A COMPARISON BETWEEN ELEMENTARY SCHOOL STUDENTS' MENTAL MODELS AND VISUALIZATIONS IN TEXTBOOKS FOR THE CONCEPT OF ATOM

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Abstract

This study was designed for two major goals, which are to describe students' mental models about atom concept from 6th to 8th grade and to compare students' mental models with visual representations of atom in textbooks. Qualitative and quantitative data were collected with 4 open-ended questions including drawings which were quantified using the Evaluation Rubric for Atomic Model Representations. Descriptive statistics were also used to describe students' mental models and textbook visual representations. The study was implemented in two elementary schools in Istanbul, Turkey with 90 students. In addition, 251 visuals from the science and technology textbooks were evaluated in the study. The results indicated that Dalton's Atomic Model was seen as the most frequent model in both the students' drawings and textbook atom visuals. However, the results were different in the each grade level. In addition, qualitative results show that motion was not frequently seen in students' drawings nor textbooks visuals.

Introduction

Understanding chemistry relies on making sense of the invisible and untouchable world; therefore, chemistry is a difficult subject for students to understand. The level of abstraction of chemical concepts such as chemical bonding, atomic theory, molecules or subatomic particles makes chemistry also difficult to get conceptual understanding for students. In addition, dynamic nature of chemistry is not directly observable to illustrate, it requires representing and translating the chemical problems between macroscopic, symbolic and submicro levels (Harrison and Treagust, 2000; Johnstone, 1991, 1993). Links between the macroscopic, symbolic, and submicro levels are necessary for deeper understanding in chemistry (Gabel, 1993; Johnstone, 1993; Lee, 1999).

The atomic model plays a crucial role in the study of chemistry because it is given in early grades in many countries such as United Kingdom, United States of America and it is given in the 7th grade in the science curriculum in Turkey. Learning atom concept is required for an understanding of structural properties of matter, but unfortunately many students have alternative conceptions about the atom concept (Ben-Zvi, Eylon, and Silberstein, 1988).

The image of atom needs to be simple, accurate and also accessible for students because it is the basis of the understanding of the molecular world (Wright, 2003). In this respect, textbooks also play an important role because students generally use textbooks by themselves, and textbooks present different atomic models for students.

Models, in general, are valuable tools because they can be used to make sense of invisible, untouchable and abstract science concepts such as the structure of atom (Pringle, 2004). Teachers help students to construct their mental models via 2D or 3D models and representations. Especially, teaching atoms and atomic structure to elementary students is really challenging because it is hard to imagine how atoms look like. When things are too small to be seen with eye or too big, models provide the visual representations to the learners (Pringle, 2004). Atoms cannot be seen with the naked eye because they are smaller than the wavelengths of visible light. Therefore, modeling is required and essential to think and work scientifically for the concept of atom. (Harrison, 2001).

Mental models are visual or abstract representations of reality and people develop them as a result of their own observations or experiences (Craik, 1943). Students also construct their own mental models in their minds. Rapp (2005) states that mental models are not just based on students' individual understanding and not always permanent or reliable, instead they can be tentative in the time being. In other words, students mental models can change in different grades like the results of Coll and Treagust's (2002) study. Therefore, students' mental models can be determined in each grade to see the academic grade level differences. Rapp (2005) also clarifies that students' mental models are abstract structures or schemas which are combination of personal perceptions, physical, and conceptual features of students' experiences. Greca and Moreira (2000) explain that mental models are personal and they are built in the basis of students' interactions with the world. In order to understand their surrounding world, mental models will help us to occur the things in their minds. In addition, synthetic models (or misconceptions) can be integration of the new and existing knowledge in students' mind. In this study, the integration of different atom models in the students' mental models was called the synthetic model (Vosniadou, 2002).

In the literature, many research questions have been devoted for students understanding for atom concept (Akyol, 2009; Ben-Zvi, Eylon and Silberstein, 1986; Çokelez and Duman, 2004; Harrison and Treagust, 1996; Justi, R., and J. Jilbert, 2000; Park and Light,2009; Pringle, 2004; Robinson, 2000; Yildiz, 2006; Wright, 2003). However, up to date, no research studies on the comparison of students' mental models and textbook visuals on the atom have been reported in the literature. The comparison of the visuals in textbooks and the students' mental models is examined in this study.

Atomic models and its subatomic particles play a central role in the study of chemistry and those are usually introduced early (7th grade) in the school curriculum. The science educators identified a wide range of alternative conceptions in the studies (Ben-Zvi, Eylon, and Silberstein, 1988, Garnett and Hacking, 1995; Griffiths, 1994; Herron, 1978; Janiuk, 1993) about atom. Most science educators agree that learners' prior knowledge highly influences their construction of new knowledge (Ausubel, 1978). Prior knowledge may stem from instructional methods, textbooks, curriculum or the combination of these factors. When we focus on textbooks' usage, we see that teachers often use textbooks for planning study programs and preparing the content of their lessons (Sanchez and Valcarcel, 1999). Especially, for the abstract and nonobservable concepts like atom, models are utilized in textbooks. Therefore, in the literature, number of recent research studies has pointed out science textbooks from different perspectives such as content, language, visuals, readability levels, questioning style, gender discrimination (Bazler and Simonis, 1990; Brincones and Otero, 1994; deBerg and Treagust, 1993; Eltinge and Roberts, 1993; Jeffery and Roach, 1994; Staver and Lumpe, 1993; Stinner, 1992; Strube, 1989). A number of studies examined also visuals (Bean et al., 1990; Dündar, 1995; Holliday, 1990; Leive and Lents, 1982; Lord, 2001; Reid 1990a,b; Pozzer and Rath 2003;) but there is not specific study that pointed out atom concept and atom visuals in textbooks.

