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A Cross-age Study on The Development of "Chemistry" Concept Through Different Grades: 7th, 9th And 11th Grades

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Abstract
In this study, the development of chemistry concept through 7th, 9th and 11th grades is determined and it is also searched that the development of chemistry concept is proportional to the historical development of it. The study was carried out with a cross-sectional research in the form of a case study in Giresun in Turkey. Firstly, a chemistry test was applied to 157 students to collect data. With the help of the data handed from the test, a new likert test consisting 12 questions was constructed. The likert test was applied to 30 students in the interviews in order to reveal students' real ideas and the reasons behind their answers of the first chemistry test. The data frequencies are calculated and tabulated. According to the findings, chemistry concept is constructed in students' minds related to their grades. There is also a direct relationship between the construction and the historical development of the concept. In order to overcome misconceptions and to teach concepts for meaningful learning, concept mapping, prediction-observation-explanation, interviews about concepts, drawings, fortune lines, relational diagrams and word association techniques are suggested for teachers.

Keywords
Chemistry concept, concept development, historical development, conceptual learning, cross-age study

Introduction

Many words in science are often used to define some scientific concepts or to facilitate the conceptual development of the student. Conceptual development is one of the major aims of the instruction because if students do not have an understanding of science language, they definitely have difficulty in science and lack of interest with their science material (Young 2005). Thus, the concept and concept formation has gained importance and educators have developed different ways of concept teaching (Driver and Easley 1978; Seiger-Ehrenberg 1981; Novak 1990; White and Gunstone 1992; Leite 2002).

Concept teaching has become so important in science education, there are a lot of studies that show some different ways to ensure conceptual teaching and change (Posner *et al* 1982; Hewson *et al* 1992; White and Gunstone 1992; Demircioğlu *et al* 2005; Masson and Abad 2006; Taştan *et al* 2008). The studies revealed that students come into class with a wide range of alternative conceptions or beliefs which are often inappropriate with the scientific ones. According to these studies, if a student develops a misconception in science or any subject, it becomes almost impossible to make it true because misconceptions are very resisstant to change (Yürük 2007). Thus, it becomes very important to teach concepts in a right way because concept teaching has turned the basis of the meaninful teaching.

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According to Cox and Fenton (1990), there are three sources pushing science educators toward concept based science programs. The first two of them are related to the proffessional organizations' reports and recommendations indicating the poor quality and quantity of science education such as NSTA, National Commission on Excellence in Education, and the National Science Board Commission on Precollege Education in Mathematics, Science and Technology. The last source arised from the researches indicating that students' conceptual development should be taken into account to provide and keep the scientific understanding.

According to Birbili (2007), in today's world, instead of teaching students all the facts, teachers could help them see relations between different themes. Birbili explained the importance of concept development in education in her article:

> It is now widely accepted that facts alone are not enough to help children discern patterns and relationships, group things together, see big ideas and solve problems. Facts need to be placed in a conceptual framework to be understood and remembered. Teachers can facilitate concept development by putting concepts and generalisations (rather than facts) at the centre of activities, providing children with a wide variety of tangible experiences, helping them learn how to observe and represent what they see and hear and providing them with multiple examples of the concepts being taught (Birbili 2007).

Teaching the history of the concept is as important as concept formation. In Turkey, new curriculum in chemistry starts with "From Alchemy To Chemistry" giving the historical explanation of the concept of chemistry (MEB 2008). So, it can be said that searching the history of the concept makes difference in the learners (Rutherford, 2001). The histroy of the concept makes the curious person gain a point of view, scientific view. The curious person feels himself close to the scientist and so can follow the same scientific way. According to Kindi, by integrating the history of science, the students are given models to look up to so that they follow in their steps or even perhaps surpass them (Kindi, 2005). In addition, inclusion of history of science also provides cultural awareness (Wang and Marsh 2002). However, inclusion of history of science facilitates making students scientifically literate citizens (Leite 2002). Therefore, it is meaningful to integrate history of science into the lessons.

The concept of chemistry has an origin of "chem" meaning black country in ancient Egyptian language and "chemeia" in Greek language. But it is more logical that chemistry arises from "chyma" meaning metal pouring in Greek language if chemistry's definition was taken into consideration. Some science historians translated alchemy into Turkish as "El-kimya" and into Arabic as "simya" (Tez 1986).

