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Dynamising Conceptual Change Approach to Teach Some Genetics Concepts

Assist.Prof.Dr.Feyzi Osman Pekel
Suleyman Demirel University-Turkey
osmanpekel@sdu.edu.tr

Prof.Dr.İsmet Hasenekoğlu *Kilis 7 Aralik University-Turkey*
ismeth@kilis.edu.tr

Abstract

This study investigates the effect of a conceptual change approach over traditional instruction on students' understanding of DNA, gene and chromosome concepts. 52 10th grade students belonging two different classes participated the study. One of the classes was assigned randomly to the control group, and the other class was assigned randomly to the experimental group. During teaching of the topic of DNA and gene related concepts in the biology curriculum, the conceptual change approach was applied in the experimental group whereas 'traditional instruction' was followed in the control group. The data were analyzed using analysis of SPSS 10.0. The results showed that the students in the experimental group performed better when compared to the control group. For the genetic concept achievement test, the posttest average percent of correct responses of the experimental group was % 79.46 and that of the control group was % 59.79 after the treatment. Add to this, it was found that students' attitudes towards biology lessons made a statistically significant contribution to the variation in students' understanding of DNA, gene and chromosome related concepts.

Key Words: Genetics concepts, conceptual change approach, misconceptions

INTRODUCTION

Genetics is considered one of the cornerstones of modern biology (Rotbain et al., 2005) but during the second half of the 20th century, it progressively became an essential field feeding controversial ethical, social, economic (Boujemaa et al., 2010) and educational debates.

In the last decade, we observe that traditional teaching approach is shifting towards enabling students to assimilate well-structured, integrated frameworks of knowledge useful for everyday life. But despite the changes in the curriculum, learners still leave high school with distorted views of biological sciences and concepts (Mintzes et al, 1998; Kibuka-Sebitosi, 2007).

Nowadays, there has been a stronger focus on students' understandings of these structures, processes and mechanisms of inheritance and better teaching implications of these subjects (Lewis, 2004). In addition, it is known that many teachers and students regard this topic as too difficult, both to teach and to learn (Fisher, 1992; Marbach-Ad and Stavy 2000; Templin and Fetters, 2002; Smith and Williams, 2007; Yılmaz etal., 2011). But, this is only one reason for a large number of students' having distorted views and alternative conceptions about genetics.

About the source of students' misconceptions Mintzes et al., (2001) and Kibuka-Sebitosi (2007) state that students might get the alternative conceptions from previous teachers, fellow colleagues, from textbooks and media, so these ideas are in turn passed on to others. These misconceptions might limit students' ability to develop an understanding of the scientific explanations (Lewis and Kattmann, 2004).

During genetics education, students are simultaneously exposed to many new concepts and processes at macro and molecular levels (Rotbain et al., 2005). Difficulties causing misconceptions especially arise at the molecular level since molecular genetics deals both with minute details and abstract concepts (Malacinski and Zell, 1996). Such concepts are possibly one of the most daunting and alien concepts confronting a learner (Burns, 1995). During molecular genetics education, many high-school teachers confront such difficulties, especially when they refer to structures of complex molecules such as processes such as protein synthesis, DNA (Rotbain et al., 2005) gene and chromosome related concepts.

Science and especially biology is such an area full of ideas that are uneasy to concretize and often counterintuitive for learners of all ages (Venville and Donovan, 2008). For this reason, analogies and models are helpful for transforming such unfamiliar, abstract and seemingly unintelligible ideas, concepts and theories into comprehensible understanding for learners in many contexts and situations. Hence, it is not surprising that models and analogies are important tools in the classroom repertoire of reputable science educators (Treagust et al., 1992; Harrison, 2008; Venville and Donovan, 2008).

In traditional teaching approach, to represent the structure of molecules, most high-school teachers and textbooks use such abstract concepts which many high school biology students have trouble in perceiving, especially if they have not taken any advanced biology course. Most textbook has drawings alongside the running text, and the learners are not usually required to do anything with them, students generally listen to the teacher or read the textbooks in a passive manner (Rotbain et al., 2005).