The present study has two major purposes: first to describe students' mental models on the concept of atom from 6th to 8th grades. Second is to compare the students' mental models with textbooks' visual representations for the atom concept.

Research Questions

The following questions will be investigated in this study:

- What features do students' mental models for atomic structure have in their grade (6th to 8th)

levels?

- How do science textbooks describe atomic models with visualizations in each grade (6^{th} to 8^{th}) level?
- What are the similarities between the textbook visualizations of atomic model and students' mental models of atom?

Methodology

This research includes a descriptive and comparative research designs which determine and describe the things in different grade levels. It involves data collection to learn students' opinions on the atom concept. This study is a cross sectional descriptive study because the data were collected from the selected students in a single time of the period but collecting data took time (Gay and Airasian, 1996).

The students in the first semester of the year 2011-2012 were involved in this study by convenient sampling. The study was implemented in two elementary schools in Istanbul, Turkey with 90 students (30 students from each level). Ethical approval for the research had also been done by The Ministry of Education, Turkey.

There were totally 251 atom visuals as 89 in the 6^{th} grade, 87 in the 7^{th} grade, and 75 in the 8^{th} grade science and technology textbooks by Ministry of Education publication.

Design and Procedure

There are three parts in this study. Firstly, students' mental models were determined; secondly visuals of atoms in textbook were evaluated according to the same criteria. Finally, students' drawings and textbook visuals were compared for the study.

In the first part of the study "Test of Mental Models of Atom" was administered to identify students' mental models of atom.

The second part of the study included analysis of visualizations of atomic models in science and technology textbooks. The visual representations of atomic models were examined by using the "Evaluation Rubric for Atomic Model Representations (ERAMR)" which was also developed by the researcher based on the previous research results (Akyol 2009; Harrison and Treagust, 2000; Parkand Light, 2009; Yildiz, 2006).

In the last part of the study, the students' mental models and textbook visuals were compared and the similarities were investigated for the concept of atom in each evaluated grade level. The ERAMR was the same rubric that was used to evaluate students' mental model drawings and explanations.

Instruments

"Test of Mental Models of Atom" which was prepared by the researcher includes 4 open-ended questions. While preparing the "Test of Mental Models of Atom (TMMA)" instrument, the results of other studies (learning difficulties in atom, Akyol 2009; students representatives for atom and molecule, Çokelez and Duman, 2004; mental models of atom and molecules, Harrison and Treagust, 1996; scientific models, Justi and Jilbert, 2000; mental model of students, Taber, 2003; mental model of students, Yildiz, 2006;) were examined, and the questions were written in the light of the results of these studies. The validity of the instrument was established qualitatively. The content validity of the questions was achieved by asking 3 experts who are the professors in chemistry education and chemistry department of the university, and also a chemistry teacher. First and third questions asked the drawings or pictorial representations of atomic structure of Sodium and Neon atoms. Sodium was chosen because it was a common example in each grade of textbooks. Neon was chosen because its

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atomic structure was not usually given in the textbooks. The second and forth questions ask the written explanations of their drawings which are asked in questions 1 and 3.

Secondly, to assure the reliability of the "Evaluation Rubric for Atomic Model Representations (ERAMR)", one researcher and one teacher evaluated the students' responses. Reliability is related to the consistency of scoring the test (Gay and Airasian, 1996). Inter-rater reliability was counted separately for the students' answers and textbook visuals. In order to determine inter-rater reliability a chemistry teacher scored randomly 20% of selected responses of students who took TMMA in each grade. Two scorers agreed in about 90%, when a disagreement occurred in evaluation, it was discussed in detail and an agreement was reached. The percentage agreement between the two scorers; in other words the inter-rater reliability was found to be 96.73%. Cohen's Kappa is used as a measure of agreement between the two individuals. Cohen's Kappa coefficient was found 0.838 which has been accepted as very good agreement. Statistics information about these analyses is given in the Table 1.

Table 1 *Cohen's Kappa coeefficients of two rater's scores for evaluation rubric*

		Value	Asymp. Std. Error	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	0.838	0.034	21.011	0.000
N of Valid Cases		612			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					

From 6th to 8th grades, a total of 3 textbooks were evaluated by using the prepared rubric, two researchers were evaluated 20% of the all visuals in textbook by for inter-rater reliability. The percent of inter-rater reliability between two scorers was found to be 92.64%. Cohen's Kappa was also used as a measure of agreement between the two individuals. Cohen's Kappa coefficient was found to be 0.801 which has been accepted as very good agreement. Statistics information about these analyses is given in Table 2.

Table 2 *Cohen's Kappa coefficients of two rater's scores for textbook visuals*

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	0.801	0.015	37.978	0.000
N of Valid Cases		2159			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					

Data analysis and Results

Students' mental models of an atom

Descriptive statistics were carried out in order to answer the corresponding research questions after the TMMA was administered to the students. Students' answers were evaluated according to 17 criteria which took place in the ERAMR.