It is supposed that chemistry has existed from the very beginning of civilization. To make a fire, to produce a pot or ceramics, and to get iron and bronze were the first chemical activities human being was interested because of their needs (Berkem 1996). But the first chemist was necessarily the first man who made a fire in the world (Vlasov *et al* 2003).

Humanbeing's dreams of being rich have started with the transformation effort of the other metals into gold. Gold has always been valuable since the ancient times. Alchemy (or simya) includes the efforts of the transformation of worthless metals into gold and finding the elixir of immortality. Alchemy is not a branch of science due to the fact that not having theoretical bases, not appropriate for experimenting, and not providing systematic knowledge (MEB 2008).

When the historical development of the chemistry concept taken into acoount, it can be said that chemistry has evolved with the alchemy and then the process of metals, cosmetic, dye, ceramic and so on. However, concept formation has great importance and research area in education, so this study tries to reveal that whether students developed the "chemistry"

concept being in accordance with the historical development of it. There are so many studies trying to explain the development of concepts in students' minds and then to overcome possible misconceptions. Therefore, it is necessary to find out the similarites between the historical development of the concept and its development in students' minds.

The purpose of this study is to determine that whether the development of the chemistry concept throughout history has similarities with the students' conceptual development of "chemistry".

Material and Method

The study was carried out with a cross-sectional research in the form of a case study because cross-sectional research does not require too much time. This method lets the study take place in a shorter time with different sample groups having similar characteristics. Therefore, to finish the study, there is no need to study with the same sample group in large time periods. And also lets to use qualitative and quantitative methods at the same time (Çepni 2007).

The sample group was 7, 9 and 11th grades students in Giresun. Firstly, a chemistry test was applied to 157 students to collect data (see app.1). The test had 2 open-ended, one drawing and one multiple choice questions. The first question in test was required writing about the first five things appearing in students' minds about chemistry. The second question was required writing in order to control whether students were aware of chemistry's topics or sub-topics. The third question was a free drawing question and it required students to draw a chemical event. The last question was a multiple choice question and it required students to choose the pictures related to chemistry directly or indirectly. The test evaluated with two chemistry educators and their ideas was taken into account. Necessary changes were done and it was reconstructed. This test was analyzed with qualitative methods. The themes of students' answers and their frequencies were determined according to the levels. With the help of the data handed from the test, a new likert test consisting 12 questions was constructed (see app.2). The likert test was applied to 30 students in the interviews in order to reveal students' real ideas and the reasons behind their answers of the first chemistry test.

Results

1. Data collected from the first open-ended question

Question: Please write down the first five concepts appearing in your mind about "chemistry".

35 7th grade students out of 55 used experiment and observation concept when they heard "chemistry". 21 of students said that chemistry is a course, and 19 of them used matter concept. 41 9th grade students out of 59 used atom concept when they heard "chemistry". 30 of students said that chemistry evoked element and compounds, and 23 of them used matter and experiment and observation concepts.

Table I. The frequencies of the concepts of 7th grade students

Themes	Frequency (N = 55*)
Formula	8
Solid – Liquid- Gas	9
Atom	12
Molecule	10
Chemical Reactions	4
Element-Compound	13
Matter	**19**
A course	**21**
Chemistry teacher – Chemist	8
Mixture	9
Drugs	5
Detergents	4
Perfume	1
Experiment and Observation	**35**
Laboratory	5
Science	3
Chemical waste	1
Solubility	3

*The total frequency is more than the total number of students because students wrote more than one concept.

Table II. The frequencies of the concepts of 9th grade students

Themes	Frequency (N = 59*)
Formula	7
Mol	1
Solid – Liquid- Gas	6
Atom	**41**
Molecule	4
Chemical Reactions	18
Periodic Table	8
Element-Compound	**30**
Alchemy	18
Matter	**23**
A course	2
Chemistry teacher – Chemist	6
Acid – Base - Salt	13
Compound	6
Drugs	3
Detergents	1
Experiment and Observation	**23**
Laboratory	3
Science	2
Chemistry Laws	3
Chemical waste	1
Solubility	1
Chemical Bonding	5
Metal – Nonmetal – Inert gas	3
Organic chemistry	3
Energy	1
Avogadro	1

*The total frequency is more than the total number of students because students wrote more than one concept.

