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THE EFFECTS OF TUTORIAL AND EDUTAINMENT SOFTWARE PROGRAMS ON STUDENTS' ACHIEVEMENTS, MISCONCEPTIONS AND ATTITUDES TOWARDS BIOLOGY ON THE CELL DIVISION ISSUE

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Abstract. *The purpose of this study was to investigate the effects of tutorial and edutainment design of instructional software programs related to the "cell division" topic on student achievements, misconceptions and attitudes. An experimental research design including the cell division achievement test (CAT), the cell division concept test (CCT) and biology attitude scale (BAS) was applied at the beginning and at the end of the research. After the treatment, general achievement in CAT increased in favor of experimental groups. Instructional software programs also had the positive effect to the awareness of students' understandings to the general functions of mitosis and meiosis. However, the current study revealed that there were still some misconceptions in the experimental groups even after the treatment. It was also noticed that using instructional software programs significantly changed students' attitudes towards biology.*

Keywords: *computer assisted instruction, instructional software, evaluation of educational technology, secondary education.*

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Introduction

For certain topics, particularly those concerned with more complex areas, such as cell division, photosynthesis, cell respiration, food chain-webs and evolution, in biology teaching can be difficult (Bahar, Johnstone, & Hansell, 1999; Lawson & Thompson, 1988; Yip, 1998). In the last decade, there have been a number of studies focusing on student misconceptions about cell division at middle and secondary schools (Kindfield, 1994; Yip, 1998). Pupils and teachers consistently place cell division near the top of these "ladders" of difficulty. It has been reported that cell division processes are poorly understood at all ages and levels of students (Smith, 1991; Lewis and Wood-Robinson, 2000). This topic is taught by starting with primary school levels. It is also perceived by most teachers to be one of the most problematic concepts in the biology (Öztaş *et al*, 2004).

One of the common teaching methods that biology teachers prefer today is the lecture method. In this the teacher transmits knowledge to the students who sit passively in the classroom and listen. Another common method is the question-and-answer approach, which was developed in order to avoid the boredom caused by lectures and to provide a more efficient learning environment. On the other hand, case studies allow the students to face the problems that occur in real life. They help to fill the gap between theory and practice through putting the previously learnt concepts and principles into use. The best part of this method is that it enables the students to apply what they have learnt to what they are living through (Sönmez, 1986).

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A useful part of instruction in biology is the performing of experiments. This can be done by demonstrations when the teacher actively carries out the experiments in front of the class or demonstrates some materials (Bayramlı, 2000) or by the students who learn about a subject by carrying out experiments in the laboratory or classroom, in which case the role of the teacher is to guide and help them where necessary.

In contrast to the previously described methods, in *Computer-Assisted Instruction* (CAI), the teacher can use computers at different times and places according to the characteristics of the subject matter, the students, and the available software and hardware. With CAI, there is a form of one-to-one instruction (or two students together at each computer), plus the opportunity for the students to proceed at their own pace, repeating parts of the exercise as they wish. None of these features are easily available in a didactic classroom situation in which the teachers deliver informational programs with little or no interaction. In addition, there is added variety and, perhaps, novelty in CAI, along with the potential to use vivid and animated graphics, enabling three dimensional aspects, and other features to be viewed more realistically. Of course, not all computer programs have these features, but the potential is certainly there (Morgil et al., 2005).

The major classifications of CAI lessons include tutorials, drill and practice, simulations, and instructional games (Alessi & Trolip, 1985). A number of other classifications, such as problem-solving and inquiry lesson designs have been discussed, but the overwhelming majority of CAI lessons fall within the previous four classifications. Each basic design provides a unique method for using the computer to teach, reinforce, practice, or apply information. In many cases, various design combinations, called hybrid designs, are developed to utilize the advantages and, in some cases, to minimize the disadvantages, of each design option.