In the 6th grade students' drawings, the atomic bomb was shown with the highest frequency as 15 drawings out of 30 followed by 9 Synthetic, 2 Dalton, and 2 Rutherford's atomic model in Table 3. In other words, the 50% of the 6th grade students drew atomic bomb picture and 30% of the 6th grade students drew the synthetic model which was created by them. In the 7th grade Dalton model had the largest number among other models with 26 students' drawings followed by 2 synthetic models, 1 atomic bomb and 1 Rutherford's atomic model. When these numbers were given by percentages the 81.3% of students drew Dalton's atomic model, 9.4% of students created their own models which were called synthetic model. In the 8th grade, Bohr's atomic model had extremely large number with 25 students; it is the 83.3% of the 8th grade students' drawings. In the 8th grade, synthetic models took place 13.3% among the 8th grade students' drawings.

Table 3 *Students' mental models of atomic structure in each grade level*

		RQ1							
		none of the models	DALTON	THOMSON	RUTHERFORD	BOHR	QUANTUM	OTHER: ATOMIC BOMB	Total
Grade	6	0	4	1	4	4	0	17	30
	7	0	25	1	2	0	0	2	30
	8	4	1	0	0	25	0	0	30
Total		4	30	2	6	29	0	19	90

Some examples from students' drawings for the atomic models are also given in Figure 1-3:

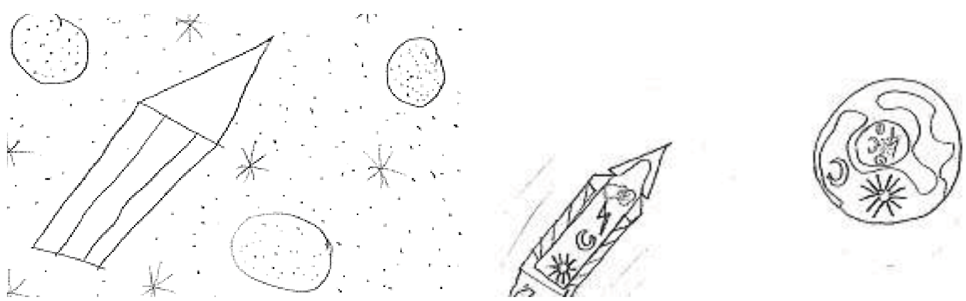

Figure 1. 6th grade, atomic bomb models

Figure 2. 7th grade, Rutherford's Atomic Model

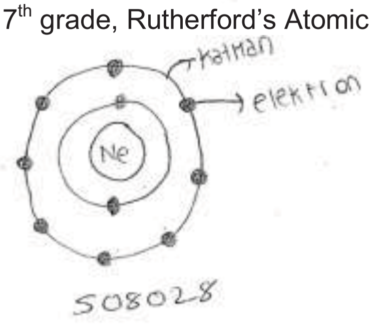

Figure3. 8th grade**,** Bohr's atomic model

Some examples for the synthetic models from each grade are given from Figure 4-10. In the Figure 4, the 1st orbital of atom is similar to the Bohr's atomic model but there are also different oriented orbitals so it is also similar to Rutherford. The atom model in the Figure 5 is a kind of Rutherford's atomic model but it does not show the positive ions in the centre of the atom. Therefore, these two atom models were also synthetic models.

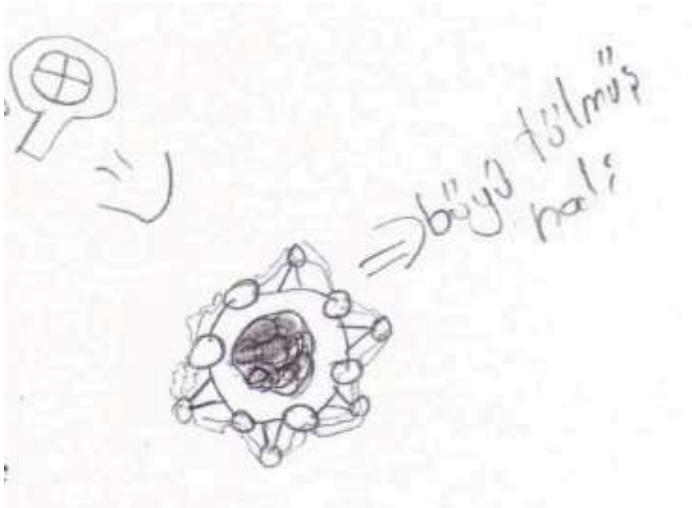

Figure 4. 8th grade, synthetic model-1

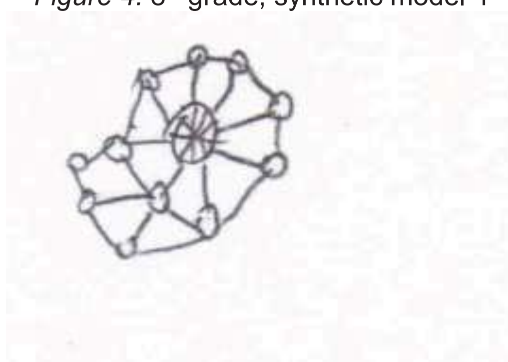

Figure 5. 8th grade, synthetic model-2

The 7th grade students' drawings are given in the Figure 6 and 7. Figure 7 has seven solid circles. These solid circles can be the separate atoms like the Dalton's atomic models or can be the number of sub atomic particles in different oriented orbitals. The model in the Figure 7 is a kind of Dalton's atomic model with the Rutherford orbitals. Therefore, these two students' drawings were also called as synthetic models.

