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Acquaintance, Knowledge and Alternative Conceptions of Eight Grade Students about Inheritance: A Three-Tiered Testing Approach

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ABSTRACT

The aim of this study research is to identify acquaintance, knowledge levels and alternative conceptions of the eighth grade students about inheritance by using a three-tiered testing approach. For this purpose a three-tiered test was designed; the first tier was to determine acquaintance of the subject, the second tier was to determine knowledge about the subject. The third tier was to determine alternative conceptions of eighth-grade students (n=393). Sample of the study was determined by using convenient sampling. This study is a descriptive research involving two data collection instruments; "three-tiered test for inheritance subject" and "personal information form". For analyzing data, frequency and percent values regarding choices of the test for each tier were calculated. Also a map was constructed by considering findings on each tier of the test. According to the findings eight-grades have alternative conceptions about inheritance involving heredity, meiosis and mitosis, chromosome, genetic diseases, adaptation, modification, DNA and regeneration subjects. Also it was determined that lack of knowledge was not a prerequisite for observing alternative conceptions about inheritance, some of the students have acquaintance and knowledge about the subject but they have alternative conceptions about the subject.

Keywords: alternative conceptions, inheritance, three-tiered testing, middle school students

INTRODUCTION

Students are faced with a number of barriers involving alternative conceptions that is affecting their learning in science classes. Alternative conceptions are inconsistent conceptions of students with scientifically accepted concepts (Yang et al., 2014). These conceptions are resistant to change by ordinary teaching and pervasive (Southerland et al., 2001; Eryılmaz, 2002). Science teachers who have to plan their instruction should know alternative conceptions of students and design their courses by considering the alternative conceptions (Wenning, 2008). Hence providing a valid and reliable way of determining alternative conceptions to science teachers is a beginning point to make suggestions for following instructional adjustments.

Students establish their conceptions by conceptual change processes. When students create new conceptions they generally utilize a schema containing the existing concepts and they partially change existent schema in learning a new concept. We call this first stage of conceptual changes as "assimilation". But students might not have an appropriate existent conception to give meaning to a new concept. Hence the learners should change completely existent schema to make new concept meaningful. Here we call this conceptual change as "accommodation" (Posner et al., 1982). Individuals might not effectively carry out assimilation and accommodation processes. There are different types of barriers for assimilation and accommodation in developing conceptions. According to Bahar (2003) alternative conceptions are ideas that are scientifically unacceptable and resistant to change, therefore they are barriers of assimilation and accommodation in developing conceptions. In this case, students have to replace their alternative conceptions with new ones or reorganize them. According to Koray and

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Bal (2002) alternative conceptions develop in formal education during the teaching of concepts. For example; alternative conceptions can emerge through incorrectly understanding of scientific concepts by students or insufficient teaching of the concepts by teachers. Fisher (1985) has listed properties and sources of the alternative conceptions that may occur in individuals in his study as shown below:

1. One or a group of alternative conceptions can appear in many people.
2. Alternative conceptions bring about alternative beliefs.
3. Many alternative conceptions are too difficult to be eliminated by ordinary teaching methods.
4. Some alternative conceptions are based on experiences in the past of the individual.
5. Alternative conceptions can originate from a) genetic basis b) variety of experiences and c) teaching in the school environment.

Alternative conceptions are generally developed during new learning situations in science classes (Koray and Bal, 2002). Especially biology topics in science courses bring new concepts to students without determining existent conceptualization and biology has concepts coming from a new language such as Latin language. Hence, biology topics should be seriously considered in terms of the formation of alternative conceptions. One of the topics bringing new abstract concepts to biology is inheritance. The development of genetics as a science that affects the pharmaceutical industry has also led to the expansion on inheritance terminology and number of inheritance concepts to be learned (Lanie et al., 2004). In the context of the evolving inheritance terminology, there are concepts that elementary level students meet for the first time such as chromosomes, mitosis, meiosis, regeneration, modification and adaptation. Knippels et al. (2005) have identified major problems as barriers to develop appropriate conceptions regarding inheritance subject. These are abstract nature of concepts, complexity of concepts, requirement of probabilistic reasoning, dense terminology, Punnett diagrams and symbolizations, having inadequate understandings of cell division and insufficient prior knowledge and cognitive maturity. Based on these problems it is clearly observed that alternative conceptions regarding inheritance have deep roots. The studies on alternative conceptions about inheritance also support this notion that students and adults from different educational levels have different alternative conceptions about the inheritance (Kibuka-Sebitosi, 2007; Lanie et al. (2004). In a study on 11th and 12th grade students' understanding on inheritance concepts, Kibuka-Sebitosi (2007) determined that students had alternative conceptions about nature of genetic knowledge in cells. As a result of analyzing concepts maps, he found that the students had also problems about understanding some inheritance concepts. These concepts are; a) differences between genes and chromosomes, b) definition of inheritance, c) definition of Mendelian inheritance. Banet and Ayuso (2000)'s study showed that students have alternative conceptions on the meiosis. They also could not understand concepts of homozygotes and heterozygotes. Lanie *et al.* (2004) asked 2 questions to the participants in their study conducted with 62 adults. The first question was "are ability and behavior hereditary?". The second question was "do genes occupy a special place in the body?". As a result of the qualitative and quantitative analysis of the answers to the questions, it was seen that people were familiar with inheritance issues through mass media devices but there are uncertainties or misunderstandings in the minds of the people in answers to the asked questions. For instance, as an answer to "do the genes occupy a special place in the body?" question, approximately 34% of participants answered correctly and 23% expressed that it is in the brain. The remaining percent answered that it is in the heart, bones, blood, reproductive cells. In Williams, Debarger, Montgomery, Zhou and Tate (2011)'s study, the authors determined 7th grade students (n=209)'s difficulties in understanding differences between meiosis and mitosis processes. Moreover it was also seen that students having medium and low level of knowledge had difficulties in understanding of the spindles in cell division and their role in the genetic transfer. Hence the findings of this study drive us to study alternative conceptions by considering acquaintance and lack of knowledge about inheritance. In the studies above, except for the last one, there was no explicit strategy for discriminating lack of knowledge and acquaintance from alternative conceptions.