In tutorials, information is taught, verified, and reinforced through interaction with the computer. In this regard, tutorials may be seen as replacing the bulk of the teaching function of textbooks, filmstrips, lectures, or other systems in which new information is presented. Tutorials, in effect, model the best techniques available for tutoring students (Bramble & Mason, 1985). In CAI, tutorials are generally used to present new information to learners, particular skills, information, or concepts. In many cases, the instruction is designed to be self-contained, that is, the teaching and learning of all relevant information are accomplished within the lesson. Students are typically questioned during the tutorial to verify comprehension. Lesson information may be further reinforced using computer-based or traditional teaching systems, but tutorials should teach well-defined objectives thoroughly enough to eliminate the need for repetition through another teaching system (Hannafin & Peck, 1988).

"Edutainment", is a hybrid genre that relies heavily on visual material, on narrative or game-like formats, and on more informal, less didactic styles of address (Buckingham & Scanlon, 2000). The purpose of edutainment is to attract and hold the attention of the learners by engaging their emotions through a computer monitor full of vividly colored animations. It involves an interactive pedagogy and, totally depends on an obsessive insistence that learning is inevitably "fun". McKenzie (2000) states another term "technotainment" which he defines as technology heavily laced with entertainment but essentially lacking in rigor or value. Technotainment often stresses technology for technology's sake without enhancing student reading, writing and reasoning skills. Similarly, "edutainment" suggests overtly entertaining learning materials, which contain messages addressed to both parents and children. Through explicit educational claims, edutainment software encourages the parents to believe that this software is beneficial in developing children's skills in a variety of subjects. They also raise learners' expectations that learning can be enjoyable and fun.

CAI is defined as any program that augments, teaches, or simulates the learning environment used in the traditional classroom (Quyang, 1993), including Web-based instruction, self-running simulations, drill-and-practice programs, and multimedia classrooms (Murphy et al., 2002). Tutorial and edutainment software programs are forms of CAI that have the following additional attributes: motivation, reward (feedback), interactivity, score, and challenge. Support also exists for these specific types of CAI and its effectiveness in the classroom (Vogel et al., 2006). However, it remains unclear as to whether or not learning through tutorial and edutainment instructional software programs will improve upon traditional teaching results. The aim of this study is to identify any possible difference in students' achievement, misconceptions, and attitudes towards biology when the subject of cell division is taught by tutorial or edutainment instructional software programs in biology education.

Methodology of Research

Instructional Software Programs

The method of selecting the software to be evaluated was determined by the following characteristics. It had to be among the published instructional software programs for computer assisted biology education in secondary schools in Turkey, developed at 9th grade level, and was produced in 1998 or later. Among the pieces of instructional software programs fit the above criteria *Vitamin* (SEBIT Education and Information Technologies Inc.) was selected as tutorial software program and *Bioscopia* (Ruske & Puhretmaier Edutainment) was selected as edutainment software program. Both of the instructional software programs covered several different subject areas, but the only portion of the software evaluated for this study was the cell division. A brief description of the two programs is given below.

Vitamin is an instructional software program series for school biology. This program consists of a range of information and screen displays that illustrate and allow investigation of biological processes. Program begins with a menu area where the student chose the topic. At the start, the students have to enter their name and select one of the two options, test or tutor mode. Within the test mode option multiple choice style questions are available. These questions which allow the students to assess their comprehension of each tutor section completed and provide additional information through feedback. The tutor mode is an interactive course that covers biology from 9th grade up through the first year of college.

Bioscopia is a role-playing science adventure game. The student's mission is to rescue a young scientist. To complete the mission and escape from *Bioscopia*, students have to learn about biology and apply that knowledge to solve *Bioscopia*'s clever puzzles. Students must search the disabled, abandoned laboratories, solve biology puzzles and eventually create the antibiotic that will ultimately save the biologist. Student will need knowledge of Human and Cell Biology, Genetics (including cell division), Botany and Zoology to solve the puzzles and unlock doors that will lead the student to be a young scientist. It's not that the puzzles themselves are that hard to solve; there is help available in the science tutor ("Big Brain") that features all the answers to the questions and is a presentation of hundreds of fascinating facts and concepts of the biology.

Sample of Research

The sample of this study consisted of 72, 9th grade level, students (aged 14 to 15 years) from one high school. The sample was randomly assigned into three groups, two experimental groups and one control group. There were 24 students in each group. The control group continued their instructions with the regular teaching method, while the experimental groups were taught with computer assisted materials.