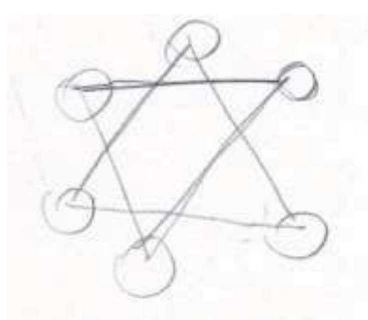

Figure 6. 7th grade, synthetic model-1

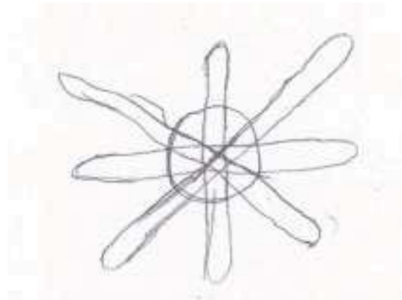

Figure 7. 7th grade, synthetic model-2

6th grade students' synthetic models are given in the Figure 8-10. Figure 8 is looking like Bohr's atomic model but the sub atomic particulates are distributed in the atom like the Thomson's atomic model. Figure 9 is a combination of Thomson's atomic model because of the distribution of the sub atomic particles. However, it is not exactly the Thomson's atomic model because there are many different spheres in the atom. Figure 10 is a kind of Dalton's atomic model with the different oriented orbitals like the Rutherford's atomic model. Therefore, these three drawings are also categorized as the synthetic models of students.

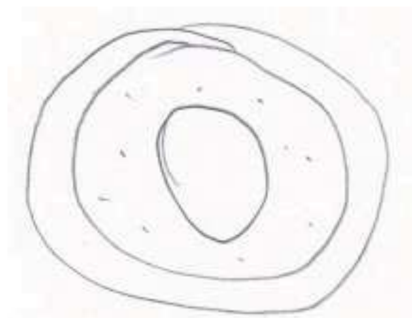

Figure 8. 6th grade, synthetic model-1

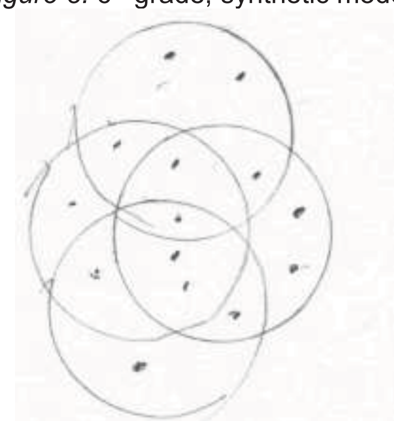

Figure 9. 6th grade, synthetic model-2

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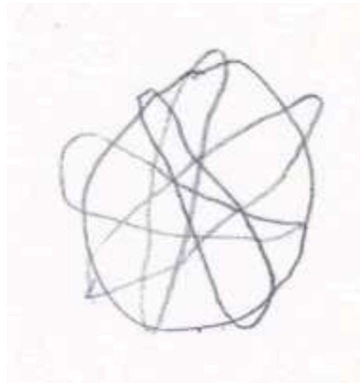

Figure 10. 6th grade, synthetic model-3

Explanations of the students' own drawings

As shown in Table 4, 54 students which is the 30% of the research sample didn't explain their drawings being 26 of them from 6th grade, 17 of them from 7th grade, 3 of them from 8th grade, were consistent with their drawings.

While none of the 6th grade student wrote extra information to their drawings, 20% of all sample with 1 student from 7th grade, 11 students from 8th grade, added extra information to explanations of their drawings.

Table 4 *Students' explanations given besides their representations at each grade level*

		RQ7Explanations							Total
		no explanation	consistent with drawing	extra info	with symbols	motion	Inconsistent With drawings	other: daily life usage	
Grade	6	26	3	0	0	0	0	1	30
	7	17	7	1	0	0	4	1	30
	8	3	11	11	1	2	2	0	30
Total		74	23	12	1	2	6	2	90

Textbook visuals

In order to respond to the research question 2, all visuals which take place in the 6th, 7th, and 8th grade textbooks were evaluated according to ERAMR. Descriptive statistics were carried out after the ERAMR application to each atom visual in the evaluated textbooks.

As shown in Table 5, there were 251 atom visuals in the elementary school textbooks. In the 6th grade textbooks the 99% of the atom visuals were Dalton's atomic model and there was just one atomic bomb picture. Figure 11 shows the representation of Dalton's atomic model which was the most frequent in the 6th grade textbooks and the atomic bomb.