When looked at the literature (Banet and Ayuso, 2000; Lanie et al., 2004; Lewis and Kattmann, 2004; Knippels et al., 2005; Kibuka-Sebitosi, 2007; Williams et al., 2011), it might be summarized that there is a number of alternative conceptions as barriers for teaching and learning of inheritance concepts and the first step in bringing a solution to the problem requires discriminating alternative conceptions from insufficient acquaintance and lack of knowledge for making description meaningful. In the study of Lanie et al. (2004) they stated that whether the participants know the concept of gene and heredity affects their answer to alternative conception situations. However determining alternative conceptions is not an easy task and multi-sided issue. First we have to determine acquaintance of the subject and then we have to separate lack of knowledge from alternative conceptions. So there is a need to apply three-tiered approach (identifying acquaintance, knowledge levels and alternative conceptions respectively) to determine alternative conceptions regarding inheritance. By this way we can determine purer alternative conceptions regarding inheritance than alternative conceptions determined by just applying one test or one-shot questioning.

Table 1. Descriptive statistics of the participants

Descriptors	Categories	Values
Age	-	13-15
Gender	Female	206
	Male	187
Class	8th grade	393

Table 2. Question Types of the Test

Question Type	Questions
Questions measuring level of knowledge about concept (YES/NO)	1, 9, 15, 21, 24, 28, 32, 36, 40
Questions for lack of knowledge about the concepts	3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 17, 18, 19, 20, 23, 26, 27, 30, 31, 34, 35, 38, 39, 42, 43
Questions for measuring misconceptions	2, 10, 16, 22, 25, 29, 33, 37, 41

As seen in the literature alternative conceptions are sometimes confused with the lack of knowledge about inheritance. Every unscientific explanation is not an alternative conception. Let's talk about a student: if this student defines the chromosome unscientifically, we cannot say that "the student has alternative conception about the chromosome". This definition might be caused of conceptual confusion, lack of knowledge or alternative conception. If the student is aware of this unscientific explanation or definition and changes this explanation or definition without any instruction in a short time, and the student do not have sufficient acquaintance of the concept we can say clearly that this student has represented a conceptual confusion. But, if the student says own explanation or definition is absolutely true and it cannot be changed by the ordinary instruction and the explanation or definition is about meaning of the concept then we can say that the student has an alternative conception about chromosome concept (Güneş, 2007). Also the student might define chromosome by using insufficient knowledge background and it can be changed by the ordinary instruction in a short time and the explanation or definition is about definition of the concept without explaining meaningful associations with other concepts. In this situation we can say that the students have lack of knowledge. Therefore the aim of this study was to determine alternative conceptions about the inheritance on eighth grade students, by determining and discriminating their acquaintance and lack of knowledge about inheritance.

METHOD OF THE STUDY

In this study quantitative cross-sectional descriptive method was used (Frankel and Wallen, 2003). Two instruments were used for data collection three-tiered test for inheritance subject and personal information form. In developing the "Three-tiered test for inheritance subject", content validity, difficulty, discrimination, internal consistency analyses were performed for validity and reliability evidence. Pilot study for understandability and format of the test was done with 8th grade students (n=8). The final form of the test was applied to 393 8th grade students. Convenient sampling approach was used in this research. **Table 1** summarizes characteristics of the participants.