Facilitating the construction of scientific knowledge, scientific models, visualizations and animated videos may help learners to make sense of abstract concepts (Treagust et al., 2002). In addition, it is believed that animations, videos are able to promote a positive attitude toward learning and school (Durkin & Barber, 2002), mainly because of their intrinsically motivating character (Annetta et al., 2009; Papastergiou, 2009; Bourgonjon, 2010). Science education is a field in which multimedia instruction has been increasingly employed to communicate complex ideas and concepts in educational settings, providing extra entry points for learners to leverage understanding using alternate forms (Gardner, 1993).

The individual components of multimedia are not new, but the recent integration of these components has made possible exciting developments in science education (Huang and Aloi, 1991).

Of course, the excitement of hands-on laboratory work cannot be completely replaced by an animation or video. However, not all schools have the necessary equipment or funding to complete all necessary experiments or dissections. While students learning videos provide them engaged in learning activities the opportunity to slow down and/or stop, replay the activity for conversation and/or reflection (Wang and Hartley 2003), or argumentation. Thus, if possible, these animated videos are also a substitute for some of these laboratory exercises (Huang and Aloi, 1991). More importantly, this animations and graphics increases student retentions, heightenes student interest and grasp of the subject, helps increased retention (Huang and Aloi, 1989), students to capture the whole picture.

The target of this study was to compare the effectiveness of the conceptual change approach (conceptual change approach accompanied by conceptual change texts, analogies and animated video demonstrations) with traditionally designed instruction on students' understanding of some genetics concepts. Hence, this study targets to address the following two research questions:

1. Does conceptual change instruction, which explicitly dealts with students' misconceptions, including analogies, conceptual change texts and animated video produce greater achievement in understanding of genetic concepts, than traditionally designed instruction, for 10th grade students attended in a biology course?
2. How does the conceptual change instruction effect students' attitude towards biology?

METHOD

Participants in this study consisted of 52 students attended in the 10th grade Biology course, from two classes given by the same teacher in the science department of Ziya Gökalp High School in Turkey. One of the class was randomly assigned as the experimental group (n = 27) while the other assigned as the control group (n = 25). While the experimental group was taught through the conceptual change approach, the control group was taught through traditional instruction. Along the four week period, each group received an equal amount of instructional time and was provided with the same content and assignments, apart from the analogies and animated video demonstrations in the experimental group. The lessons consisted of four 40-minute periods per week during four weeks.

In this study, pre-test–post-test control group design was used to find out the effectiveness of two different models (conceptual change approach and traditionally designed instruction).

Table 1.
Research Design

Groups	*Pre-tests*	*Application*	*Post-tests*
Experimental Group	T_1, T_2	*Conceptual Change Approach*	T_1, T_2
Control Group	T_1, T_2	*Traditional Instruction Approach*	T_1, T_2

* T_1: *Biology Attitude Test*
* T_2: *GCAT (Genetic Concept Achievement Test)*

Genetics Concepts Achievement Test (*GCAT*). With the aim of assessing students' understanding of DNA, genes and chromosomes a concept test composed of 28 multiple-choice questions was employed. Some of the test items were taken from literature (Lewis et al., 1997; Bahar et al., 1999a; Lewis and Wood-Robinson 2000; Lewis et al., 2000a; 2000b; Marbach-Ad and Stavy, 2000; Wood-Robinson et al., 2000; Yip, 2001) and the rest were developed by the authors. All items of the GCAT were aimed to assess learners' perceiving of various genetic concepts. Some of the concepts were tested from different perfectives through two different questions. The items of the GCAT were having three or four distracters which aimed to catch learners' probable alternative conceptions and one correct answer reported in the regarded literature. In the qualitative part of the GCAT, there were four steps which were considerated during the construction process of the GCAT: first, in order to define the content of the GCAT, educational aims of the related concepts (e.g. DNA, gene, chromosome and other related concepts) in the national curricula were examined. Then we examined students' alternative conceptions related to genetic in the literature and interviewed with the students to diagnose their alternative conceptions.

All questions were piloted and necessary modifications were made on the former form before the administration of the test. For the content validity of the test items, two professors of biology education and three senior lecturers were carried out the test items during the development process of GCAT. The reliability coefficient of the test, computed by Cronbach Alpha estimates of internal consistency, was found to be 0.89.

According to Nilsson et al., (1996) correlation coefficient values between .80 and 1.0 indicate a high degree of reliability, and a correlation coefficient between .60 and .79 indicates moderate reliability. So we can conclude the reliability of the test was good given the purpose of the study.