Research Instruments

The cell division achievement test, the cell division concept test and the biology attitude scale were used in the study.

Cell division achievement test

To measure students' cell division achievement, a cell division achievement test (CAT) was developed by the authors of this study and its content validity and reliability were checked by applying guidelines described previously (Black, 1986; Davis, 1988; Haladyna, 1994). The test content and objectives were determined according to the Ministry of National Education's high school curriculum. The CAT items

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were selected from the textbooks and preparation books written for the University Entrance. There were 24 multiple choices type items in the test. The items were based on the following categories: the purposes of mitosis, mitosis and the cell cycle, the stages of mitosis, the results of mitosis, the purposes of meiosis, meiosis and the sexual reproduction, the stages of meiosis, the results of meiosis, the division of the cytoplasm, prokaryotic cell division mechanism, the comparison of mitosis and meiosis. The reliability of the test ($r = 0.81$) was determined by using the Cronbach's alpha.

Cell division concept test

A written test was designed to ascertain students' misconceptions about cell division. The cell division concept test (CCT) was modified on the basis of review of related literature (Lewis *et al*, 2000; Lewis & Robinson, 2000). The set of questions was designed to probe the student's understanding of the processes, purposes, and products of cell division. The set of the questions was divided into two parts. Part 1 was focused on mitotic cell division through a consideration of the production of skin cells. Part 2 was focused on meiosis through a consideration of the production of an egg cell. In each part, students were asked to compare the chromosome number and genetic information in the original and the new cell, identify where in the body this type of cell division takes place and say whether or not such cell division also occurs in the plants. The reliability coefficient of this CCT computed by Cronbach's alpha estimates of internal consistency was found to be 0.76.

The frequency of responses to each question were noted, together with the types of reasoning used to justify each option, and the frequency with which each type was used. Furthermore, in order to make a more detailed comparison into the students' understanding of cell division, their misconceptions were identified by their reasoning's to the questions.

Biology attitude scale

Canpolat's (2002) attitudes scale was adapted as biology attitude scale (BAS) in this study to assess the sample's (participants') attitudes towards science lessons. 15 sentences occurring in a Likert-type scale and with five alternatives were given students to determine their ideas about the biology lesson. In these sentences there were positive and negative statements. In the scale, positive statements were scored as 1, 2, 3, 4, and 5 according to its grade. Negative statements were scored as 1, 2, 3, 4, and 5 according to its grade. BAS was given at the beginning and end of the implementation to the four groups. The internal consistency reliability of the scale was found to be 0.84.

Procedure

This study was conducted for four-weeks during the fall semester of 2005–2006 academic year at a high school located in Bayburt. An experimental research design including CAT, CCT and BAS were applied at the beginning and at the end of the research as pre-test and post-test measures. Written questions were designed to be answered within one lesson (approximately 1 hour). The "Vitamin" software program was used in the first experimental group (EG_1), while the "Bioscopia" software was used in the second experimental group (EG_2).

Experimental groups had their instruction in the computer laboratory. All the students were computer literate, since they took computer courses as part of the school's regular curriculum. Since instructional software programs were new for the students, before the treatment students in the experimental groups were trained about the usage of instructional software programs. Students in experimental groups worked individually in a computer lab without any guidance or help from the instructor who was also the researcher. Students in EG_1 and EG_2 followed the instructional program as projected to a screen from the teacher's personal computer as well as their own computers. The teacher made a brief introduction about the subject that going to be learned and simply presented the contents of the lecture. Then, the students were left to work alone, with minimal interference from the teacher who was present only to respond to questions raised by individual students.

The control group (CG) was given a traditionally designed instruction, which is a dominant approach in contemporary Turkish Educational System. In the CG, the teacher-directed strategy was used as traditional instruction. The teacher used lecture and discussion methods to teach cell division. The students were required to read the related topic of the lesson from the textbook before lecture. The teacher described and defined the issues and afterward, students were engaged to discussion through teacher-directed questions. The major part of instruction time (70–80%) was devoted to instruction and engaging in discussions stemming from the teacher's explanation and questions.

Data Analysis

In order to compare the differences between control group and experimental groups for the CAT, CCT and BAS, the ANOVA test was applied.