Validity and Reliability Studies of the Three-tiered Test for Inheritance Subject

The test has three tiers; Yes-No questions for acquaintance about the aspects of the subject, multiple choice questions for knowledge background regarding the concepts of the subject and multiple choice alternative conception questions for concepts of inheritance subject. The concepts regarding "inheritance" subject were determined by considering the content of 8th grade "Cell Division and Inheritance" unit in the first stage of preparing the test. A table of specification was established for content validity. In the first tier, the purpose of YES/NO questions is to determine whether the student has prior acquaintance with the concepts. If students answered "NO" to the first tier questions, they should not give answer to the multiple-choice questions. The multiple-choice questions on the alternative conceptions aimed to determine the alternative conceptions about the concepts after being sure that students are acquainted with the concept and have knowledge about the concepts. The questions on alternative conceptions regarding the concepts were determined by considering the alternative conception statements provided by the literature. Also expert opinion about the questions on knowledge regarding inheritance and alternative conceptions was taken. The prepared questions were applied to eight students as a pilot study for understandability and format of the test. The final form of the test consisted of 43 questions.

All the questions in the final form of the test were also evaluated by one science education expert and three science teachers in terms of readability, understandability level and conformity for determining alternative conception and knowledge levels. The final questions were also checked for appropriateness of the number of questions, grammar and spelling errors. The final form of the test was applied to the 392 eighth grade students.

Table 3. The results of the analysis of all multiple-choice questions in the test with ITEMAN program

Statistics	Value
Number of items	33
Number of participant	392
Mean	18.93
Variance	47.12
Minimum	0
Maximum	32
Alpha (KR-20)	0.87
Difficulty index	0.57
Discrimination index	0.47

Table 4. Acquaintance situation of the participants about the concepts of inheritance

Questions	Statistics	YES	NO
Question-1. Do you have acquaintance with chromosomes?	Frequency	387	5
	Percent	98.72%	1.28%
Question-2. Do you have acquaintance with "heredity" concept?	Frequency	376	17
	Percent	95.66%	4.34%
Question-3. Do you have acquaintance with "genetic disease" concept?	Frequency	387	5
	Percent	98.72%	1.28%
Question-4. Do you have acquaintance with "modification" concept?	Frequency	382	10
	Percent	97.45%	2.55%
Question-5. Do you have acquaintance with "adaptation" concept?	Frequency	379	13
	Percent	96.68%	3.32%
Question-6. Do you have acquaintance with "regeneration" concept?	Frequency	344	48
	Percent	87.76%	12.24%
Question-7. Do you have acquaintance with "DNA" concept?	Frequency	385	7
	Percent	98.21%	1.79%
Question-8. Do you have acquaintance with "mitosis" concept?	Frequency	385	7
	Percent	98.21%	1.79%
Question-9. Do you have acquaintance with "meiosis" concept?	Frequency	380	12
	Percent	96.94%	3.06%

"Yes-No" questions were not involved in difficulty, discrimination, internal consistency analyses because they were not accepted as true or false choice. They were just used for checking acquaintance. The data of multiple-choice questions were analyzed by ITEMAN program. The findings are represented in the **Table 3**.

The alpha value as .87 in **Table 3** shows an acceptable value as an internal consistency evidence of the measurement tool (Rudner and Schafer, 2002). Discrimination level of the test scores (Point biserial correlation) has been determined as over .25 it is an acceptable value (Wells and Wollack, 2003). Also it has been observed that difficulty level of questions in the measurement tool has .57 that means a medium level difficulty.

FINDINGS

The data collected by the test showed that approximately all of the participants were acquainted with the concepts regarding inheritance subject except for "regeneration" concept. **Table 4** represents acquaintance situation of the participants about the concepts of inheritance.

As seen in **Table 4**, great majority of the participants acquainted with nearly all of the concepts of inheritance except for "regeneration" concept. In spite of their acquaintance with the concepts, small number of the students did not have any acquaintance with the concepts. After determining the participants' acquaintance with the concept, second tier of the test was examined and the results showed that the students do not have acceptable knowledge about the concepts of inheritance. **Table 5** represents knowledge of the participants about the concepts regarding inheritance.