Table III. The frequencies of the concepts of 11th grade students

Themes	Frequency (N = 43*)
Formula	2
Mol	4
Environment	3
Solution	7
Solid – Liquid- Gas	7
Atom	**19**
Molecule	2
Chemical Reactions	**16**
Periodic Table	**15**
Element-Compound	12
Alchemy	1
Matter	**16**
Dalton	1
A course	2
Chemistry teacher – Chemist	**16**
Cancer	1
Acid - Base - Salt	11
Mixture	3
Drugs	3
Detergents	3
Experiment and Observation	**16**
Laboratory	5
Science	1
Technology	2
Chemistry Laws	1
Molarity	1
Equilibrium	4
Chemical Waste	1
Solubility	1
Reaction Rate	1
Chemical Bonding	1
Metal – Nonmetal – Inert gas	1
Organic chemistry	2

*The total frequency is more than the total number of students because students wrote more than one concept.

19 11th grade students out of 43 used atom concept when they heard "chemistry". 16 students said that chemistry evoked chemical reactions, matter, chemistry teacher or chemist, and experiment and observation. 15 of them used periodic table concepts.

2. Data collected from the second open-ended question

Question: What can be the topics or subtopics of chemistry?

19 students of 7th grade students wrote that "matter" was the topic of chemistry. 15 students wrote that chemistry was a branch of science. 11 students gave an answer of atom as a topic of chemistry.

36 students of 9th grade students wrote that "matter" was the topic of chemistry. 26 students gave an answer of atom as a topic of chemistry. 12 students wrote that chemistry's topic was elements and compounds.

Table IV. The frequencies of the concepts of 7th grade students

Themes	Frequency (N = 55*)
Element – compound	6
Metal – Nonmetal – Inert gas	2
Atom	**11**
Discoveries	2
Solid – Liquid- Gas	3
Chemical Reactions	2
Matter	**19**
Biology	4
Drugs	5
Biochemistry	1
Molecule	10
Mixture	9
Science	**15**

*The total frequency is more than the total number of students because students wrote more than one topic.

Table V. The frequencies of the concepts of 9th grade students

Themes	Frequency (N = 59*)
Periodic Table	5
Solid – Liquid- Gas	2
Element – compound	**12**
Metal – Nonmetal – Inert gas	2
Atom	**26**
Chemical Reactions	7
Solubility	2
Matter	**36**
Physics	3
Biology	3
Mathematics	1
History	1
Drugs	6
Radioactivity	1
Everything around us	2
Molecule	1
Acid – base – salt	5
Industry	3
Alchemy	2
Organic chemistry	2
Mixture	1

*The total frequency is more than the total number of students because students wrote more than one topic.

Table VI. The frequencies of the concepts of 11th grade students

Themes	Frequency (N = 43*)
Solution	4
Molarity	1
Periodic Table	7
Solid – Liquid- Gas	3
Element – compound	6
Metal – Nonmetal – Inert gas	1
Atom	**9**
Chemical Reactions	**9**

Table VI. Continue

Themes	Frequency (N = 43*)
Solubility	4
Equilibrium	5
Matter	**25**
Physics	1
Biology	2
Mathematics	1
The creation of the world	1
Drugs	**8**
Radioactivity	1
Biochemistry	4
Everything around us	4
Reaction energy	1
Molecule	1
Mol	3
Acid – base – salt	1
Reaction Rate	2
Industry	3
Alchemy	1
Organic chemistry	1

*The total frequency is more than the total number of students because students wrote more than one topic.

25 students of 11th grade students wrote that "matter" was the topic of chemistry. 9 students gave an answer of atoms and chemical reactions as the topics of chemistry. 8 students wrote that chemistry's topic was drugs.

3. Data collected from the drawing question

Question: Please draw a chemical event.

Table VII. The frequencies of the themes of 7th grade students' drawings

Themes	Frequency (N = 55)
Gas and gas pressure	2
Atom	2
Experiment	**19**
Transition States	**8**
Chemical Reactions	1
Dissolution	1
Element- Compound	**3**

Figure 1. A 7th grade student's drawing of a chemical event: experiment and observation

Most of students drew an experiment picture (19 students out of 55 students), 8 students drew a transition state picture, and 3 of them drew an element or compound picture. 19 students did not draw any pictures. An example of an experiment picture of a student is given below.