The final form of the test was applied to both experimental and control groups as pre-test before the instruction and post-test after the instruction. Three sample items of the GCAT are given as an example in *Table 2.*

Table 2
Sample items from the GCAT

1. *Where can we see chromosomes using light microscope? (17th question of the GCAT).*
a) In every normal cells, b) Cells in division stage, c) Only in reproductive cells, d) Only in somatic cells.
2. *A multicellular developed organism's somatic cells are different in shape, structure and size. Which of the followings is not the reason for this difference? (21th question of the GCAT).*
a) Having different functions of different cells, b) Difference of the tissues, c) Differences of genetic structures, d) Difference of cytoplasmic amounts
3. *Which of the followings is correct about "genetic information"? (26th question of the GCAT).*
a) information in our memory b) being biologic code of our life activities c) being a chain composed of amino acids d) information we learned about daily activities

Attitude Scale towards Biology (ATB)

We adapted Attitude Scale towards Chemistry (ATC) which developed by Geban et al. (1994) to the biology and formed in to Attitude Scale towards Biology (ATB). It composes of 15 Likert-type items.

Students are asked to express agreement or disagreement of a five-point scale (strongly agree, agree, undecided, disagree, strongly disagree). The Cronbach-alpha reliability of the test was found to be 0.92.

Before and after the instruction, ATB test was applied to both experimental and control groups. Three sample items of ATB test are given in Table 3.

Table 3
Example statements from attitude scale towards biology.

Attitude Scale towards Biology					
	Strongly agree	*Agree*	*Undecided*	*Disagree*	*Strongly disagree*
Biology is one of the lessons I like very much					
I like reading books related to biology					
I would like to learn more about biology subjects					

In this study, conceptual change based instruction was used to cope with the students' alternative conceptions related to DNA, gene, chromosome concepts. The study was carried out over a four-week period. A total of 52 students from two biology classes were participated in the study. The instruction for both groups was given by the same teacher. One of the classes was assigned as the experimental group and other as the control group. The experimental group was instructed using conceptual change approach accompanied by conceptual change texts, analogies and animated video demonstrations. The control group received traditional biology instruction. The topics related to DNA, genes and chromosome concepts were included as part of the formal classroom curriculum in the biology course. The classroom instruction for both groups was consist of four 40 min periods per week. The same topics, DNA, genes, chromosomes and interrelations were covered for both experimental and control groups. In principal, students were given equal opportunities to fulfill the activities in each group. In the control group students were taught using the traditional approach which was based on the teacher provided instruction through a lecture and discussion activities. Instruction based on mainly teacher explanations and textbooks, without considering students' alternative conceptions. The students studied their course books at home before the lessons.

During the lessons of the control group, teacher wrote the definition of the related concepts on blackboard and organized the class as a team. The primary underlying principle was that it is the teacher's responsibility to transfer the knowledge to the students in traditional approach. After teacher's explaining and defining the concepts, some concepts were discussed through the questions directed by teacher. The teacher provided teaching activities through lecturing and discussing the concepts and using reasoning methods about relationships that involve DNA, genes, chromosome concepts and interrelations of them. This type of the class was based on the idea that teacher knows and teach the 'best knowledge/way' for all problematic circumstances. But, there wasn't any restriction for students directing questions to the teacher. When any alternative conception verbalized obviously by a student, the teacher overcame the alternative concept using classroom debates.

In the experimental group, students were taught with conceptual change text instruction that took misconceptions into account and focused on explanations that would maximise the plausibility of the related scientific conceptions. Before the preparation of the conceptual change texts, literature reviewed and interviewed with the students and teachers. The four conditions of the conceptual change proposed by Posner et al. (1982) were considered while designing the conceptual change texts. These texts provided set of guidelines to help students comprehend the concepts. These guidelines constituted special learning environments, such as identifying common misconceptions, activating students' misconceptions through giving examples and asking questions, presenting descriptive evidence in the text that the typical alternative conceptions were incorrect, and providing scientifically correct explanations of the situation. While studying the conceptual change text, the teacher enabled opportunities for students to ask/answer question and discuss his/her ideas. In the conceptual change text, students' common alternative conceptions were introduced, why alternative concepts are unacceptable and what were the inconsistencies of the common alternative conceptions were explained. In the texts, the topics were starting with an introducer question, and students' probable scientifically unaccepted answers were following the question. In this way students were expected to be dissatisfied with their own conceptions. Then more plausible and intelligible scientifically acceptable explanations were presented. Also, if needed, examples and figures were included in the texts with the purpose of further assisting students comprehend the scientific concept and realize the limitations of their own ideas (Dilber, 2010).