Table 5. Knowledge of the participants about the concepts regarding inheritance

Concepts	Questions	Choices				
Chromosome	**Question-1.** **I)**If an organism has more number of chromosomes than others, it is a more advanced organism. **II)**If an organism has more number of chromosomes than others, it reproduces more number of offspring. **Which one/ones of the statements is false?**	**Only I**	**Only II**	**I and II***	**None of them**	**Blank**
	Frequency	27	36	275	48	6
	Percent	6.89%	9.18%	**70.15%**	12.24%	1.53%
	Question-2. **I)** There is no relationship between number of chromosomes and developmental status of organism. **II)** Having more number of chromosomes than others does not affect reproductive success. **Which one/ones of the above statement is true?**	**Only I**	**Only II**	**I and II***	**None of them**	**Blank**
	Frequency	24	46	282	32	8
	Percent	6.12%	11.73%	**71.94%**	8.16%	2.04%
	Question-3. **I)**In spite of similarity in number of chromosomes, real reason of similarity between individuals is difference in their gene phosphates. **II)** The number of chromosomes in body cells of an organism is different from the number of chromosomes in reproductive cells. **Which one/ones of the above statement is false?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	211	56	58	57	10
	Percent	**53.83%**	14.29%	14.80%	14.54%	2.55%
	Question-4. **I)** The number of chromosomes in reproductive cells and body cells of an organism are equal to each other. **II)** Despite the fact that number of human chromosomes is same, the main reason of differences in humans is variation of gene sequences. **Which one/ones of the above statement is true?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	37	228	75	38	14
	Percent	9.44%	**58.16%**	19.13%	9.69%	3.57%
	Question-5. **I)** The chromosome numbers of organisms classified in same species group is same. **II)**The chromosome numbers of organisms classified in different species is absolutely different. **Which one/ones of the above statement is false?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	59	213	70	40	10
	Percent	15.05%	**54.34%**	17.86%	10.20%	2.55%
	Question-6. **I)** The chromosome numbers of organisms classified in different species group can be same. **II)**The chromosome numbers of organisms classified in same species group is different. **Which one/ones of the above statement is true?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	263	29	67	26	7
	Percent	**67.09%**	7.40%	17.09%	6.63%	1.79%
Heredity	**Question-7.** **I)**Father's or mother's genes can be dominant. **II)** Nevus is not hereditarily transferable. **Which one/ones of the above statement is false?**	**Only I**	**Only II**	**I and II**	**None of them***	**Blank**
	Frequency	30	158	28	156	20
	Percent	7.65%	40.31%	7.14%	**39.80%**	5.10%
	Question-8. **I)**If there is a nevus on a human's body, his/her brother or sister has the same nevus on the same location of body. **II)** Father's genes are always dominant than mother's genes. Because of this children always carry the father's genes. **Which one/ones of the above statement is true?**	**Only I**	**Only II**	**I and II**	**None of them***	**Blank**
	Frequency	56	48	31	238	19
	Percent	14.29%	12.24%	7.91%	**60.71%**	4.85%
	Question-9. **I)**Genetic structures of bone cell and nerve cell are different. **II)**If a family has four children; three boys and a girl, it doesn't mean that just boys carry the dominant genes. **Which one/ones of the above statement is false?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	68	77	43	183	21
	Percent	**17.35%**	19.64%	10.97%	46.68%	5.36%
	Question-10. **I)**A family has four children; three boys and a girl. We can say that just boys have the dominant genes. **II)**There is no structural difference between bone cells and nerve cells in terms of genetic structure. **Which one/ones of the above statement is true?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	88	66	47	165	26
	Percent	22.45%	**16.84%**	11.99%	42.09%	6.63%
Genetic Diseases	**Question-11.** **I)**Genetic diseases are transferred by dominant or recessive genes. **II)**An accident in the past may cause color blindness. **Which one/ones of the above statement is false?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	40	206	79	59	8
	Percent	10.20%	**52.55%**	20.15%	15.05%	2.04%
	Question-12. **I)** An accident in the past doesn't cause color blindness. **II)**Genetic diseases transferred by only dominant genes. **Which one/ones of the above statement is true?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	180	61	83	62	6
	Percent	**45.92%**	15.56%	21.17%	15.82%	1.53%

Table 5 (continued). Knowledge of the participants about the concepts regarding inheritance