Table VIII. The frequencies of the themes of 9th grade students' drawings

Themes	Frequency (N = 59)
Gas and gas pressure	3
Atom	5
Experiment	**11**
Transition States	**8**
Chemical Matter	1
Chemical Reactions	**23**
Dissolution	1
Organic chemistry	1
Alchemy	1
Periodic Table	1
Element- Compound	1

Most of students drew a chemical reaction picture (23 students out of 59 students), 11 students drew an experiment picture, and 8 of them drew a transition state picture. 3 students did not draw any pictures. An example of a chemical reaction picture of a student is given below.

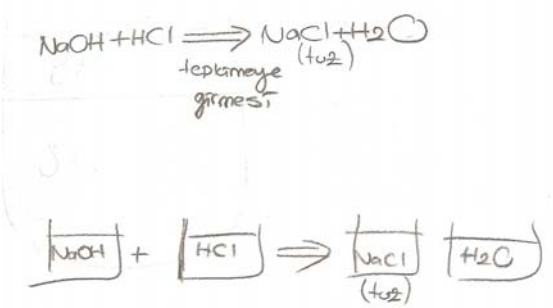

Figure 2. A 9th grade student's drawing of a chemical event: chemical reactions

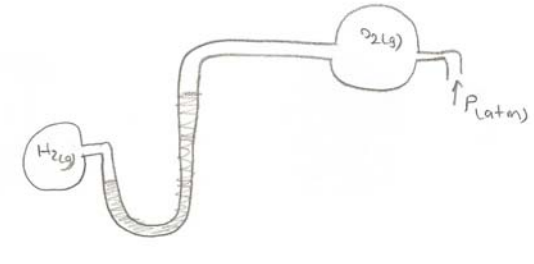

Figure 3. A 11th grade student's drawing of a chemical event: gas pressure

Most of students drew a chemical reaction picture (13 students out of 43 students), 5 students drew an experiment picture, and 4 of them drew a gas or gas pressure picture. 7 students did not draw any pictures. An example of a gas pressure picture of a student is given below.

Table IX. The frequencies of the themes of 11th grade students' drawings

Themes	Frequency (N = 43)
Gas and gas pressure	**4**
Atom	2
Experiment	**5**
Transition States	3
Chemical Matter	2
Chemical Reactions	**13**
Dissolution	2
Acid - Base	1
Electrolysis	2
Distillation	1
Element- Compound	1

4. Data collected from the multiple choice question

Question: According to you, choose the picture(s) which are related to chemistry directly or indirectly.

Table X. The frequencies of the pictures of 7th grade students

Themes	Frequency (N = 55*)
Chemical Detergents	**46**
Vinegar - Acid	29
Cooked egg – chemical event	19
Fired candle – chemical event	30
Riding a bicycle – Energy	1
Lemon – acid	9
Grape – acid	11
Flower – organic chemistry	6
To run a car	26
Experiment	**50**
Fiber – polyester	10
T-shirt – polyester, dye	4
Aspirin	**45**
Wine	12
Students who chose all the pictures	0

*The total frequency is more than the total number of students because students chose more than one picture.

Table XI. The frequencies of the pictures of 9th grade students

Themes	Frequency (N = 59*)
Chemical Detergents	**53**
Vinegar - Acid	49
Cooked egg – chemical event	35
Fired candle – chemical event	**50**
Riding a bicycle – Energy	7
Lemon – acid	41
Grape – acid	24
Flower – organic chemistry	12
To run a car	14
Experiment	**55**
Fiber – polyester	9
T-shirt – polyester, dye	12
Aspirin	48
Wine	28
Students who chose all the pictures	5

*The total frequency is more than the total number of students because students chose more than one picture.

50 of the 7th grade students chose the experiment picture which are related to chemistry. 46 of them chose detergent picture and 45 of them chose aspirin picture. There was no students which selected all the pictures.

