

**COMPUTER SIMULATION USAGES IN SCIENCE AND  
BIOLOGY EDUCATION**  
**FEN BİLGİSİ VE BİYOLOJİ EĞİTİMİNDE BİLGİSAYAR  
SİMÜLASYON KULLANIMLARI**

*Lütfullah TÜRKMEN\**

**ABSTRACTS**

The purpose of this study was to reveal the aspects of computerized simulations in science and biology courses mostly in primary and secondary education levels. At the beginning of newly developed computer simulations in the science education area, the results showed some positive results but in some cases the applications of some simulations gave not significant changes than conventional instructional methods. Later, with the developing of simulations in science and biology areas, some of deficiencies have been overcome especially by means of the multimedia software and Internet applications. In the result, in science and biology courses simulations help the students to conceive scientific concepts and change misconceptions, to do some of the scientific experiments almost in real taste easily, and to have more positive attitudes toward science.

**Key Words:** Science and biology education, computer simulations

**ÖZET**

Bu çalışma, bilgisayar ve bilgisayara bağlı teknolojilerden simülasyon programlarının ilköğretim, orta öğretim (Lise döneminde) fen bilgisi ve biyoloji derslerinde değişik kullanımlarını mevcut literatür ve araştırmaları baz alarak etkinliğini ortaya çıkarmak amacıyla yapılmıştır. Bugünkü anlamda bilgisayar teknolojisinin ve donanımının (hardware) tam olarak gelişmediği ve hızlı olmadığı dönemlerde elde mevcut bazı simülasyon ve yazılımlarla (software) yapılan araştırmalarda klasik metot ile bilgisayar destekli biyoloji eğitimi arasında çok fazla anlamlı (significant) düzeyde bir farklılığa rastlanamamıştır. Fakat, daha sonraları bilgisayarların multimedya (çoklu ortam) özellikler kazanması ve etkileşimli (interactive) yazılımların ve internetin kullanımının artması sonucu istenilen sonuçlar alınmaya başlamıştır. Sonuç da, biyoloji ve fen bilgisi eğitiminde kullanılan simülasyon programlarının bazı sonuçları şöyle özetlenebilir; bir kısım deneyleri bilgisayar ortamında kolaylıkla yapılabilir hale getirmiş, anlaşılması zor olan bazı bilimsel kavramları kolaylıkla anlaşılabilir olmuştur, öğrencilerin fen bilimlerine yönelik tutumlarını pozitif olarak değiştirmiştir.

---

\* Yard.Doç.Dr., AKÜ Uşak Eğitim Fakültesi, İlköğretim Bölümü.

**Anahtar Kelimeler:** Fen ve Biyoloji Eğitimi, Bilgisayar Simülasyonları

\*\*\*

## INTRODUCTION

When computers were found, perhaps no one could imagine about the future and using of computers. Generally, there is one tendency that societies seem to use the new technological advances in their daily lives. Education, also, is an important part of today's society. Nowadays, in many countries, societies seem to show a change from industrial society to information society. One of the results of these changes is mainly based on the using computers in every aspect of our lives. For example, according to 1996 data, in the United States, the schools spend around four billion dollars and additionally in order to log on Internet for every student is required two billion dollars (U.S. News and Word Report, December 2, 1996). It means that schools have to put a big portion of money from their budgets for instructional technology. This is not so different for many developed or developing countries around the world. It can be said this type of instructional technology could be so necessary but also expensive. It can be defined instructional technology as generally high tech instrument, such as technological hardware and software packages used in classroom to promote education.

Due to different types of computer usage in science and biology classrooms, the study was divided into three main parts, computer simulations, computer-assisted instructions, and the Internet. That is why, the sub-purposes of the study are to investigate the different aspects of computer make space simulations, computer assisted instruction, and the Internet in science and biology classrooms.