Results of Research

Students' Achievement

One-way ANOVA was used to compare the CAT mean scores for the responses. As seen in Table 1, at the beginning the pre-test means of EG_1, EG_2, and CG were 8.33, 7.83 and 7.083, respectively (see Table 1). These results showed that the sample's pre-treatment knowledge levels were very close to each other and there was not a statistical difference between the groups ($F(2, 69) = 0.448$, $p > 0.05$). But, at the end of the treatment, the post-test scores of EG_1, EG_2, and CG were 15.58, 13.33 and 10.04, respectively. A statistical significant difference was found between the groups ($F(2, 69) = 15.025$, $p < 0.05$). Post-hoc analyses, using L.S.D., show that the EG_1 differed significantly from EG_2 and CG. Furthermore, EG_2 had significantly the second higher mean scores. The mean scores from the experimental groups were all significantly higher than the mean score for CG. This means that all instructional software programs had significantly higher effect than CG.

Table 1. One-way ANOVAs with post hoc comparisons for the four groups' CAT scores.

	N	M	S.D.	df	Mean Square	F	Sig.	Post hoc
Pre-test								
EG1	24	8.333	4.940					
EG2	24	7.833	3.985	2	9.500			
CG	24	7.083	4.835	69	21.225			
Total	72	7.750	4.571	71		0.448	0.641	
Post-test								
EG1	24	15.583	2.394					
EG2	24	13.333	3.252	2	186.431			
CG	24	10.041	4.572	69	12.408			
Total	72	12.986	4.160	71		15.025	0.000*	EG1>EG2>CG

* $p < 0.05$

Students' Attitudes

Table 2 presents the results of a one-way ANOVA analysis for the BAS. The means related to biology attitude of the EG_1, EG_2, and CG before the treatment were 53.41, 52.54, and 52.77, respectively and there was not a statistical significant difference from one another ($F(2, 69)=0.113$, $p>0.05$). After the treatment, post-test scores of the EG_1, EG_2, and CG were 63.87, 66.87, and 58.62, respectively. There

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were significant differences in mean scores for biology attitudes, as measured on the BAS, for students from the three groups (F (2, 69) =6,852, p<0.05). The Post-hoc L.S.D. revealed that the students from the EG_1 and EG_2 reported higher mean score for BAS differing significantly than CG. These results illustrate that the instructional software programs influences students' attitudes towards biology lessons in a positive way.

Table 2. One-way ANOVAs with post hoc comparisons for the four groups' BAS scores.

	N	M	S.D.	df	Mean Square	F	Sig.	Post hoc
Pre-test								
EG1	24	53.416	9.287					
EG2	24	52.541	7.661	2	7.514			
CG	24	52.777	7.347	69	66.310			
Total	72	52.541	8.040	71		0.113	0.893	
Post-test								
EG1	24	63.875	6.848					
EG2	24	66.875	6.758	2	418.500			
CG	24	58.625	6.920	69	46.824			
Total	72	63.125	7.569	71		8.938	,000*	EG1, EG2>CG

* p< 0.05

Misconceptions

Before the implementation, we looked at percentages for each question in the pre-test. There was not much difference between the groups in terms of their prior knowledge and misconceptions. For example, the first question, "How many chromosomes would be found in the egg cell?", as percent in EG_1, EG_2, and CG was 54.2%, 58.3%, and 58.3, respectively. After the implementation, some of the related concepts are examined in detail.

Misconceptions about chromosome number

Students were asked to give their responses to the question "How many chromosomes would be found in the new skin cells?". The students' responses indicated that they held misconceptions about chromosome number (Table 3): 54.2% in the EG_1, and EG_2, 58.3% in CG. After the treatment, the students' responses indicated that their misconception dismissed in EG_1, decreased to 4.2% in EG_2, and 12.5% in the CG.

Misconceptions concerning genetic information after cell division

The results in Table 3 showed that students had a misconception that "after mitosis new cells contain different genetic information". The rate of misconceptions is in EG_1, EG_2, and CG was 33.3%, 25%, and 25%, respectively. After the treatment, the rate of misconception decreased to 4.2% in the EG_1, 8.3% in the EG_2, and 12.5% in the CG.