In order to increase the texts' intelligibility and clarity, scientific conceptions were explained by examples including analogies. Many experimental studies emphasize that analogies help students' learning complex scientific concepts and promote conceptual change (Dagher, 1994; 1995; Harrison, 2008; Stavy, 1991; Treagust et al., 1992; Canpolat et al., 2006; Pınarbaşı et al., 2006, Çetingül and Geban, 2011). Two excerpt of the conceptual change texts are given in Figure 1.

Figure 1: Two excerpt of the conceptual change texts

Activity 12. 1. Do all the cells of our body have the same chromosome number? The only human cells that do not contain pairs of chromosomes are reproductive cells, or gametes (sperms or human egg cell) which carry just one copy of each chromosome. They are haploid, in other saying they have n chromosome. When two reproductive cells unite, they become a single cell that contains two copies of each chromosome. Now they are diploid, or in other saying they have 2n chromosome. This cell then divides and its successors divide numerous times, eventually producing a mature individual with a full set of paired chromosomes in virtually all of its cell except its' gamet cells.

Activity 12. 3. Can we say developed organisms have much more chromosomes than the basic organisms? Chromosome number is not a scale for development. Chromosome number is constant for the same species. Not all living things have 46 chromosomes, like humans. For example, Mosquitos have 6, Onions have 16, Carp have 104, Orangutan have 48, Potato have 48, Turkey have 82, Fern have 1260 chromosomes.

Implementation of conceptual change texts:

The conceptual change texts of the related topics would be covered were distributed to all the students of experimental group. Then the teacher asked students to read the text silently. Each text was beginning a question and presenting evidence about students' typical alternative conceptions, explaining why those conceptions are incorrect. Lastly, scientifically correct explanations of the concepts were presented. After the students finished reading the texts, the teacher asked if anything they had just read was surprising and emphasized common misconceptions held by students related to the subject. The students discussed the conceptual change texts with each other's and teachers under the teacher's chairman.

At the end of the treatment, genetics concepts achievement test (GCAT) and attitude scale towards biology (ATB) were administered to both experimental and control groups as post-test.

RESULTS

Prior to treatment, an independent-samples t-test was employed to determine whether a statistically significant mean difference existed between the control and experimental groups with respect to genetics concepts achievement and attitudes towards biology. No statistically significant mean difference between the two groups was found with respect to genetic concept achievement (t = 0.98, p = 0.330) and attitudes towards biology (t = 0.22, p = 0.826), indicating that students in the experimental and control groups were similar regarding these two variables.

After the treatment, a paired-samples t-test was employed to determine whether a statistically significant mean difference existed between the pre-test and post-test mean scores of control and experimental groups with respect to genetics concepts achievement. Between the pre-test and post-test scores of the control group, there was a statistically significant mean difference was found with respect to genetics concepts achievement (t = 11.89, p = 0.000; $\overline{X}$ pretest = 9.52, $\overline{X}$ posttest = 14.08). There was also a statistically significant mean difference with respect to genetics concepts achievement between the pre and post-test scores of the experimental group (t = 12.03, p = 0.000; $\overline{X}$ pretest = 8.87, $\overline{X}$ posttest = 19.54).

These results indicate that there was a statistically significant difference between the pre and post-test mean scores of the students taught with the conceptual change approach (experimental group) and those taught with traditional instruction (control group) with respect to understanding regarding genetics concepts. But while there was a nearly 50% increase between the pre and post-test mean scores of the control group there was an increase nearly above then 100% between the pre and post-test mean scores of the experimental group.

We also compared the post-test results of control and experimental groups with respect to genetics concepts achievements using independent-samples t-test whether a statistically significant mean difference existed. There was also a statistically significant mean difference between the two groups was found with respect to genetic concept achievement (t = 6.19, p = 0.000).

The results show that students in the experimental group performed better on GCAT (Genetic Concept Achievement Test) than students in the control group. The actual mean score of the control group was 14.08, and that of the experimental group was 19.54 on the Genetics Concepts Achievement Test. Before the treatment, the average percentage of correct responses from the students was 41% in the experimental group and 40.5% in the control group. After the treatment, the average percentage of correct responses of the experimental group was 79.4%, and that of the control group was 59.7%.