Concepts	Questions	Choices				
Genetic Diseases	**Question-13.** **I)** All children having a hemophilic father are possibly not hemophilic. **II)**Genetic diseases pass to infants from mother because babies feed from mother's blood before prenatal period. **Which one/ones of the above statement is false?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	30	206	36	104	16
	Percent	7.65%	**52.55%**	9.18%	26.53%	4.08%
	Question-14. **I)** All children having a hemophilia father are certainly hemophilic. **II)** There is no relationship between genetic diseases in babies and feeding from mothers' blood before prenatal period. **Which one/ones of the above statement is true?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	27	194	35	125	11
	Percent	6.89%	**49.49%**	8.93%	31.89%	2.81%
Modification	**Question-15.** **I)**If you cut tail of a mouse, its offspring will also born with a cut tail. **II)**Accidentally occurred blindness is transferred to the next generations. **Which one/ones of the above statement is true?**	**Only I**	**Only II**	**I and II**	**None of them***	**Blank**
	Frequency	41	70	24	240	17
	Percent	10.46%	17.86%	6.12%	**61.22%**	4.34%
Adaptation	**Question-16.** **I)**Properties of adaptation are transferred to next generations. **II)**Adaptations occur at only level of phenotypes. **Which one/ones of the above statement is <u>false</u>?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	59	216	50	50	17
	Percent	15.05%	**55.10%**	12.76%	12.76%	4.34%
	Question-17. **I)**Adaptations occurs at the level of genotypes. **II)**Adaptations are seen at the level of individuals. **Which one/ones of the above statement is true?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	143	82	66	76	25
	Percent	**36.48%**	20.92%	16.84%	19.39%	6.38%
Regeneration	**Question-18.** **I)**The severed ear of the cat can completely regenerate itself. **II)**Regeneration can't be seen in humans. **Which one/ones of the above statement is <u>false</u>?**	**Only I**	**Only II**	**I and II***	**None of them**	**Blank**
	Frequency	85	83	137	30	57
	Percent	21.68%	21.17%	**34.95%**	7.65%	14.54%
	Question-19. **I)**Regeneration can be seen in humans. **II)**The severed ear of the cat can't completely regenerate itself. **Which one/ones of the above statement is true?**	**Only I**	**Only II**	**I and II***	**None of them**	**Blank**
	Frequency	67	76	162	30	57
	Percent	17.09%	19.39%	**41.33%**	7.65%	14.54%
DNA	**Question-20.** **I)**DNA is found in all body cells with nuclei. **II)**DNA doesn't replicate itself. **Which one/ones of the above statement is <u>false</u>?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	35	257	57	22	21
	Percent	8.93%	**65.56%**	14.54%	5.61%	5.36%
	Question-21. **I)** DNA replicates itself. **II)** DNA is seen in only reproduction cells. **Which one/ones of the above statement is true?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	263	21	68	22	18
	Percent	**67.09%**	5.36%	17.35%	5.61%	4.59%
Mitosis and Meiosis	**Question-22.** **I)** Mitosis occurs in plants whereas meiosis does not occur in plants. **II)** Mitosis occurs during re-repair of broken bones. **Which one/ones of the above statement is <u>false</u>?**	**Only I***	**Only II**	**I and II**	**None of them**	**Blank**
	Frequency	170	75	33	94	20
	Percent	**43.37%**	19.13%	8.42%	23.98%	5.10%
	Question-23. **I)**Meiosis occurs during re-repair of broken bones. **II)**Both mitosis and meiosis occur in plants. **Which one/ones of the above statement is true?**	**Only I**	**Only II***	**I and II**	**None of them**	**Blank**
	Frequency	40	194	56	82	20
	Percent	10.20%	**49.49%**	14.29%	20.92%	5.10%
	Question-24. **I)**Meiosis provide the reproduction of all living things. **II)**Meiosis allows evolution and reproduction of zygote. **Which one/ones of the above statement is <u>false</u>?**	**Only I**	**Only II**	**I and II***	**None of them**	**Blank**
	Frequency	71	91	138	68	24
	Percent	18.11%	23.21%	**35.20%**	17.35%	6.12%

As seen in **Table 5**, majority of the participants (over 53%) have sufficient knowledge background about the chromosome concept; relationship between numbers of chromosomes and, reproductive and developmental status of organisms, association of numbers of chromosomes with similarity of organisms, difference between body cells and reproductive cells in terms of number of chromosomes, association of numbers of chromosomes with being member of the same species. However less than 50% of the participants have sufficient knowledge background about heredity; genetically transferability of nevus, dominancy of parental genes, genetic similarity of different cell types. About 50% of the participants have sufficient knowledge background about genetic diseases; transfer of hemophilia, transfer of genetic diseases from mother to baby, dominancy of genes of genetic diseases and genetically transfer of diseases caused by an accident. Over the 60 % of the participants have sufficient knowledge background about modification; genetically transfer of physical changes and genetically transfer of blindness caused by an accident. For the adaptation concept, their level of knowledge was higher (over 50%) for occurrence of adaptations at the level of phenotype while level of knowledge was low (36%) for occurrence of adaptations at the level of genotype and individual. As another concept, knowledge levels of the participants about "regeneration"; occurrence of regeneration in humans and regeneration of severed ear, were not as high as expected. Less than 50% of the participants answered correctly to the questions. Knowledge levels of the participants about "DNA"; Place of DNA in body cells, DNA replication, existence of DNA in reproduction cells were high, majority of the participants (over 65%) answered correctly to the questions. For the meiosis and mitosis concepts; occurrence in plants, broken bones, role of meiosis and mitosis in evolution and reproduction, unfortunately less than 50% of the participants answered correctly to the questions. After determining knowledge levels of the participants, their alternative conceptions were determined by using conceptual questions. The findings are represented in **Table 6**.

As seen in **Table 6**, the students have alternative conceptions regarding the concepts of inheritance subjects. Their percent values about alternative conceptions for the ***chromosome, heredity, genetic disease, modification, adaptation, regeneration, DNA, meiosis and mitosis are 19%, 48%, 19%, 31%, 25%,22%, 44%, 60% and 25% respectively.*** As an example, if we look at all the tables (**Table 4**, **5** and **6**) together, it can be seen that most of the students (98.72%) declared they have acquaintance with chromosome concept, over 53% of them have knowledge about chromosome concept and 19% of the students have alternative conceptions about chromosome concept. Comparison of the percent values regarding acquaintance, level of knowledge and alternative conceptions is made in **Table 7**.