55 of the 9th grade students chose the experiment picture which are related to chemistry. 53 of them chose detergent picture and 50 of them chose fired candle picture. 5 students signed all the pictures that were related to chemistry.

Table XII. The frequencies of the pictures of 11th grade students

Themes	Frequency (N = 43*)
Chemical Detergents	**38**
Vinegar - Acid	27
Cooked egg – chemical event	20
Fired candle – chemical event	**34**
Riding a bicycle – Energy	10
Lemon – acid	21
Grape – acid	15
Flower – organic chemistry	11
To run a car	23
Experiment	**43**
Fiber – polyester	12
T-shirt – polyester, dye	10
Aspirin	8
Wine	25
Students who chose all the pictures	8

*The total frequency is more than the total number of students because students chose more than one picture.

All of the 11th grade students chose the experiment picture which are related to chemistry. 38 of them chose detergent picture and 34 of them chose fired candle picture. 5 students signed all the pictures that were related to chemistry.

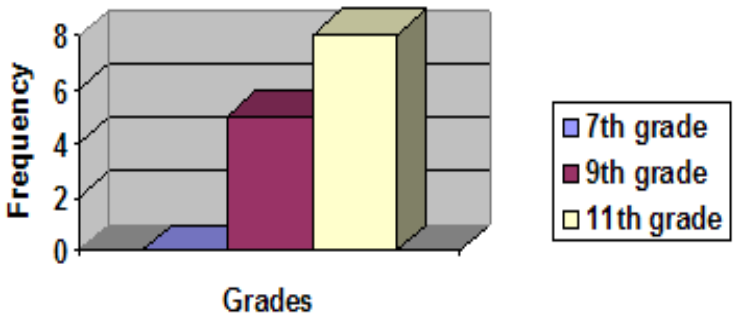

Figure 4. The frequency of students who relate chemistry with all pictures given in the question.

As seen in the figure 4, none of 7th grade students related chemistry with the pictures by selecting all of them. 5 students in 9th grade students and 8 students in 11th grade students marked all the pictures and it can be said they established a relation between chemistry and the pictures directly or indirectly.

5. Data collected from the sample through likert test during interviews

With the help of the data handed from the above test, a new likert test consisting 12 questions was constructed. The sentences used in the likert test were taken from the chemistry test. The likert test was applied to 30 students (10 students from each grade) in the interviews in order to reveal students' real ideas and the reasons behind their answers of the chemistry test for the drawing and multiple choice question.

Table XIII. Interview answers of 7th grade students

	Sentences	***Example Student Explanations***	***Student (N = 10)***
1.	Oxidation of iron is a physical change.	"Because the physical appearence changes"	8 (agree) 2 (undecided)
2.	Everything around us is related to chemistry directly or indirectly.	"For example walking is not related to chemistry"	6 (agree) 1 (undecided) 3 (disagree)
3.	All drugs we use are chemical.	"I think there may be some drugs that are not chemical, so I can not say all are chemical or not."	7 (agree) 3 (undecided)
4.	The vaporization and freezing of water are chemical changes.	"Because we learned vaporization and freezing of water in chemistry part of the science lesson"	8 (agree) 2 (disagree)
5.	The melting of ice is a physical change.	"Because when we freeze water, it will be ice again, so it is physical"	9 (agree) 1 (undecided)
6.	Electrolysis is a chemical separation technique.	"I can not be sure because there is electric, it should be physical, but it should be chemical logically"	3 (agree) 6 (undecided) 1 (disagree)
7.	To ride a bicycle has a chemical aspect because it requires using energy.	"I do not think so, because energy topic is in physics part of science lesson, so it should be physical"	5 (agree) 2 (undecided) 3 (disagree)
8.	Melting of a candle is a chemical event.	"We can not revert melted candle to the first state, so chemical"	5 (agree) 1 (undecided) 4 (disagree)
9.	To bake an egg is a physical event.	"Because egg is again egg but its physical appearence changed"	6 (agree) 1 (undecided) 3 (disagree)
10.	Grape has a chemical aspect because it is acidic.	"If grape can be accounted as acid, so it can have a chemical aspect"	5 (agree) 4 (undecided) 1 (disagree)
11.	Combustion of a candle is a chemical event.	"I think combustion is chemical"	7 (agree) 2 (undecided) 1 (disagree)
12.	All chemicals are harmful for human health.	"Because whenever harmful food is talked on TV, it contains some chemicals"	6 (agree) 2 (undecided) 2 (disagree)

In the Table XIII, 7th grade students' answers to likert test and their interpretations are given. For the 5 sentences of 12 sentences (1st, 4th, 8th, 9th and 12th sentences), most students gave wrong answers; for one sentence (6th sentence), majority of students remained undecided; and for 6 sentences of 12 sentences, most of the students gave correct answers.