Before addressing of the purpose of this paper, it should be useful to explain some of the terminologies used in this area, such as technology, science, and biology. In the general sense, technology attains for applying scientific knowledge to practical usage. Thus, the technology can be seen every part of our daily life. However, for education, it implies educational or in some sense instructional technology developments that can be used in classrooms in order to promotes learning and teaching environment. Hooper and Rieber<sup>1</sup> state that educational technology was seen as the technological hardware and software, such as computers, software, CD-Rooms, etc. In the classrooms, also, the main purpose of technology referring to products or

---

<sup>1</sup> Hooper, S., and L.P. Rieber (1995). Teaching, instruction, and technology. *Contemporary Issues in Curriculum*. Boston, USA.

hardware is to make easy or improve a task. Furthermore, the products of technologies depend on machine designed innovations, such as VCRs, filmstrip viewers, overhead projectors, video laser disc players, video camera, hand calculators, computers, CD-Roms and modems. However, these machine designed technological innovations may be combined in the classroom with different taste, for example; computer assisted instruction (CAI), simulations, games, drill and practice, hypermedia, multimedia, and communication networks (e-mail, internet, gopher, World Wide Web) <sup>2,3</sup>.

The next definition is science that according to Rutherford and Ahlgren<sup>4</sup>, science attends for “a process for producing knowledge”. It mentions that the scientific method or way to understand or world and universe by observing, asking questions, gathering data, testing hypothesis and reaching conclusion. On the other hand, there are other definitions of science and one of the most accepted one is that “science is a human endeavor to explore the universe”<sup>5</sup>.

For Computer Assisted Instruction (CAI), different terminologies can be used such as Interactive Video Disk, Intelligent Computer Assisted Instruction, and Multimedia<sup>6,7</sup>. Sometimes, Computer Assisted Instruction can be classified into two parts, tutorial and simulations. Computer Assisted Instruction was planned to meet some learning subjects that are necessary drill and practice. The main advantage of this technology supplies the learner an immediate feedback and reinforcements from a computer. Lately, this type of instructions has made such a progressive movement that the learner can interactively use the software to help the understanding of a topic in science education. On the other hand, there are some disadvantages of CAI that students can be bored easily<sup>8</sup>.

---

<sup>2</sup> Ibid

<sup>3</sup> Rooze, G. E. and Northup, T. (1989). *Computers, Thinking, and Social Studies*. Englewood, Colorado, USA.

<sup>4</sup> Rutherford, J. F. and Ahlgren, A. (1990). *Science for all Americans*. New York, USA, p:4.

<sup>5</sup> Harlen, Wynne (1998). *The Teaching of Science in Primary Schools*, London, Great Britain, p:2.

<sup>6</sup> Huang, S., D., and Aloi, J. (1991). The impact of using interactive video in teaching general biology. *The American Biology Teacher*, 53(5), 281-284.

<sup>7</sup> Dori, J., Dori, D., and Yochim, J., M. (1992). Characteristics of an intelligent computer assisted instruction shell with an example in human physiology. *Journal of Computers in Mathematics and Science Teaching*, 11(3/4), 289-302.

<sup>8</sup> Abruscato, J. (1986). *Children, Computers and Science Teaching: Butterflies and Bytes*. New Jersey, USA.

While CAI enables students especially in science laboratories to do lab experiments accurately in a short time accurately<sup>9</sup>, simulation are little different from CAI. One of the main differences is that a simulation provides a situation that cannot be experienced to a learner<sup>10</sup>. Also, some lab exercise can be very expensive or take too much time, and may not be suitable for students, such as dissections in biology labs<sup>11</sup>. Moreover, according to Linn<sup>12</sup>, simulation encourages students to understand a situation easily and can present dynamic representations to complex relationships. In science labs, naturally occurring events could be simulated its original taste by using computer-based simulations. However, computer simulation are not completely a better instructional tool than other instructional tools, they are more active and viable instruction approaches that can influence content knowledge<sup>13</sup>.

Another important development in computer usage in science courses as well as other courses is to use the Internet. Many times, there are different terminologies for the Internet, for example, World Wide Web (WWW), e-mail, gopher. On the other hand, the main idea is the same that using different computers via phone lines provides tremendous knowledge and interactive communication with the other user(s). Especially, receiving and sending information from one computer to another computer change the world to a big library or learning environment. Today, some simulation or other computer programs can be used by means of Internet browsers. Therefore, using the Internet can be classified as a computer assisted instruction or simulation in science classrooms but some cases, it can, also, bring some specific problems related to using this technology.