As seen in **Table 7**, acquainting a concept of heredity and having knowledge about it do not guarantee lack of alternative conceptions about the concepts of inheritance. Hence it is seen that for measuring alternative conceptions, use of conceptual questions rather than knowledge questions leads to different findings about alternative conceptions.

Table 6. Alternative conceptions of the participants about the concepts regarding inheritance

	Frequency	Percent
Question-1. What is chromosome?		
Scientifically accepted answer: An element of cell which carries genes and is composed of DNA and nucleoproteins.	309	78.83
Alternative conception: Organelles carrying the organism's hereditary characteristics	62	15.82
Alternative conception: Administrative molecule in organisms	10	2.55
Alternative conception: Structural units of nucleic acids (DNA, RNA)	5	1.28
Blank	6	1.53
Question-2. What is heredity?		
Alternative conception: It involves the different forms of the same characteristic of an organism; it also means changing and diversity.	108	27.55%
Alternative conception: Branch of science that examines the cell.	22	5.61%
Scientifically Accepted Answer: Transfer of an organism's genetic code to the next generation.	225	57.40%
Alternative conception: All genes of an organism.	18	4.59%
Blank	19	4.85%
Question-3. What is genetic disease?		
Alternative conception: It is the damages of environmental factors on the phenotype of organisms.	30	7.65%
Scientifically Accepted Answer: Diseases transferred via the genes of parents.	313	79.85%
Alternative conception: Diseases results from unhealthy nutrition.	20	5.10%
Alternative conception: Infectious diseases that can be transferred from person to person.	23	5.87%
Blank	6	1.53%
Question-4. What is modification?		
Alternative conception: Renewal of wounds and damaged organs in organisms.	41	10.46%
Alternative conception: Genetic characteristics of organisms that increase the chance of survival and reproduction, and allow to the adaptation to the environment.	44	11.22%
Alternative conception: It involves the different forms of the same characteristic of an organism; it also means changing and diversity.	37	9.44%
Scientifically Accepted Answer: Changes occurring in living organisms' phenotype due to environmental impacts.	258	65.82%
Blank	12	3.06%
Question-5. What is adaptation?		
Scientifically Accepted Answer: Genetic characteristics of organisms that increase the chance of survival and reproduction, and allow to the adaptation to the environment.	278	70.92%
Alternative conception: It involves the different forms of the same characteristic of an organism; it also means changing and diversity.	27	6.89%
Alternative conception: Changes occurring in living organisms' phenotype due to environmental impacts.	45	11.48%
Alternative conception: Renewal of wounds and damaged organs in organism.	27	6.89%
Blank	15	3.83%
Question-6. What is regeneration?		
Alternative conception: Changes occurring in living organisms' phenotype due to environmental impacts.	33	8.42%
Scientifically accepted answer: Renewal of wounds and damaged organs in organism.	251	64.03%
Alternative conception: It involves the different forms of the same characteristic of an organism; it also means changing and diversity.	32	8.16%
Alternative conception: Damages of environmental impacts on living organisms' phenotype.	18	4.59%
Blank	58	14.80%
Question-7. What is DNA?		
Alternative conception: Building structures of nucleic acids.	40	10.20%
Alternative conception: It is a nitrogenous purine base in nucleic acid structure.	25	6.38%
Scientifically Accepted Answer: Administrative molecule in organisms.	205	52.30%
Alternative conception: All of the genes in an organism.	105	26.79%
Blank	17	4.34%
Question-8. What is meiosis?		
Alternative conception: Meiosis is the division of cells, which form two new cells with different properties from the parental cell.	40	10.20%
Alternative conception: Meiosis is the division of cells, which form four new cells with same properties from the parental cell.	133	33.93%
Scientifically Accepted Answer: Meiosis is the division of cells, which form haploid (n) cells from diploid (2n) cells.	172	43.88%
Alternative conception: Meiosis is the division of cells, which form two new cells with same properties from the parental cell.	25	6.38%
Blank	22	5.61%
Question-9. What is mitosis?		
Scientifically Accepted Answer: Mitosis is the division of cells, which form two new cells with same properties from the parental cell.	273	69.64%
Alternative conception: Mitosis is the division of cells, which form haploid (n) cells from diploid (2n) cells.	43	10.97%
Alternative conception: Mitosis is the division of cells, which form four new cells with different properties from the parental cell.	36	9.18%
Alternative conception: Mitosis is the division of cells, which form four new cells with same properties from the parental cell.	21	5.36%
Blank	19	4.85%

Table 7. Comparison of the percent values regarding acquaintance, level of knowledge and alternative conceptions about the concepts of inheritance