After the treatment, a paired-sample t-test was employed to determine whether a statistically significant mean difference existed between the pre and post-test scores of attitudes towards biology of the control and experimental groups. No statistically significant mean difference between the pre and post-test scores of the control group was found (t = 0.16, p = 0.871). Contrary to this result, there was a statistically significant mean difference between the pre and post-test scores of the attitudes towards biology of the experimental group was found (t = 7.06, p = 0.000). So we can conclude that students taught through conceptual change approach (including the combination of analogies, conceptual change texts and animated videos) developed not only a deeper, meaningful understanding of DNA, gene, chromosome and related concepts but also promoted a positive attitude for learning biology.

Table 4

Statistical Summary of the GCAT.

	Group	$\overline{X}_{pretest}$	S	Sd	t	P
GCAT	*Exp* $_{pretest}$ *Cont* $_{pretest}$	8,87 9,52	2,30901 2,27523	47	0,985	,330
GCAT	*Exp* $_{posttest}$ *Cont* $_{posttest}$	19,54 14,08	2,96324 3,20052	47	6,192	,000
GCAT	*Cont* $_{pretest}$ *Cont* $_{posttest}$	9,52 14,08	2,27523 3,20052	24	11,896	,000
GCAT	*Exp* $_{pretest}$ *Exp* $_{posttest}$	8,87 19,54	2,30901 2,96324	23	12,036	,000

* *Exp* $_{pretest}$: *Pretest scores of Experimental group* * *Cont* $_{pretest}$: *Pretest scores of Control group*
* *GCAT: Genetic Concept Achievement Test*

Table 5

Statistical Summary of the ATB Test.

	Group	$\overline{X}_{pretest}$	S	Sd	t	P
ATB	*Exp* $_{pretest}$ *Cont* $_{pretest}$	50,46 49,70	11,09678 13,62920	51	0,221	,826
ATB	*Cont* $_{pretest}$ *Cont* $_{posttest}$	49,70 50,18	13,62920 12,71292	26	0,164	,871
ATB	*Exp* $_{pretest}$ *Exp* $_{posttest}$	50,46 58,11	11,09678 7,64893	25	7,060	,000

* *Exp* $_{pretest}$: *Pretest scores of Experimental group* * *Cont* $_{pretest}$: *Pretest scores of Control group*
* *ATB Test: Attitude Towards Biology*

DISCUSSION

The prior aim of this study was to determine whether an educational manipulation designed to promote conceptual change and learning about DNA, gene, chromosome and related concepts would improve students' performance. Research relating to education which is designed to remove students' misconceptions focused on strategies to facilitate conceptual change by challenging students' misconceptions. We hypothesized that students using the combination of the conceptual change texts, analogies and watching animated videos about the related concepts would demonstrate better conceptual understanding of related genetic concepts than students exposed to traditionally designed instruction. As hypothesized, the conceptual change texts, analogies and animated videos combination did lead to better conceptual understanding of related genetic concepts. These results support the findings of former studies in which text-based conceptual change approach can facilitate learning of scientific concepts (Chambers & Andre, 1997; Hynd, Alvermann, & Qian, 1997; Sungur, Tekkaya & Geban, 2001; Cakir et al., 2002; Alparslan, Tekkaya & Geban, 2003; Pekel, 2005; Pinarbasi et al, 2006; Beerenwinkel et al., 2011), importance of analogies (Stavy, 1991; Dagher 1994; 1995; Durkin & Barber, 2002; Canpolat et al., 2006; Çetingül and Geban, 2011), importance of video (Beentjes & VanderVoort, 1991; Schnotz, 2002; Wang & Hartley, 2003; Annetta et al., 2009), animations (Annetta et al., 2009; Papastergiou, 2009; Bourgonjon, 2010). In addition, students exposed to conceptual change based instruction had more positive attitudes than the students exposed to traditional instruction.

During the implication, the experimental group received instruction using conceptual change approach oriented applications such as, conceptual change texts and analogies accompanied by the animated video while students in the control group received traditional instruction based on textbooks. The results showed that conceptual change texts and analogies accompanied by the animated video made a significant contribution to students' understanding of DNA, gene, chromosome related concepts. The results of this study support the thought that it is not easy to remove misconceptions just by employing traditional educational methods. In this study with "the traditional instruction" we mean lectures given by the teacher, using textbooks and explaining the critical concepts to the students. Teacher's responsibility was to transfer new knowledge to the students. The difference between the two strategies we used was that conceptual change approach clearly dealt with students' alternative conceptions, while the traditional approach did not.