Computers, in schools (K-12), are being used for many purposes. One of the most important reasons to use computers is to promote or enhance instructions in classroom. In that point, many questions can come to mind how computers work in education, what are their functions, how they can be integrated to a classroom, and "what are the different types are aspects of using computers" related to science education

---

<sup>9</sup> Adams, D., D., and Shrum, J., W., (1990). The effects of microcomputer-based laboratory exercises on the acquisition of line graph construction and interpretation skills by high school biology students. *Journal of Research in Science Teaching*, 27(8), 777-787.

<sup>10</sup> Linn, M., C. (1987). Establishing a research base for science education: challenges, trends, and recommendations. *Journal of Research in Science Teaching*, 24(3), 191-216.

<sup>11</sup> Strauss, R., and Kinzie, M., B. (1994). Student achievement and attitudes in a pilot study comparing and interactive videodisc simulation to conventional dissection. *The American Biology Teacher*, 56(7), 398-402.

<sup>12</sup> Linn, *ibid*, p:191-216.

<sup>13</sup> Stevens, J., M. (1995). The impact of computers on attitudes toward learning in sixth grade science students. *Unpublished Doctoral Dissertation*, University of Nebraska-Lincoln.

In biology and science classroom or in education, the using of computers has constantly increased since the last decade. As the mentioned above, there are several reasons to use this instructional technology. Generally, the using of computers in biology and science education should be placed to three main groups, (1) Simulations, (2) World Wide Web (WWW), and (3) Computer Assisted Instructions (CAI). Computer simulations generally imply a sample, case, experiment or natural event working or happening in computer environment like real by means of multi media computer applications.

### **The Purpose of Study**

The main purpose of this study was to investigate the different aspects of computer simulations in science courses and relating areas such as, chemistry, earth science, and general science courses dealing with mostly biological subjects. The purpose of study was converted to research question formats. Mainly, the cover of this study should be primary and secondary education science courses. However, in college level, introductory science courses might not be different from advance high school science courses. Therefore, similar studies conducted in collage level science courses should be reviewed.

### **METHODS**

In order to find the research questions, firstly, the secondary references were controlled and they gave some ideas to the researcher about the topic. Later, ERIC (Educational Resource Information Catalogs) and other data resources were controlled and many of the articles used in this research paper were come from ERIC documents. Finally, the research questions were answered by reviewing the articles related to the research paper.

### **SIMULATION PROGRAMS IN SCIENCE AND BIOLOGY EDUCATION**

#### **The Needs of Using Simulation Programs**

According to Geban, Askar, and Özcan<sup>14</sup>, computers can be used in science education as teaching devices. With the tremendous development in technology, in the United States, science educators have emphasized the alternative techniques<sup>15</sup>. In this point, computers have several capacities to

---

<sup>14</sup> Geban, O., Askar, P., and Özkan, I. (1992). Effects of computer simulations and problem-solving approaches on high school students. *Journal of Educational Research*, 86(1), 5-10.

<sup>15</sup> Kumar, D., D., Helgeson, S., L., and White, A., L. (1994). Computer technology-cognitive psychology interface and science performance assessment. *Technology-Psychology Interface and Assessment*, 42(4), 6-16.

enhance science or biology education. Traditionally, computers are being used in biological investigations for collecting data, searching literature, planning experiments, and analyzing data. These functions are very common in many science and biology laboratories. However, simulations are important for formulating and, improving the conceptual models that scientist and science teachers use in their practice and teaching. Also, there are several reasons to use computer simulation in science and biology classrooms. As Hilbish and Goodwin<sup>16</sup> state:

*"Computer simulations, unlike artificial examples, are not limited to real time but may be used to simulate selection over hundreds or thousands of generations.... The advantage of teaching with artificial examples is that they illustrate the basic concept of natural selection and are often inexpensive. Computer simulations are valuable because they allow students to explore the factors affecting natural selection. Neither of them, however, is a real example of natural selection. Both show what could happen, not what is happening in the world simulation used in dissections can be used by students several times and give an immediate feedback to student."*