In the Table XIV, 9th grade students' answers to likert test and their interpretations are given. For the 2 sentences of 12 sentences (1st and 7th sentences), majority of students gave wrong answers; for one sentence (12th sentence), majority of students remained undecided; and for 9 sentences of 12 sentences, most of the students gave correct answers.

Table XIV. Interview answers of 9th grade students

	Sentences	*Example Student Explanations*	*Student (N = 10)*
1.	Oxidation of iron is a physical change.	"Oxidation is a physcial change"	7 (agree) 3 (disagree)
2.	Everything around us is related to chemistry directly or indirectly.	"Everything is related to chemistry because chemistry's fundamental topic is matter"	4 (agree) 3 (undecided) 3 (disagree)
3.	All drugs we use are chemical.	"Drugs have a chemical formula"	8 (agree) 2 (undecided)
4.	The vaporization and freezing of water are chemical changes.	"Vaporization and freezing are physcial because water's chemical structure is not changed"	3 (agree) 7 (disagree)
5.	The melting of ice is a physical change.	"Melting changes ice's physical structure"	8 (agree) 2 (undecided)
6.	Electrolysis is a chemical separation technique.	"Electrolysis is chemical because water is separated into hydrogen and oxygen"	8 (agree) 1 (undecided) 1 (disagree)
7.	To ride a bicycle has a chemical aspect because it requires using energy.	"Energy is a physics topic, I do not think the relation of energy with chemistry"	3 (agree) 3 (undecided) 4 (disagree)
8.	Melting of a candle is a chemical event.	"Melting is not chemical, but burning of the candle is chemical"	2 (agree) 1 (undecided) 7 (disagree)
9.	To bake an egg is a physical event.	"Baking is chemical because its structure is different any more"	3 (undecided) 7 (disagree)
10.	Grape has a chemical aspect because it is acidic.	"Acids and bases can be counted as chemical"	7 (agree) 1 (undecided) 2 (disagree)
11.	Combustion of a candle is a chemical event.	"Combustion is a chemical reaction"	8 (agree) 2 (disagree)
12.	All chemicals are harmful for human health.	"I think all chemicals can not be harmful because drugs kill pain"	2 (agree) 4 (undecided) 4 (disagree)

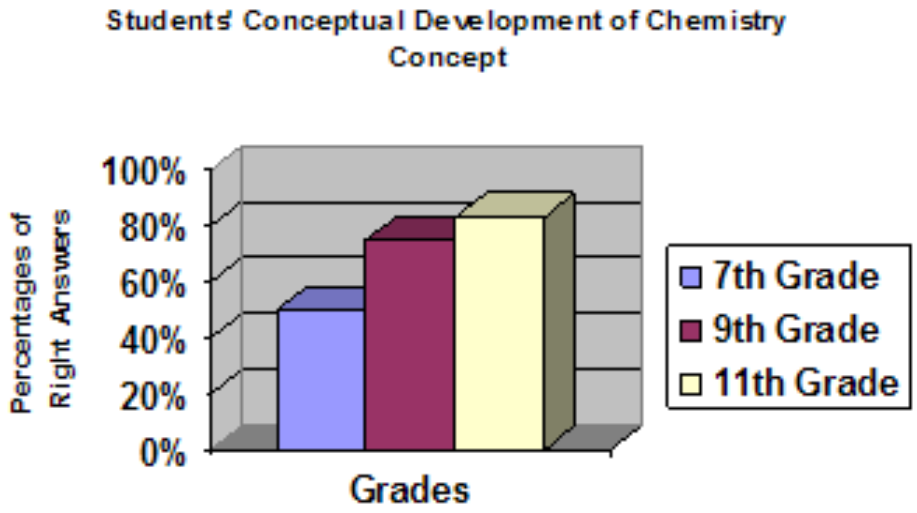

Figure 5. Percentages of right answers of the likert test questions of 7th, 9th and 11th grade students.