It can be concluded that students' continued alternative conceptions in their conceptual framework may be one of the reasons for their low achievement to acquire DNA, gene, chromosome related concepts in traditionally designed biology instruction classroom. Table 6 also shows that there is a significant difference between the percentages of misconceptions of students in the experimental and control groups after the treatment. These results suggest that conceptual change texts and analogies accompanied by the animated video demonstration assist students to swap their pre-existing conceptions or misconceptions with scientifically acceptable ones.

The higher success of students in the experimental group in this study can be explained as follows: the activities students' involved in the experimental group helped them revising their initial knowledge and tackle with their alternative conceptions. For instance, stressing on why their alternative conceptions are baseless in the conceptual change texts caused students' being dissatisfied with their existing conceptions and this enabled them to accept scientific conceptions that were introduced. Many studies report that by reading conceptual change texts many students change their intuitive non-scientific conceptions to more scientific ones (Alvermann & Hague, 1989; Canpolat, 2002; Al khawaldeh, 2013). In addition, Guzzetti (2000) reports that even though conceptual change texts cause students' cognitive conflict and dissatisfaction with their existing beliefs, cognitive conflict alone is not sufficient to produce conceptual change, particularly for those with reading and writing difficulties. For this reason, in order to construct a good social learning atmosphere, we used a combination consist of conceptual change texts, analogies and animated video. In this atmosphere students are encouraged to interact with teacher, other students and materials during the lessons. Similarly, Treagust et al. (1996) report the utilities of using conceptual change approach oriented analogical teaching approach. Demonstrations or animations which challenge students' existing understanding can be fruitful too. These activities are most productive when they performed in an encouraging atmosphere in which students test their ideas and construct their own meanings through social interaction facilities. Parallelly to our study, Thompson and Soyibo (2002) also revealed that, the combination of lectures, teacher demonstrations, classroom discussions and student practical work in small groups significantly increased students' understanding the subject much better than their control group counterparts. Based on the studies mentioned above, beside the conceptual change texts, analogies and animated videos combination were intentionally used to concretise abstract concepts regarding genetics, such as DNA, gene and chromosome.

Table 6

Percentage of some common misconceptions about DNA, gene, chromosome and related concepts held by experimental and control group after treatment.

	Percentage of Students	
Misconceptions	*Experimental group*	*Control group*
We can find Timin nucleotide within the body of RNA.	8	33
All DNA molecules must have a Timin nucleotide.	62	83
(But DNA molecule may not contain a Timin nucleotide)		
We can understand the correctness of the DNA replication through examining the structure of nucleotids or deocsyriboses.	54	76
We can always find DNA in the nucleus of the cell. (But prokaryote organism doesn't have a nucleus)	88	96
The cause of muscle development of body builders and developmental differences during larval state between the queen bee and worker bee is our hereditarily characteristics.	22	50
If they are homozygote, recessive alleles cannot be expressed on phenotype.	7	54
One living thing's allel genes must be the same with each others.	26	77
Chromosome is longer than DNA.	30	77
Genes are bigger than chromosomes	21	63
Trees, mammalians, insects and ferns contain chromosome but fungi, bacteria and viruses have not a chromosome.	10	19
We can see chromosomes during cell division through light microscope but there aren't any chromosomes during interphase.	4	70
Trees, mammalians, insects and ferns contain genetic information but fungi, bacteria and viruses have not genetic information.	9	20

In our study, it is found that conceptual change based instruction not only has significant effects on students' understanding of some genetic concepts, but also it made a significant difference to students' attitude towards biology too. When compared, experimental group showed a more positive attitude towards biology after the treatment (t=6,192 , P=0,000). But there was not a statistically meaningful difference between the pretest and posttest scores of the attitudes about biology. (t=0,221 , P=0,826).

In addition, our treatment resulted in a progress in the learning of DNA, gene, chromosome related concepts. The findings of this study on students' conceptions of DNA, gene, chromosome related concepts may also help to our understanding of some of the difficulties that students encounter in their biology classes and may help the arrangement of teaching activities. So, we believe that while teaching genetic concepts, the combination of conceptual change texts, analogies accompanied by embodying animations can provide a more useful alternative to traditional methods to rectify alternative conceptions about DNA, gene, chromosome related concepts.