In science and biology laboratories, everyday there are some risks that students encounter because of hazardous substances. Also, some of lab experiments are expensive and too much time consuming for classroom use. In this case, very high quality computer simulations can reduce these risks. Furthermore, Friedler, Merin and Tamir<sup>17</sup> reported the same points for biology classrooms. They found some obstacles for biology laboratory experiments as the following:

- "1. Every year it becomes increasingly difficult to identify novel experiments.*
- 2. Certain areas in biology, such as heredity and microbiology, can not be obtained in relatively short time available during the examination.*
- 3. Time constraints do not permit the use of replications and the free manipulation of variables*
- 4. There are often constraints within the school laboratory, such as limited equipment, cost of materials, and handling living organisms."*

---

<sup>16</sup> Hilbish, T., J., and Goodwin, M. (1994). A simple demonstration of natural selection in the wild using the common dandelion. *The American Biology Teacher*, 56(5), p:286.

<sup>17</sup> Friedler, Y., Merin, O., and Tamir, P. (1992). Problem-solving inquiry-oriented biology tasks integrating practical laboratory and computer. *Journal of Computers in Mathematics and Science Teaching*, 11(3/4), 347-357.

Integrating computerized simulations can solve these problems in biology classrooms or labs. Moreover, Lewis, Stern, and Linn<sup>18</sup> studied for computer simulations used to teach thermodynamics in physics courses and their reasons conducting the research were the same as mentioned above.

Another point is that many reports in education show the effectiveness of using computer simulations in science education<sup>19</sup> and their findings about computer simulations are:

*"Simulations can help to improve science process skills in the following ways: (a) expand the basis of inference through accession of larger data bases, (b) activate learning, furnish situations and techniques that are too dangerous, are too expensive, are otherwise unavailable, require too much or too little time to measure manually, are too noisy or usually frustration due to complicate techniques"*

As can be seen in their conclusions about computer simulation using in science courses, it deals with the same topics that other researchers found<sup>20</sup>. Finally, under these studies and for the sake of students, computer simulations with developing new technologies and designs can take their places in science and biology classrooms.

### **Effectiveness of using Computer Simulations in Science and Biology Education**

Science and biology educators wonder how simulation is effective in science and biology education. In that case, it should be compared with conventional lecture and laboratory methods.

According to Geban, Askar, and Özkan<sup>21</sup>, computerized simulation in science classroom has different advantages from conventional styles. In science laboratory classes, some activities are the following;

*"Basic processes such as observing, measuring, inferring, predicting and collecting, and recording data, also more complex processes such as interpreting data, formulating hypothesizes, designing experiments, and drawing conclusions."*

---

<sup>18</sup> Lewis, E., L., Stern, J., L. and Linn, M., C. (January, 1993). The effect of computer simulations on introductory thermodynamics understanding. *Educational Technology*, 45-58.

<sup>19</sup> Faryniarz, J., V. and Lockwood, L., G. (1992). Effectiveness of microcomputer simulations in stimulating environmental problem solving by community college students. *Journal of Research in Science Teaching*, 29(5), p:455.

<sup>20</sup> Lewis, Stern, and Linn, *ibid*, p:45-58

<sup>21</sup> Geban, Askar, and Özkan, *ibid*, p:7.

Moreover, other findings in computerized simulations show how different results of effectiveness of using simulation. It allows students to correctly solve problems related to the experiments in a linear sequence. Another advantage of computer simulated experiments is that students deal with data in a controlled setting the data that can be obtained directly by computer and stored; and students can change variables easily. These results lead students to understand scientific concepts much more than conventional models. Moreover, they reexamine experiment but in traditional method they cannot<sup>22, 23</sup>. Besides, Simmons and Lunetta<sup>24</sup> found that learning environments that incorporate meaningful and appropriate computer based upon instructional activities could stimulate the formations and developments of science concepts and problem-solving skills and abilities in learners.