Concepts	Acquaintance with the Concept	Having Knowledge about the Concept (Mean percent)	Having Alternative Conceptions about the Concept
Chromosome	98.72%	62%	19%
Heredity	95.66%	34%	*48%*
Genetic Disease	98.72%	50%	19%
Modification	97.45%	61%	31%
Adaptation	96.68%	45%	25%
Regeneration	87.76%	38%	22%
DNA	98.21%	66%	44%
Meiosis and Mitosis	97.57%	42%	*43%*

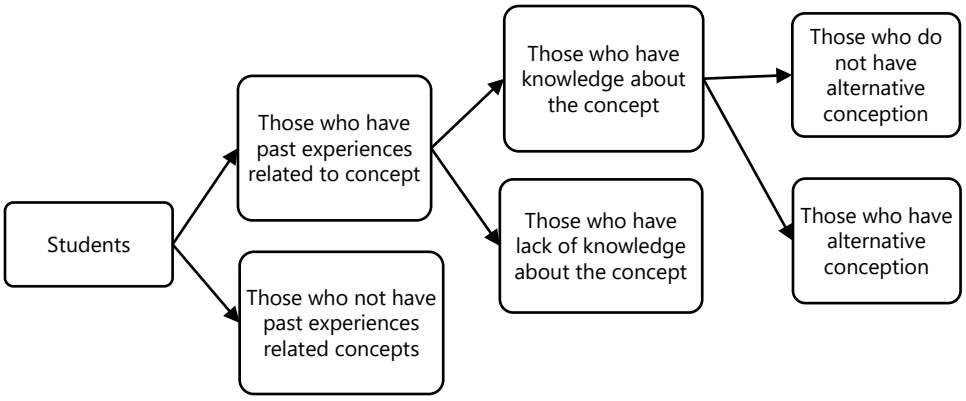

Figure 1. Map of Conceptual Understanding Path of the Students

RESULT AND DISCUSSION

In this study, acquaintance and lack of knowledge, alternative conceptions of 8th grade students about the concepts of inheritance were examined. According to findings obtained in this study, the students were acquainted with the concepts of inheritance, since they took courses on the concepts before the eight grade. However they had limited knowledge about the concepts. In literature elementary level students' lack of knowledge about the concepts of inheritance was shown (Williams et al., 2012; Lewis and Wood-Robinson, 2000). Williams et al. (2012) studied understandings of 209 seventh graders on the relationship between cell division and genetic inheritance. They found that the students did not have strong knowledge background, for example some of them could not explain the association of mitotic and meiotic divisions with genetic information. Also Lewis and Wood-Robinson (2000) studied knowledge background of 482 students aged 14-16. They found that the students had a poor understanding of the genetic information transfer and a lack of basic knowledge about gene and chromosome concepts. After collection of information regarding acquaintance and lack of knowledge about the concepts of inheritance, there is a need to collect data about alternative conceptions of the students to decide about their conceptual understandings regarding the concepts. Hence three-tiered approach of assessment in conceptual understanding studies provides advantage in discriminating the problems rooted from acquaintance and lack of knowledge, alternative conceptions in conceptual understandings.

In further analysis the data showed that the students had different alternative conceptions about inheritance subject. Alternative conceptions of 8th grade students about "Cell Division and Inheritance" unit mostly focus on heredity, modification, DNA, mitosis and meiosis concepts. In the literature (Banet and Ayuso, 2000; Lanie et al., 2004; Lewis and Kattmann, 2004; Knippels et al., 2005; Kibuka-Sebitosi, 2007; Williams et al., 2011) we observed that students had similar alternative conceptions. In our study, it can be seen clearly that students seriously having problems especially about, heredity, DNA and meiosis. When literature examined (Banet and Ayuso, 2000; Lanie et al., 2004; Lewis and Kattmann, 2004; Knippels et al., 2005) it was observed that existence of this problem was supported by our work. By using three-tiered assessment approach we can also draw path of conceptual understanding of the group. According to findings of our study, the group of the students represented a path of conceptual understating on the concepts. This path is presented in **Figure 1**.

As seen in **Figure 1**, the students were classified in terms of their past experiences about the concepts so prior learning or experiences related to the concept was determined before determining alternative conceptions. This is an important condition in the formation of alternative conceptions. Individuals who have not any previous experience or acquaintance regarding a concept cannot develop alternative conceptions. Hence determining alternative conceptions without asking the participants' previous acquaintance might drive the researcher to urge the participants to give answer to the test questions about which they have no idea. According to our findings, students having past experience about the concepts emerge as two different groups as the students having knowledge and the students having lack of knowledge. But both of the group represented alternative conceptions regarding the concepts of inheritance. This part of the path shows that having knowledge about a concept does not guarantee to have a conceptual understanding about a concept. So there is a need to assess alternative conceptions by discriminating them from acquaintance problem and lack of knowledge about the inheritance. In spite of the valuable contributions of this study, the following studies should make the following suggestions;

1- The sample size in next studies should be expanded.

2- Research is limited to certain concepts (chromosomes, genetics, genetic diseases, modification, adaptation, regeneration, DNA, mitosis, meiosis) in the "Cell Division and Inheritance" unit. Other concepts on this issue should be studied.