The results of this study provide further evidence to support the findings of a growing body of literature indicating that students hold a variety of alternative conceptions about DNA, gene and chromosome related concepts.

EDUCATIONAL IMPLICATIONS

One of the main challenges in the biological sciences today is the need to focus on meaningful learning and conceptual understanding of scientific information (Mintzes et al., 2001; Kibuka-Sebitosi, 2007).

In this direction, we agree Schnotz (2002) and Annetta et al. (2009) that cognitive processing is an important factor that contributes to effective learning, but if we really want to be more successful in science education then we should consider affective impacts and motivational factors as well. While students learning, video technology provide students a rich and different teaching situations and create flexible ways of representing and connecting information, students' engaging in learning activities the opportunity for conversation, reflection (Wang and Hartley, 2003) and argumentation. And students produce more precise and accurate recall after exposure to information in a video format (Beentjes and VanderVoort's, 1991). That is to say, if new technologies (such as animated videos, educational entertainments about the subject) are more engaging and appealing to students and if in turn these learners are motivated to interact with these learning environments longer than with traditional print materials then, we will be closer to achieve our educational goal.

We remind the reader that there is not any educational method that is always producing the best results in every situation. If we want to leverage understanding in science education we should design better combinations composed of teaching methods. For this reason, when considered the results of this study, we suggest teachers to use the combination of conceptual change approach techniques, analogies and animated videos on teaching DNA, gene, chromosome related concepts to the high school students if they want to get a deeper and meaningful biology education.

The study presented here also revealed that the teacher-centered and textbook-oriented instruction fail to improve students' conceptual understanding. To improve meaningful learning in the learning process, we suggest that instructional strategies such as analogies and conceptual change texts, which take into consideration students' pre-existing knowledge and encourage students to be active participants, both physically and emotionally, should be integrated into the curriculum. Students were given opportunities to test their own ideas (Yılmaz et al. 2011) and to work collaboratively with their friends to increase their conceptual understanding. The present study suggests using the combination of animated videos, analogies and conceptual change texts instructions as alternatives to teaching implications to enhance students' meaningful understanding of genetics concepts.

However, for a successful implementation of such strategies teachers should be informed about students' prior knowledge and their probable alternative conceptions and they should arrange the teaching activities accordingly.

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Genetik Kavramlarının Öğretiminde Kavramsal Değişim Yaklaşımının Etkinliğinin Arttırılması

Yrd.Doç.Dr.Feyzi Osman Pekel
Suleyman Demirel Üniversitesi-Türkiye
osmanpekel@sdu.edu.tr

Prof.Dr.İsmet Hasenekoğlu
Kilis 7 Aralik Üniversitesi-Türkiye
ismeth@kilis.edu.tr

Genişletilmiş Özet

Amaç: Kavram yanılgıları öğrencilerin bilimsel açıklamaları anlama yeteneklerini sınırlandırarak (Lewis and Kattmann, 2004), diğer konu ve kavramları eksik, ilişkisiz öğrenmelerine ve başka kavram yanılgılarına neden olarak daha sonraki öğrenmelerini engelleyebilmektedir. Dolayısıyla bu çalışmanın amacı, kavramsal değişim yaklaşımının, lise öğrencilerinin DNA, gen ve kromozom kavramlarını ile ilgili başarılarına ve biyolojiye karşı tutumlarına olan etkisini, geleneksel öğretim yaklaşımı ile karşılaştırarak ortaya koymaktır.

Yöntem: Çalışmanın örneklemini bir lisenin fen bölümlerinde öğrenim gören aynı öğretim elemanın ders verdiği iki farklı şubedeki 52 ikinci sınıf öğrencisi oluşturmaktadır. Şubelerden biri, kavramsal değişim yaklaşımın kullanılacağı deney grubu; diğeri ise geleneksel öğretim yaklaşımının kullanıldığı kontrol grubu olarak rastgele seçilmiştir. Deney grubunda DNA, gen, kromozom kavramları ile ilgili konular kavramsal değişim yaklaşımını esas alan yöntemlerle, kontrol grubunda ise geleneksel ders anlatım yaklaşımlarına uygun yöntemlerle işlenmiştir. Çalışmada veri toplama aracı olarak tarafımızca oluşturulan DNA, Gen, Kromozom Kavram Testi ve literatürden adapte ettiğimiz Biyoloji Dersi Tutum Ölçeği olmak üzere iki ölçekten yararlanılmıştır. Araştırmada ileri sürülen hipotezleri test etmek için bilgisayar ortamında SPSS paket programındaki “Independent sample t-test” ve “Paired sample t-test” kullanılmıştır.