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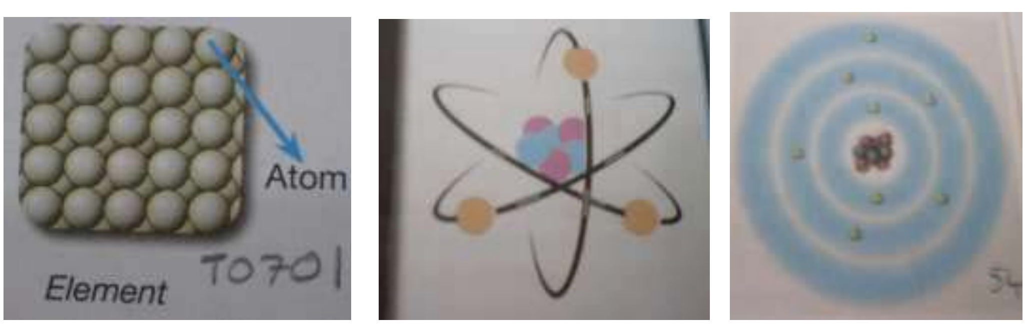
Table 5 *Distribution of representations of atomic models given in textbooks for each grade level*

		none of the models	DALTON	THOMSON	RUTHERFORD	BOHR	QUANTUM	OTHER: ATOMIC BOMB	TOTAL
Grade	6	0	88	0	0	0	0	1	89
	7	0	20	2	1	63	1	0	87
	8	3	62	0	0	10	0	0	75
Total		3	170	2	1	73	1	1	251

(a) (b)

Figure 11. (a) Dalton's atomic model representation in 6th grade science and technology textbook (b) Atomic bomb representation in 6th grade science and technology textbook

Figure 12 represents Dalton's atomic model, the Rutherford's atomic model and the Bohr's atomic model which was the most frequent in 7th grade textbook. In the 7th grade, 73% of visuals in textbooks represent the Bohr's atomic model and 23% of the visuals in textbooks represented the Dalton's atomic model. Rutherford's and Thomson's atomic models took only 1% in the 7th grade textbook. It was observed that in the representation of Bohr's atomic model there were blue regions; but when the picture was small, students could not realize the region; they might realize them as a line instead of a region.



(a) (b) (c)

Figure 12. (a) Dalton's atomic model representation in 7th grade science and technology textbook (b) Rutherford's atomic model representation in 7th grade science and technology textbook (c) Bohr's atomic model representation in 7th grade science and technology textbook

In the 8th grade science and technology textbook, 83% of the atom visuals were Dalton's atomic model and 13% of the atom visuals were the Bohr's atomic model. The most frequent representation of atom was the representation of Dalton's atomic model as seen in Figure 13.

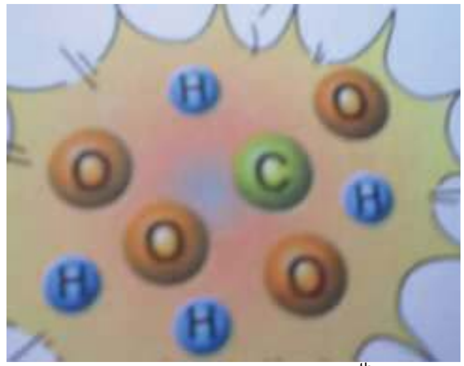


Figure 13. Dalton's atomic model representation in 8th grade science and technology textbook

Table 6 *The percentage distribution of atomic models in textbooks for each grade level*

		RQ1								
		NONE OF THE MODEL	DALTON	THOM-SON	RUTHER-FORD	BOHR	QUAN-TUM	LEWIS	OTHER: ATOMIC BOMB	SYN-THETIC MODEL
Grade_ Visual Type	grade 6 textbook	0%	99%	0%	0%	0%	0%	0%	1%	0%
	grade 7 textbook	0%	23%	2%	1%	73%	1%	0%	0%	0%
	grade 8 textbook	4%	83%	0%	0%	13%	0%	0%	0%	0%

Motion of atomic species in the visual representation of textbooks

In the 6th grade textbook, motion was not represented in the visuals. In the 7th grade textbook, there were 3 motion included in visuals; one of them showed visuals with symbols or arrows. In the 8th grade textbook, 31 visuals included motion and 20 of them showed motion with arrows or symbols. In other words, the arrows helped to include motion in the 2 Dimensional visuals. Figure 14 and 15 are the examples of the textbook visuals including motion.

Table 7 *The percentage distribution of the representations of motion of subatomic species in the textbook visuals for each grade level*

		RQ6Motion			
		Not shown	With symbols, arrows	With words	Other
Grade	6	100%	0%	0%	0%
	7	97%	1%	0%	2%
	8	59%	27%	0%	14%
Total		72%	21%	0%	7%

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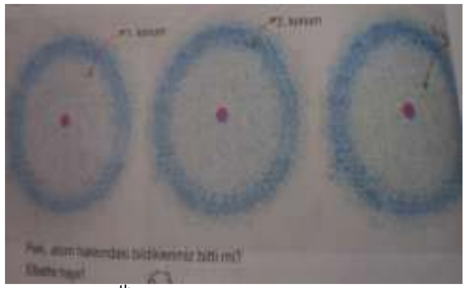

Figure 14. 7th grade visual including motion

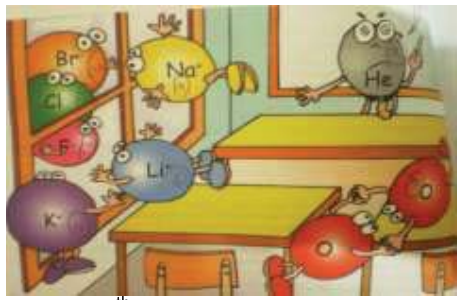

Figure 15. 8th grade visual including motion

Comparison of students' representations of an atom and textbooks' visuals of an atom

Comparison of students' mental models of atomic structure with the visual representations of textbooks in the 6th grade

As shown in Table 8, while the representations of Dalton's atomic models were seen the most frequently in the 6th grade textbooks with the 99%, atomic bomb model representation was seen the most often as 50% of 6th grade students but there was only one visual representation of atomic bomb in the 6th grade textbook. In addition, even though there were not any representations of Rutherford's atomic models in the 6th grade textbook, 7% of students drew the Rutherford's atomic model in their drawings. Finally, 29% of 6th grade students created their own models by integrating the different kinds of atom models. The bar graph of this comparison between 6th grade textbook and 6th grade students' mental model drawings are given in the Figure 5.34.