Another effectiveness of computer simulation in science education is that many laboratory experiments take time and cost. During experiments, students need to wait the results of experiment but they seem to waste their time. Also, for experiments, equipment is expensive that is problem for poor school districts and third world and some of the developing countries<sup>25</sup>. For instance, generally a computer-simulated experiment can take 40 minutes but hands-on experiment can be finished between 140 and 160 minutes. However, simulation provides students to understand lecture concepts and finish experiments great speed and ease. Remaining time, in computerized labs, could be used to interpret data, and draw graphs. While students do experiments with computer, they can receive immediate feedback. Also, students using computer simulations have opportunities for reinforced practice without having teacher spending extra time to prepare supportive materials. On the other hand, significantly there is no difference between students using computer simulations and students doing hands-on experiments<sup>26</sup>.

Computer simulations show that between girls and boys after taking posttest there is no differences of out-come learning. This indicates that computer simulations in science courses can decrease the gender differences

---

<sup>22</sup> Faryniarz and Lockwood, *ibid*, p:453-470.

<sup>23</sup> Duhrkopf, R., and Kramer, D., W. (1991). Enhancing biology lectures with videodisc. *The American Biology Teacher*, 53(1), 48-53.

<sup>24</sup> Simmons, P., E. and Lunetta, V., N. (1993). Problem-solving behaviors during a genetics computer simulations: beyond the expert/novice dichotomy. *Journal of Research in Science Teaching*, 30(2), 153-173.

<sup>25</sup> Jegede, O., J., Okebukola, P., A., and Ajewole, G., A. (1991). Computers and the learning of biological concepts: attitudes and achievement of Nigerian students. *Science Education*, 75(6), 701-706.

<sup>26</sup> Strauss and Kinzie, *ibid*, p:398-402.



<sup>27</sup> Moreover, Friedler, Merin, and Tamir<sup>28</sup> found very valuable research results, some of which are:

- "(1) It is possible to teach new biological topics using computerized simulations.*
- (2) Learning via computer involves heavy demands on the students who have to learn simultaneously new topics and a new medium.*
- (3) It can not be assumed that since students were born in the "computer era" they can work with the computer. They need to be taught how to do so.*
- (4) Some students exhibit a high level of anxiety toward the computer. They should receive special instruction to overcome their fears.*
- (5) The computer provides the opportunity to adjust different levels of activities to different students and allows each of them to work at his/her own pace.*
- (6) The teacher still has a main role in the classrooms, even when teaching with computers. S/he should make sure that every student would benefit from the computer..."*

Additionally, Friedler, Merin, and Tamir<sup>29</sup> stated the effectiveness of computer usage and simulations as the following: *"Integrating computers into the classroom will help to broaden and deepen the students' knowledge as well as to expose students' difficulties in conceptualization. Learning via another medium might help to decrease situations such as we encountered where students say, "This is the biology of the laboratory. I know the term 'independent variable' form the classroom, but it is not the same in the laboratory."*

For gender differences, another interesting finding is that there is no significant difference between boys and girls if they use computer simulations in the biology lab. However, in hands-on experiments, boys gain more achievement than girls do<sup>30</sup>.

Moreover, in computer simulation is that in college level basic introductory courses are over-crowded. Traditionally, overhead, films, and

---

<sup>27</sup> Friedler, Merin, and Tamir, *ibid*, p:347-357.

<sup>28</sup> *Ibid*, p:356.

<sup>29</sup> *Ibid*, p:356.

<sup>30</sup> Choi, B., and Gennaro, E. (1987). The effectiveness of using computer simulated experiments on junior high students' understanding of the volume displacement concept. *Journal of Research in Science Teaching*, 24(6), 539-552.

videotapes have been used. According to Fifeld and Preifer<sup>31</sup>, using computer-based multimedia and simulations can enhance lecture presentation. Consequently, when students and teachers use computer simulations, it was reported that their attitudes toward computerized technologies and science courses were positively changed. Also, it helps to learn correctly many scientific concepts in science and biology courses<sup>32</sup>.