Misconceptions related to the location of cell division

Students were asked to give their responses to the question "Which of the following parts of the body would divide by mitosis or meiosis?". The misconceptions were grouped into two categories as "mitosis occurs in gonads" and "meiosis occurs in somatic tissues" in Table 3. The pre-test results showed that students had misconception at the rate of 20.8% and 20.8% in the EG_1, 29.2% and 33.3% in the EG_2, 20.8% and 29.2% in the CG. After treatment, the rate of misconceptions decreased to 0% and 4.2% in the EG_1; 4.2% and 8.3% in the EG_2, 16.7% and 16.7% in the CG control group, mitosis occurs in gonads and meiosis occurs in somatic tissues respectively.

Misconceptions about cell division in plants

Students' awareness that the mitosis or meiosis also takes place in plants was probed using the question "Does the same type of cell division, for the same purpose, occur in plants?". The misconceptions were grouped into two categories as "mitosis does not occur in plants" and "meiosis does not occur in plants". The pre-test results showed that students had misconception at the rate of 41.7% and 58.3% in the EG_1, 45.8% and 25% in the EG_2, 50% and 37.5% in the CG. After treatment, the rate of misconceptions decreased to 25% and 20.8% in the EG_1 and in the EG_2, 37.5% and 50% in the CG (Table 3).

Table 3. Results of pre and post-test concerning misconceptions.

Categories and misconceptions	Pre-test %			Post-test %		
	EG1	EG2	CG	EG1	EG2	CG
Chromosome number						
after mitosis the chromosome number would double	25	29.2	33.3	0	0	4.2
after mitosis the chromosome number would halve	29.2	25	25	0	4.2	8.3
after meiosis the chromosome number would remain the same	29.2	37.5	25	12.5	16.7	33.3
after meiosis the chromosome number would double	25	20.8	33.3	4.2	0	16.7
Genetic information after cell division						
after mitosis new cells contain different genetic information	33.3	25	25	4.2	8.3	12.5
after meiosis sex cells contain same genetic information	50	33.3	33.3	12.5	25	20.8
Location of cell division						
mitosis occurs in gonads	20.8	29.2	20.8	0	4.2	16.7
meiosis occurs in somatic tissues	20.8	33.3	29.2	4.2	8.3	16.7
all cell division occurs in somatic tissues	20.8	20.8	20.8	4.2	8.3	16.7
all cell division occurs in gonads	20.8	20.8	12.5	0	0	4.2
Cell division in plants						
mitosis does not occur in plants	41.7	45.8	50	25	25	37.5
meiosis does not occur in plants	58.3	50	62.5	20.8	20.8	50

Analyses of misconceptions

In table 4, analyses of students mean scores for the responses on the CCT are given. At the beginning the pre-test means of EG_1, EG_2, and CG was 4.58, 4.12, and 4.31, respectively (see Table 1). Before the treatment, results indicated that misconceptions on cell division did not differ significantly across the groups ($F(2, 69) = 0.288$, $p > 0.05$). After the treatment, post-test scores of the EG_1, EG_2, and CG were 8.50, 7.54, and 5.87, respectively. There were significant differences in mean scores, as measured on the CCT, for students from the four groups ($F(2, 69) = 13.368$, $p < 0.05$). Post-hoc analyses, using L.S.D., show that although EG_1 and EG_2 did not differ significantly from one another, the mean scores of these two groups were all significantly higher than the mean score for CCT in CG. These results illustrate that, the instructional software programs provided significant contribution for students to eliminate misconceptions.

Table 4. One-way ANOVAs with post hoc comparisons for the four groups' CCT scores.