Table 8 *Comparison of 6th grade students' mental models of sodium atom with the visual representation of sodium atom in 6th grade textbook*

		RQ1					
		None of the models	Dalton	Rutherford	Bohr	Other:Atomic Bomb	Synthetic Model
Grade_Visual Type	grade 6 textbook	0%	99%	0%	0%	1%	0%
	grade 6 student	7%	7%	7%	0%	50%	29%

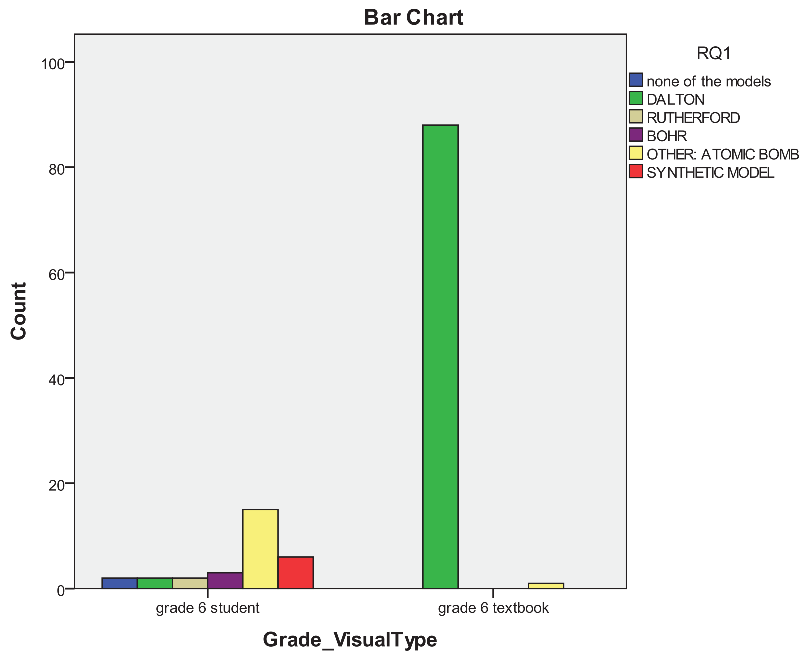

Figure 16. Comparison of 6th grade students' mental models of sodium atom with the visual representation of sodium atom in 6th grade textbook

Comparison of students' mental models of atomic structure with the visual representations of textbooks in the 7th grade

When this study implemented to the 7th grade students, they haven't covered the atom chapter "The structure and Properties of Matter" in the 7th grade textbook so their mental models were compared with the visuals in the 6th grade textbook. As shown in Table 9, 84% of the 7th grade students represented Dalton's atomic model in their drawings. The 99% of visuals in the 6th grade textbook were also Dalton's atomic model. Therefore, 7th grade students' mental models were found to be parallel with the visuals in the 6th grade textbook. In the 7th grade, 3% of students also draw the atomic bomb model which was represented in the 6th grade textbook. More surprisingly, 10% of 7th grade students drew their own model by integrating different models. Figure 17 represents the percentage distribution of 7th grade students' mental models of atomic representations and textbook representations of 6th grade which were seen for the 7th grade students.

Table 9 *Comparison of 7th grade students' mental models of sodium atom with the visual representation of sodium atom in 6th grade textbook*

		Dalton	Rutherford	Other: Atomic Bomb	Synthetic Model
Grade_VisualType	Grade 6 textbook	99%	0%	1%	0%
	Grade 7 student	84%	3%	3%	10%

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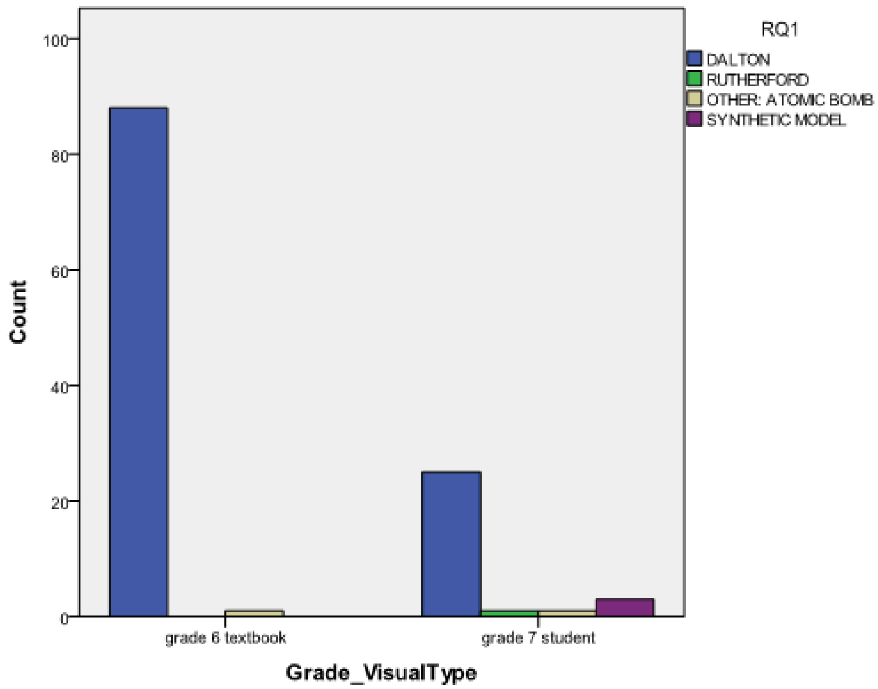

Figure 17. Comparison of 7th grade students' mental models of sodium atom with the visual representation of sodium atom in 6th grade textbook.