### **Disadvantages of Using Computer Simulations in Biology Education**

While computerized simulations bring positive effects to science classroom and labs. They may cause some problems. In this case, we can not exactly say disadvantages of using simulations but what kind of problems have when the simulations are used in science classrooms and laboratories. One of the problems is that to use computer simulations in biology and science courses both students and teachers should believe in the effectiveness of computer usage, but some of teachers and students seem to be reluctant to use this new technology<sup>33</sup>. Generally, science and biology teachers mainly rely on textbooks and other supplementary resources, such as lab manuals, and test books. Also, some of students and teachers do not know enough information how computer simulations can be applied effectively. Therefore, they need to have computer usage background<sup>34</sup>.

Another problem in computer simulation applications, especially in lab classes, students cannot feel the real hands-on experiments taste. We know that as possible as if students sensory organs, such as hearing, seeing, and touching, participate to learning activities, student learning achievement should be much better than other types of teaching. On the other hand, computer simulations cannot give some of these feelings, like touching. In this case, computer simulations are somehow perceived impersonal but only machine by students<sup>35</sup>. Another point in computer simulations is the educational fitness the student learning environments and needs. Some simulation programs are the lack of well preparation because some times students can not understand how to use very complex simulations and simulation programs may not fit the learning age of students. For example, if a simulation program is prepared for college level introductory biology

---

<sup>31</sup> Fifield, S., and Peifer, R. (1994). Enhancing lecture presentations in introductory biology with computer-based multimedia. *Journal of Computer and Science Teaching*, 235-239.

<sup>32</sup> Geban, Askar, and Özkan, *ibid*, p:5-10.

<sup>33</sup> Duhrkopf, R. (1994). A review of bio tutor. *The American Biology Teacher*, 56(5), 309-310.

<sup>34</sup> Geban, Askar, and Özkan, *ibid*, p:5-10.

<sup>35</sup> Straus, and Kinzie, *ibid*, p:398-402.

courses, it makes problem when it is used in a high school biology course as it may not be proper for high school students<sup>36, 37</sup>.

## **RESULT AND DISCUSSION**

As mentioned above, when the computer technology began to employ after the Second World War, no one could not image the aspects and dimensions of usage computers every part of our daily life, as today. Also, education is one of the major concerns of today's society and one of the most important goals of nations is to reach and sustain the level of information and civilized nations.

After 1980's, computerized instructional technology began to give the first examples of educational applications in schools. Some of the results of using computerized instructional technologies were so hopeful at the beginning. With the developments of computer technology and the expenses of decreasing prices, computers widely began to be used in schools especially in the developed countries. Mostly, these computerized instructional technologies were applied in science and mathematics education areas. One of the reasons for these applications in science education area is that generally primary, secondary and college level students have a problem to learn and conceive scientific concepts, negative attitudes towards science and deficiencies in science courses.

There are different aspects of using computerized instructional technologies in science and biology education, for instance; Computer Assisted Instruction, Simulation, Animation, Multimedia Applications, and Internet. In this paper, it was tried to reveal the different aspects of using computerized simulations in science and biology education at the level of primary, secondary and college level introductory science and biology courses.

Generally, simulations should help students to conceive the scientific concepts, easily to change misconceptions they have already held, to have more positive attitudes toward science, and to increase their achievements in science and biology courses. However, some research results<sup>38, 39</sup> showed that students' achievements in science courses were not significantly changed by means of simulations. These kinds of results seem to decrease early hopes expected from simulations. However, later newly updated and developed software and hardware technologies in computer area overcome

---

<sup>36</sup> Kumar, Helgeson, and White, *ibid*, p:6-16.

<sup>37</sup> Simmons and Lunetta, *ibid*, p:153-173.

<sup>38</sup> Straus, and Kinzie, *ibid*, p:398-402.

<sup>39</sup> Duhrkopf, *ibid*, p:309-310.

many of these deficiencies by means of widely using of Internet and multimedia software. In the result, simulations in science and biology education help to make rich students' learning environments as well as students easily to do some lab experiments almost in real taste, to learn scientific concepts and to have more positive attitudes toward science.