	N	M	S.D.	df	Mean Square	F	Sig.	Post hoc
Pre-test								
EG1	24	4.583	2.518					
EG2	24	4.125	2.006	2	1.347	0.288	0.751	
CG	24	4.250	1.916	69	4.681			
Total	72	4.319	2.141	71				
Post-test								
EG1	24	8.500	1.532					
EG2	24	7.541	1.999	2	42.347	13.368		
CG	24	5.875	1.776	69	3.168			
Total	72	7.305	2.066	71			0.000*	EG1, EG2 >CG

* $p<0.05$

Conclusions and Discussions

Computer-assisted instruction is a widely studied and supported method of teaching. Numerous meta-analyses and review articles have been published showing positive effect sizes supporting CAI over the other teaching methods on student's academic achievement (Bayraktar, 2001; Chambers, 2002; Christmann & Badgett, 2003; Cohen & Dacanay, 1992; Fletcher-Flinn & Gravatt, 1995; Kulik, 1994; Lowe, 2001; Powell et al., 2003; Soe, Koki, & Chang, 2000; Tsai & Chou, 2002; Tuysuz et al., 2005). The findings of this study concerning the effects on students' achievement are consistent with the ideas of the previous reports. It was revealed in the study that the both of the experimental groups at cell division achievement were more successful than the CG after the treatment.

The significant academic achievement of the students in the experimental groups could be explained by the fact that the instructional software programs created a learning environment in which students can learn at their own pace. Interactive teaching makes students more aware of their own knowledge. Software programs appeared to made students more active, compared with being passive recipients of knowledge as in CG.

In addition, in regard to students' academic achievement there were some differences between the experimental groups. The data obtained from CAT illustrated that tutorial software was more effective than edutainment software on students' learning's. In edutainment software, the game format was more on the foreground than tutor format. Students spent most of their time exploring strange locales, searching for clues and collecting needed items rather than benefiting from the science tutor. The game format offers possibilities that students often find appealing, but it must be emphasized that their purpose is first and foremost to develop, reinforce, and refine some aspect of learning. Unlike a simple noninstructional computer game, instructional games must retain instructional value as their primary goal. Whereas, several skills are typically used to play an instructional game, the focal point of the game should be on the application of well-defined learning skills.

Many studies have been implemented about the influences of computer based instructions on students attitudes do not agree whether it makes positive changes in attitudes towards science and science lessons (Mitra, 1998). For example, Selwyn (1999) reported that computer assisted material develops a positive attitude towards science education. In contrast to this, Shaw and Marlow (1999) suggested that computer assisted material do not show a positive effect on students' attitudes. Besides, students' attitudes towards science are quite negative if traditional teaching methods are used in science classes (Colletta & Chiappetta, 1989). In this study, instructional software programs were more effective than CG on student's attitudes.

Instructional software programs provided "more student-centered learning", teaching students how to learn by themselves. Implementations provided by software programs require students to work at their own pace through a structured set of learning experiences. Software programs were able to present text and graphic materials to students in a coordinated manner, and questioning techniques means that the learners were active during the learning process.

Misconceptions are very important during the learning processes of individuals. It is well known that it is not easy to eliminate the misconceptions by just employing traditional instructional methods. One of the alternative ways of overcoming this problem may be using computer assistant materials in science classrooms (Çepni et al, 2006). In the present study, instructional software programs provided better learning environments for students to understand cell division with respect to CG. Both of the experimental groups at building cell division concepts were more helpful than the CG after the treatment. However, this study revealed that there were still some misconceptions in the experimental groups even after the treatments. These misconceptions were generally related to the abstract concepts as general functions of mitosis (growth and repair) and meiosis (preparation for reproduction) and thus to visualize and conceptualize them is difficult for students. This shows that misconceptions may be reduced and/or dismissed if teaching–learning activities are given at comprehension and application levels (Karamustafaoğlu et al., 2003).

It is critical that lessons are planned in such a way so as to concentrate using the computer assisted materials on the topics in a lesson that will help to computer-based learning. Having an entire teaching module on a CD-ROM with multimedia assets are more effective to improve student's academic learning. Keeping the balance between the educational content and computer entertainment is critical to realize desired educational goals. Otherwise, changing students' attitudes towards science lessons without improving academic achievement will be distant from the purposes of CAI.

Although many educators devote tremendous efforts with great expectation that computer assisted material will dramatically increase students' achievement, the results of this study provide to classroom teachers a research-based evidence for positive outcomes by using different computer assisted materials in instruction. The present study also revealed the effects of some software's learning benefits from CAI experiences for students. It can be concluded that computer assisted materials could improve student achievement, change misconceptions and improve students' attitudes toward biology lessons

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