Comparison of students' mental models of atomic structure with the visual representations of textbooks in the 8th grade

Table 10 shows the comparison of the drawings of 8th grade students in the "Test of Mental Models of Atom" with the 6th and 7th grade textbook visuals because the 8th grade students were only encountered with the 6th and 7th grade textbooks in this study. The 87% of the 8th grade students drew atom similar to Bohr's atomic model which was the most frequently seen in the 7th grade textbook with 73% of visuals. Moreover, 14% of the students in the 8th grade created their own models which were the integration of different atom models and not similar to any other atom models. In addition, 3% of students from 8th grade also drew the representation of Dalton's atomic model which was seen the most frequently in the 6th grade as 99% of visuals. Figure 18 represents the percentage distribution of 8th grade students' mental models of atomic representations and textbook representations for 6th and 7th grade.

Table 10 *Comparison of 8th grade students' mental models of sodium atom with the visual representation of sodium atom in 6th and 7th grade textbooks*

		Dalton	Thomson	Rutherford	Bohr	Quantum	Other: atomic Bomb	Synthetic Model
Grade_Visual Type	grade 6 textbook	99%	0%	0%	0%	0%	1%	0%
	grade 7 textbook	23%	2%	1%	73%	1%	0%	0%
	grade 8 student	3%	0%	0%	83%	0%	0%	14%

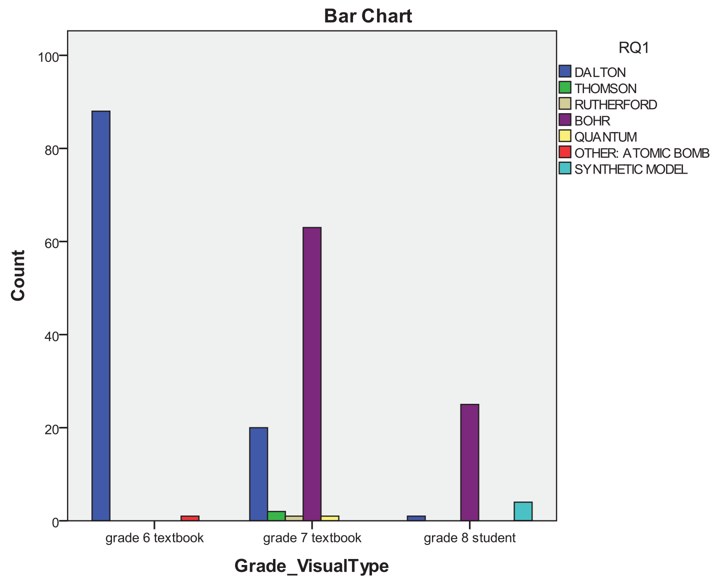

Figure 18. Comparison of 8th grade students' mental models of sodium atom with the visual representation of sodium atom in 6th and 7th grade textbooks

Discussion and Conclusion

When the structural properties of matter are considered in a scientific frame, a good understanding of the atomic model becomes important for students not to have alternative conceptions about the concept of atom (Ben-Zvi, Eylon, and Silberstein, 1988). This is a very complicated issue since the nature of atom is within a nonobservable world. Then, the invisible atom concept becomes challenging and abstract for elementary school students since it is different form what they are already familiar (Taber, 2003). To identify the abstract representations of students about atom concept, students' mental models were investigated in this study. It was also seen that students might have totally different or mixed mental models derived from the scientific ones. These alternative models were called synthetic models (Vosniadou, 2002). Therefore, to improve better teaching strategies and learning environments, it is important to know students' alternative conceptions and the type of those conceptions.

Researchers have argued that science textbooks are the major source of curriculum that determines the representation of scientific methodology (Chiapetta *et al.*, 1991; Gabel, 1983). Therefore, it is crucial to give importance how textbooks represent scientific methodology. The comparison of the examples throughout the textbooks and students' drawings made it possible to determine and evaluate how they address atomic models.

The mental models of students about atom are shaped by the visuals in textbooks, the teachers' emphasized models, and the social environments such as the Internet or television (Yıldız, 2006). In our study, it was seen that only solid sphere of the atom was given in the early years of elementary school textbooks. In addition, a clear atomic model was not given in the 6th grade textbooks. In that point, while there is a restriction to show atomic models in the early grades of elementary school textbooks, more freedom is given to teachers to show atomic models to students. Teachers can represent the basic model of atom to students for simple understanding. When a mental model is composed in students' mind, it is not easy to change it in the higher grades. Driver, Guesne, and Tiberghien (1985) also stated that changing students' alternative conceptions based on their existing knowledge is very hard during their education life.

