLE VI. The Percentage and Frequency Values Related to The Students' Views About the Structure of Models.

Views	*Frequency (n)*	*Percentage (%)*
Low Level	16	3.9
Middle Level	138	33.7
High Level	255	62.4

It is seen that most of the students (62.4%) had information about the structure of the models. It is seen that 33.7% of the students had information about the structure of the models in middle level. And it is seen that a few numbers of students (3.9%) had no information about the structure of the models.

D. Students' Views about the Changeability of Models:

Totally three expressions exist in this factor. The maximum score which can be gotten from this factor is 15, and the minimum score is 5. According to this, it is thought that the students' views are in high level if the total score of them taken from this factor is between 15 and 12; in middle level if it is between 12 and 8; and in low level if it is between 8 and 5. The views of the students existing in these levels were given in percentages and frequencies (Table VII).

TABLE VII. The Percentage and Frequency Values Related to The Students' Views About the Changeability of Models.

Views	*Frequency (n)*	*Percentage (%)*
Low Level	22	5.4
Middle Level	147	35.9
High Level	240	58.7

It is seen that more than half of the students (58.7%) considered that the models can change. It is seen that 35.9% of the students considered that the models can change in middle level. And it is seen that a few numbers of students (5.4%) considered that the models cannot change.

E. Students' Views about Being Realistic of Models:

Totally five expressions exist in this factor. The maximum score which can be gotten from this factor is 25, and the minimum score is 5. According to this, it is thought that the students' views are in high level if the total score of them taken from this factor is between 25 and 18; in middle level if it is between 18 and 12; and in low level if it is between 12 and 5. The views of the students existing in these levels were given in percentages and frequencies (Table VIII).

TABLE VIII. The Percentage and Frequency Values Related to the Students' Views about Being Realistic of Models.

Views	*Frequency (n)*	*Percentage (%)*
Low Level	71	17.4
Middle Level	216	52.8
High Level	122	29.8

It is seen that almost half of the students (52.8%) considered that the models are realistic. It is seen that 29.8% of the students considered that the models are realistic in middle level. And it is seen that 17.4% of students considered that the models are not realistic.

IV. CONCLUSIONS

The "Role of the Scientific Models Scale" whose reliability and validity analyses were performed consists of five factors and 21 items. The Cronbach's alpha reliability coefficient of the scale was found as 0.86. The names of the factors obtained as a result of the factor analysis done are called as "abstractness of the models", "content of the models", "structure of the models", "changeability of the models", and "being realistic of the models". By means of the scale obtained, 9th and 10th grade students' views related to the modeling were investigated according to the sub-factors.

It is concluded that more than half of the students considered that the models can be abstract and changeable. Similarly, it is concluded that most of the students had information about the content and structure of the models. However, it is seen that almost half of the students considered that the models are realistic. And the number of the students who considered that the models are not realistic is not so few.

Although the students generally know what the models are, the models' content and structure; it is seen that the number of middle and high level students who considered that the models are not realistic is not so few.

Teachers should give importance to modeling at schools, and they should use the models in the lectures. Especially certain activities displaying that the models are exactly the same as reality should be done. Here, it can be thought that the models are confused with the simulations and analogies.

The researchers who are studying in this field should develop various abstract and concrete models which can be used in the lectures, and should test their applicability.

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