Figure 5 shows the percentages of right answers of the likert test through the different grades. As seen in figure 5, percentages of students' right answers are increased in accordance with the grades. Therefore, conceptual development of chemistry concept in students is also increased. 9th grade students' conceptual development is better than 7th grade students and 11th grade students' conceptual development was better than 9th grade and 7th grade students.

In the table XV, 11th grade students' answers to likert test and their interpretations are given. For the one sentence of 12 sentences (12th sentences), majority of students gave wrong answers; for one sentence (7th sentence), majority of students remained undecided; and for 10 sentences of 12 sentences, most of the students gave correct answers.

Table XV. Interview answers of 11th grade students

	Sentences	***Example Student Explanations***	***Student (N = 10)***
1.	Oxidation of iron is a physical change.	"Oxidation is a reaction of oxygen, so it is chemical"	2 (agree) 8 (disagree)
2.	Everything around us is related to chemistry directly or indirectly.	"Because everything has a chemical structure"	9 (agree) 1 (undecided)
3.	All drugs we use are chemical.	"Our teacher said that they made aspirin in the chemistry laboratory"	9 (agree) 1 (undecided)
4.	The vaporization and freezing of water are chemical changes.	"They are physical changes"	1 (agree) 9 (undecided)
5.	The melting of ice is a physical change.	"Melting is a transition of state, so transition of states are physical"	10 (agree)
6.	Electrolysis is a chemical separation technique.	"Because water's structure changed into oxygen and hydrogen"	10 (agree)
7.	To ride a bicycle has a chemical aspect because it requires using energy.	"Riding a bicycle requies energy but energy is not chemical"	4 (agree) 5 (undecided) 1 (disagree)
8.	Melting of a candle is a chemical event.	"Melting has to be physical because the structure of the matter is not changed"	2 (agree) 8 (disagree)
9.	To bake an egg is a physical event.	"Baking changes the egg's molecular structure, so it is chemical"	2 (agree) 8 (disagree)
10.	Grape has a chemical aspect because it is acidic.	"Acid is strongly related to chemistry"	9 (agree) 1 (undecided)
11.	Combustion of a candle is a chemical event.	"Combustion is a reaction of oxygen with another matter"	9 (agree) 1 (disagree)
12.	All chemicals are harmful for human health.	"Most chemicals are harmful but, I do not know all of them is harmful"	4 (agree) 3 (undecided) 3 (disagree)

Discussion

According to data obtained from the first question of the chemistry test, the majority of 7th grade students established a strong relation between "chemistry" and "experiment and observation". But 9th grade students and 11th grade students pointed the relation between chemistry and atom. The reason of choosing experiment and observation may be that 7th grade students were affected from their environment, TV or friends studying at high school. Because 7th grade students did not have adequate information, when they heard chemistry concept, experiment came in their mind. This consequent is valid for the findings of the third question. In the drawing question, 7th grade students established a strong relation between "chemistry" and "experiment and observation", therefore they mostly drew an experiment picture. But 9th grade students and 11th grade students drew chemical reactions pictures.

When the findings of the second question are taken into account, it is clear to see that most students of each grade said that matter was a topic of chemistry. The rationale of choosing "matter" may be that students firstly learned the matter and its properties topic in a science or chemistry course, so they easily connected the matter with the chemistry.

According to the data obtained from the fourth question, 7th grade students chose the experiment, chemical detergents, and aspirin pictures which are related to chemistry directly or indirectly. They were not ready to relate chemistry with all the pictures. But five of 9th grade students and eight of 11th grade students marked all the pictures. This shows us students improved an understanding of the relation of chemistry with everything around us. Students developed a feeling such that if chemistry is about matter, then everything is connected with chemistry because everything is a matter. This is a good point for the development of chemistry concept.