Bulgular: Uygulama öncesi uygulanan “Bağımsız gruplar t-testi” deney ve kontrol gruplarımız arasında genetik kavramlar başarı testi açısından ($t = 0.98$, $p = 0.330$) ve biyoloji dersine ilişkin tutumları açısından ($t = 0.22$, $p = 0.826$) istatistiksel olarak anlamlı bir farklılık olmadığı görülmüştür. Uygulama sonrasında gerçekleştirilen “Bağımlı gruplar t-testi” kontrol grubunun genetik kavramlar ön ve son test ortalamaları arasında istatistiksel olarak anlamlı bir farklılığın olduğunu ($t = 11.89$, $p = 0.000$; $\overline{X}_{\text{pretest}} = 9.52$, $\overline{X}_{\text{posttest}} = 14.08$), benzer şekilde deney grubunun ön ve son test ortalamaları arasında da ($t = 12.03$, $p = 0.000$; $\overline{X}_{\text{pretest}} = 8.87$, $\overline{X}_{\text{posttest}} = 19.54$) istatistiksel olarak anlamlı bir farklılığın olduğu ortaya koymuştur.
Deney ve kontrol gruplarının genetik kavramlar testi son test başarı ortalamaları “bağımsız gruplar t-testi” kullanılarak karşılaştırıldığında aralarında deney grubu

lehine istatistiksel olarak anlamlı bir farklılık (t = 6.19, p = 0.000) olduğu tespit edilmiştir. Ayrıntılı bilgi için bakınız Tablo 4.

Deney ve kontrol gruplarının ön ve son test biyoloji dersine ilişkin tutum puanları arasında kullanılan yöntemlerden kaynaklanan farklılık bulunup bulunmadığını belirlemek amacıyla “bağımlı gruplar t-testi” yapılmıştır. Bu test sonuçlarına göre kontrol grubu ön ve son test tutum puanları arasında istatistiksel anlamlı bir farklılığa rastlanmazken (t = 0.16, p = 0.871), deney grubunun ön ve son test tutum puanları arasında (t = 7.06, p = 0.000) istatistiksel olarak anlamlı bir farklığa rastlanması deney grubunda kullandığımız stratejilerin sadece derse ilişkin başarı sağlamakla kalmadığını, aynı zamanda öğrencilerin derse ilişkin olumlu tutumlar geliştirmesini de sağladığı şeklinde yorumlanmıştır. Ayrıntılı bilgi için bakınız Tablo 5.

Yorum ve Öneriler: Bu çalışmanın önemli tespitlerinden biri, öğretmen merkezli ve ders kitabı tabanlı öğretimin öğrencilerin kavramsal öğrenmelerini geliştirmede istenen başarı düzeyini sağlayamadığıdır. İkinci önemli tespiti ise, DNA, gen, kromozom kavramlarının öğretiminde kavramsal değişim yaklaşımı çerçevesinde analoji, kavramsal değişim metinleri, animasyonlu video stratejilerin kullanılmasının öğrencilerin bu kavramları daha ileri ve anlamlı düzeyde öğrenmelerini sağlamasıdır. Üçüncü önemli tespiti de, kullandığımız stratejiler kombinasyonunun öğrencilere sıkıcı gelen soyut kavramları somutlaştırabilmelerine, fikirlerinin doğruluğunu test etmek için işbirlikli çalışabilmelerine imkan sağladığından biyoloji dersine karşı daha olumlu tutumlar kazanmalarına vesile olmasıdır. Bu nedenle, DNA, gen, kromozom gibi soyut moleküler genetik kavramlarına yer verilen derslerde öğretmen ve araştırmacılara bu kavramların öğretiminde işe koştuğumuz stratejileri kullanmalarını tavsiye ediyoruz.

Anahtar kelimeler: Genetik kavramlar, Kavramsal değişim yaklaşımı, Kavram yanılgıları.