3- Gender differences should be addressed.

REFERENCES

Ayas, A., Çepni, S., Akdeniz, A. R., Özmen, H., Yiğit, N., & Ayvacı, H. Ş. (2010). *Kuramdan Uygulamaya Fen ve Teknoloji Öğretimi* [Teaching Science and Technology: From Theory to Practice]. Ankara: Pegem Akademi.

Bahar, M. (2003). Misconceptions in Biology Education and Conceptual Change Strategies. Educational Sciences. *Theory & Practice*, *3*(1), 55–64.

Baker, W. P., & Lawson, A. E. (2001). Complex instructional analogies and theoretical concept acquisition in college genetics. *Science Education*, *85*, 665–683.

Banet, E., & Ayuso, E. (2000). Teaching genetics at secondary school: A strategy for teaching about the location of inheritance information. *Science Education*, *84*, 313–351.

Elmesky, R. (2012). Building capacity in understanding foundational biology concepts: a k-12 learning progression in genetics informed by research on children's thinking and learning. *Research on Science Education*, *43*, 1155.

Eryilmaz, A. (2002). Effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. *Journal of Research in Science Teaching, 39*(10), 1001–1015.

Fisher, K. (1985). A Misconception in Biology: Amino Acids and Translation. *Journal of Biology Education*, *22,* 53–62.

Fraenkel, J. R., & Wallen, N. E. (2003). *How to design and evaluate research in education, (5th ed.).* New York: Mcgraw-Hill Publishing.

Güneş, B. (2007) *Fizikteki kavram yanılgıları*. Retrieved on 7 June 2013 from http://www.bilalgunes.com

Kaptan, F. (1999). *Fen Bilgisi Öğretimi*. İstanbul: Milli Eğitim Basımevi.

Kibuka-Sebitosi, E. (2007). Understanding genetics and inheritance in rural schools. *Journal of Biological Education*, *41*(2), 56–61.

Knippels, M.-C. P. J., Waarlo, A. J., & Boersma, K. T. (2005). Design criteria for learning and teaching genetics. *Journal of Biological Education*, *39*(3), 108–112.

Koray, Ö., & Bal, Ş. (2002). Fen Öğretiminde Kavram Yanılgıları ve Kavramsal Değişim Stratejisi. *G.Ü. Kastamonu Eğitim Fakültesi Dergisi*, (10), 83–90.

Lanie, A. D., Jayaratne, T. E., Sheldon, J. P., Kardia, S. L. R., Anderson, E. S., Feldbaum, M., & Petty, E. M. (2004). Exploring the public understanding of basic genetics concepts. *Journal of Genetic Counseling*, *13*(4), 305-320.

Lewis, J. & Wood-Robinson, C. (2000). Genes, chromosomes, cell division and inheritance – do students see any relationship? *International Journal of Science Education, 22*, 177–195.

Lewis, J., & Kattmann, U. (2004). Traits, genes, particles and information: re-visiting student's understandings of genetics. *International Journal of Science Education*, *26*(2), 195–206.

Posner, G. J., Hewson, P. W., Strike, K. A., & Gertzog, W. A. (1982). Accomodation of a Scientific Conception : Toward a Theory of Conceptual Change. *Science Education*, *66*, 211–227.

Reckase, M. D., & McKinley, R. L. (1991). The discriminating power of items that measure more than one dimension. *Applied Psychological Measurement, 15*, 361-373.

Rudner, L. & Schafer, W. (2002). What teachers need to know about assessment. Washington, DC: National Education Association.

Southerland, S., Abrams, E., Cummins, C., & Anzelmo, J. (2001). Understanding students' explanations of biological phenomena: Conceptual frameworks or p-prims? *Science Education, 85*(4), 328–348.

Wells, C. S., & Wollack, J. A. (2003). A method for maintaining scale stability in the presence of test speededness. *Journal of Educational Measurement, 40*, 307-330.

Wenning, C. j. (2008) Dealing more effectively with alternative conceptions in science, *Journal of Physics Teacher Education Online, 5*(1), 11-19.

Williams, M., Debarger, A. H., Montgomery, B. L., Zhou, X., & Tate, E. (2011). Exploring middle school students' conceptions of the relationship between genetic inheritance and cell division. *Science Education*, (96), 78–103.

Williams, M., Montgomery, B. L., & Manokore, V. (2012) From Phenotype to Genotype: Exploring Middle School Students' Understanding of Genetic Inheritance in a Web-Based Environment. *The American Biology Teacher, 74*(1), 35-40.

Yang, C., Noh, T., Scharmann, L.C., & Kang, S. (2014) A Study on the Elementary School Teachers' Awareness of Students' Alternative Conceptions about Change of States and Dissolution*, The Asia-Pacific Education Researher, 23*(3), 683–698.

http://www.ejhbe.com