When the findings of interview are considered, it is possible to see that students gave more logical answers to the likert test and they could explain the reason why they chose the option according to the grades. For example 7th grade students marked 6 questions out of 12, and 9th grade students marked 9 correct options, and 11th grade students chose 10 correct options. Students of 11th grade were the most self-confident group while they were responding and explaining the questions. The reason may be that they were studying a lot because 11th grades students will enter the university entrance exam one year later, therefore they were more interested in lessons. As understood from the likert test and interview findings, chemistry concept's development improves with grades. While 7th grade students' development was 50%, 9th grade students' development was 75%, and finally 11th grade students' development was 83,3%.

In the literature, there are alike studies searching the conceptual development via cross-age methods (Coll and Treagust 2000; Ünal *et al* 2006; Şahin *et al* 2008). The results of these studies showed similarities. The concept development of some concepts was almost the same. At the beginning of the study, our research questions were: does the conceptual development increase with grades? And if so, is it similar to the historical development of the concept? Our first question is answered when the findings are considered. But in order to answer the second one it is necessary to look at the history of chemistry. Chemistry arised from alchemy, i.e, from metals and metal pouring. It was a very limited area for chemistry in contrast to today's world. Today, chemistry has relations with almost all areas of industry, medicine, manufacturing, dye, cosmetic, and so on. 7th grade students relate chemistry concept with 18 different concepts, 9th grade students with 27 different concepts, and 11th grade students 33 different concepts. Thus, it is possible to say that there is consistency between the development of the chemistry concept in students with the historical development of chemistry throughout history.

It is extremely difficult to teach scientific abstract concepts to students and also to create a mental image in students' minds. Reports and tests identified that even if students learned the concept, they failed at the application of it to the new situations (Seiger-Ehrenberg 1985). To teach students basic concepts can facilitate students' learning of whole subject. According to Novak (2006), it is necessary to learn main concepts for meaningful learning. And concept maps are beneficial tools in order to teach the concepts and to find out the relations between concepts. Therefore, teachers should use concept maps in their instructions. If not, students do not learn the concepts completely or they have misconceptions. Gilbert, Osborne and Fensham (1982), named misconceptions as children's science (cited by Duit and Teagust 2003), Hewson and Hewson (2003), named as alternative conceptions. In order to

determine students' knowledge and to remove their alternative conceptions, there are a lot of methods such as concept mapping, prediction-observation-explanation, interviews about concepts, drawings, fortune lines, relational diagrams and word association techniques (White and Gunstone 1992). Teachers should use such methods in their classrooms in order to overcome the students' misconceptions. Using these methods will help students learn the subjects meaningfully.

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APPENDIX 1

1) Please write down the first five concepts appearing in your mind about “chemistry”.

2) What can be the topics or subtopics of chemistry?

3) Please draw a chemical event.

4) According to you, choose the picture(s) which are related to chemistry directly or indirectly.

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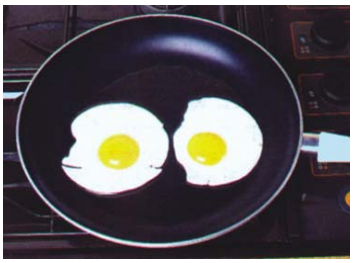

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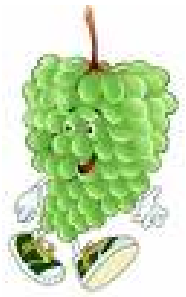

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APPENDIX 2

	Sentences	Agree	Undecided	Disagree
1	Oxidation of iron is a physical change.	**( )**	**( )**	**( )**
2	Everything around us is related to chemistry directly or indirectly.	**( )**	**( )**	**( )**
3	All drugs we use are chemical.	**( )**	**( )**	**( )**
4	The vaporization and freezing of water are chemical changes.	**( )**	**( )**	**( )**
5	The melting of ice is a physical change.	**( )**	**( )**	**( )**
6	Electrolysis is a chemical separation technique.	**( )**	**( )**	**( )**
7	To ride a bicycle has a chemical aspect because it requires using energy.	**( )**	**( )**	**( )**
8	Melting of a candle is a chemical event.	**( )**	**( )**	**( )**
9	To bake an egg is a physical event.	**( )**	**( )**	**( )**
10	Grape has a chemical aspect because it is acidic.	**( )**	**( )**	**( )**
11	Combustion of a candle is a chemical event.	**( )**	**( )**	**( )**
12	All chemicals are harmful for human health.	**( )**	**( )**	**( )**