In the light of elementary school students' mental models, half of the 6^{th} grade students drew the atomic bomb picture instead of the Dalton's atomic model which is the most frequently seen in the 6^{th} grade textbooks. It shows that students' mental models about atom were not determined by only visual representations in the textbooks. The science teacher may give the example of the atomic bomb in the class because it is very hard to say that students are affected by just one atomic bomb picture in the 6^{th} grade textbook. This result is consistent with the Nakiboglu's (2002) study. According to her study, the elementary school students drew the solar system model as their mental models instead of any scientific model. In addition, in the Yıldız's (2006) study, it is stated that elementary school students' mental models of atom are also related with pictures in the Internet or television. In the present study, some elementary school students explained that they saw the atom in a movie or in a television program. Yıldız (2006) explained that these kinds of models which are seen in the Internet or in the other media sources called mediatic models.

In our study, different than the study of Yıldız (2006), the historical changes of atomic models from Dalton's atomic model to Quantum atomic model were given in the elementary school science and technology textbook with explanations (grade 7). In the 7^{th} grade, Quantum atomic model was explained by giving example of cat: You have a cat in your home. You are not at home but you can predict the location of the cat approximately. It is similar to the atomic structure. We cannot see atom but we can predict the location of electrons in the atom. The probable location of the electrons is called as electron clouds. The research also showed that establishing relationship with the historical improvement of atom models is an effective teaching strategy and prevents the alternative conceptions (Garnett, 1995; Griffiths, 1994; Herron, 1978). However, in our study none of the students mentioned about electron clouds or the Quantum atomic model even the historical improvement of atom models was given in the 7^{th} grade textbook. According to the results of our study even historical improvement of the atom models is included in the textbooks, students are still drawing the simpler or understandable models, the results also parallel with the related literature (Akyol, 2009; Ben-Zvi, Eylon and Silberstein, 1986; Yıldız, 2006). It is recommended that Quantum atomic model can be explained before giving the historical changes of atomic models otherwise students adopt the basic or understandable model as their mental models.

Even though many teachers or the authors of textbooks do not have enough knowledge about modelling and the usage of models, their mental models have important impact on the students' mental models (Gulcicek, Bagcı and Mogol, 2003; Yıldız, 2006). Teachers prefer to choose easier models during their instructions rather than explaining all models with their insufficient properties. Therefore, students' modelling stays in the low level with only one model, and the textbooks are not sufficient to explain the different atom models by themselves.

In addition, in our study Dalton's atomic model was the most common model throughout the students' mental model drawings showing a meaningful similarity with visuals in textbooks. Dalton's atomic model was also the most frequent atom model representation in the textbooks. According to these results, students' drawings were parallel with the visuals in textbooks used in our study.

The other conclusion from the study was that elementary school students do not have a clear place about atom models in their minds; they do not realize the lack of previous models in the history of atom.

None of the students in our sample showed the motion in their drawings. However, it can also support that it is not easy to show motion in the two-dimensional drawing pad. Several research studies showed that students cannot explain chemical phenomena at the submicro level, instead students use symbols without understanding the meaning of the chemical concepts (Nakhleh, 1993; Nurrenbern and Pickering, 1987). It was challenging for the elementary school students to show motion in their drawings because they cannot imagine arrows or adding frame to create motion. Actually, there was only 1 visual in the 7^{th} grade textbook including motion by adding different frames, motion was created by adding frames to the previous frame in that visual. The location of electrons was different in the each frame, so that the total frame images represented the motion. Under this situation, it was not meaningful to check 6th and 7th grade students' drawings with respect to motion because there were not enough visual representations in the textbooks to leave a permanent mark on students' minds about motion of atoms. However, it is important to include motion for atoms in the elementary school textbooks not to create alternative conceptions for students in the higher grades because previous knowledge by creating alternative conceptions could be an obstacle to get the right concepts (Taber, 2003).

Recommendations for Further Research and Implications

In order to generalize results, a similar study may be carried out with more students from different schools including not only public schools but also private schools. In addition, different publications of textbooks could also be integrated into the study. Results may differ with a larger student sample size and different textbook publications. In addition, interviews should be done with students to explain their mental models effectively in the qualitative analysis.

There are also recommendations for the textbook authors and curriculum planners. The motion should be shown in more effective ways. There was just one good example in the 7th grade textbook. There, the motion of electrons was shown by putting different snapshots one after the other to indicate the uncertainty of the location of electrons. That kind of visuals can be recommended to take place more frequently in the textbooks. The textbooks can also include CDs as supporting sources for students by considering textbooks' insufficiency. It can be more helpful for the elementary grade students because they draw the atomic bomb picture more frequently when asked to draw atom. In addition, for further research, students' mental models can be evaluated with computer-based 3-Dimensional programs rather than a paper based test.

Moreover, using 3-Dimensional programs can be helpful to understand students' mental models from their animations rather than their 2-Dimensional drawings. It is challenging to see the mental models in the 2-dimensional paper based tests especially for a non-observable concept like atom which also includes motion.

The recommendations for the science or chemistry teachers are also the following: the atom models should be given with the explanations, and in the beginning of the atom concept teachers should not mention about the analogies that may affect students' thinking. It should be emphasized that the previous atom models are not valid today because of their deficiencies in the explaining of the correct atom concept. The limitations of the historical atom models should be given during instruction. In addition, teachers should show the 3D animations or simulations about the concept of atom in the instruction of atom concept.

For developing scientific knowledge, models and modelling are very important. Thus, students' modelling skills should be improved by the help of more effective visuals in textbooks and activities which are provided by teachers during instruction.

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