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Tel: 1-323-984-7526, 323-410-1082
Fax: 1-323-984-7374, 323-908-0457
E-mail: teacher@davidpublishing.com; teacher@davidpublishing.org; edu1658@yahoo.com

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The Effects of Smartphone Use on Organic Chemical Compound Learning

Nuray Zan
Karatekin University, Çankırı, Turkey

As a result of rapid technological advances, smartphones have recently enjoyed widespread use. The basic purpose of this study is to examine the effects of smartphones when they are used as educational tools in learning environments. To assess the effects of smartphone use on learning, this study uses smartphones as educational tools in a chemistry course that focuses on naming organic chemical compounds. Text and multimedia messages that are sent to students' smartphones include the names, formulas, pronunciations, and usage areas of compounds, along with questions related to these compounds. These messages are supported with audio-visual content to make the information more permanent. In the second stage of the study, questions are sent via text message to evaluate the students' levels of understanding in the field of naming and writing compounds. In addition to this evaluation, students' attitudes about this method have been researched. As a result of evaluating the gathered data, this study has made a statistically significant contribution to the literature on students' learning of chemical compounds. Students showed positive behaviours when using smartphones as educational tools and said that learning with smartphones was easier than with other learning methods.

Keywords: smartphone, chemistry education, multimedia message, organic chemical compound, formula, symbolic language

Introduction

Technological developments have caused major changes in many fields. Communication networks have changed rapidly as computers have been integrated into people's daily lives. Computer and Internet-based studies have made information easy to access. Although computers are thought to be requirements, there are fewer personal computers than mobile phones in Turkey (Turkish Statistical Institute, 2006). According to the results of this study, only 18.5% of households have computers, while 83% of households have mobile phones. Mobile phone usage, especially for social purposes, starts in childhood in the most parts of the world and in Turkey. These results show that mobile phone usage is widespread in Turkey.

The importance of mobile phones has been increasing daily in recent years, as access to information has become a primary goal. Education is one of the fields that has been affected by rapid information retrieval. Mobile phones have major potential in terms of contributing to education fields. Through the multimedia capacity of mobile phones, education can be supported everywhere and at any time via mobile phones (Ağca & Bağcı, 2013). According to Gülmez (2005), 90% of university students have mobile phones. Karaaslan and Budak (2012) found that the short message service (SMS) was the most used application to connect students

Nuray Zan, Ph.D., assistant professor, Educational Science Department, Karatekin University.

with other people. They found that 73% of students prefer using SMS to connect with one another.

Each new technology is thought to have potential in learning environments (Saran & Seferoğlu, 2010). Another study found that although many studies have been conducted in the field of education, there are few studies that investigate students' reactions to mobile phones as educational tools (Corbeil & Valdes-Corbeil, 2007).

Mobile Phone Use in Chemistry Education

In this literature review, few studies have been identified that relate to the effects of mobile phone use in education. Ring (2001) researched the effects of mobile phone use. In Ring's study, mobile phones were used as distance learning tools in a business administration course. Students accessed the distance learning materials using the mobile phone's Wireless Access Point (WAP) features (e.g., an Internet-connected computer). Only short texts and short examinations were used as distance learning materials. A survey that related to mobile learning was distributed among students. Most of the surveyed participants (93%) defined mobile learning as a helpful tool, while 50% of the participants thought mobile learning was not secure. Given these results, it can be argued that mobile learning has positive results if it is used alongside traditional learning methods. Using mobile learning methods exclusively is not appropriate for student learning.

Jones and Marsden conducted a "text worm" project in 2004. In this project, teachers projected questions overhead and expected students to send answers in real time via SMS. However, there was a debate about open-ended questions in this study, as students were distracted when writing answers to open-ended questions via SMS. In addition, the SMS feature charges additional fees to send messages, which has been discussed as another negative aspect in Jones and Marsden's (2004) study.

The literature review revealed that mobile phones were preferred as educational tools in the field of foreign language learning. For example, a study by Saran and Seferoğlu (2010) investigated the effects of mobile phone use on learning new words via SMS. They found that mobile phones had positive effects on new word acquisition in foreign language learning. In another study by Regan, Mabogunje, Nash, and Licata (2000), mobile phones were used as tools to learn Spanish. This study showed that mobile phones significantly aided students in learning new foreign language vocabulary.

Thornton and Houser (2005) and Levy and Kennedy (2005) studied the effects of mobile phone use on learning new words in English and Italian, respectively. Both studies demonstrated the positive effect of mobile phone use in the educational system. Studies in the field of education were only conducted with the SMS feature of mobile phones. However, mobile phones can also send audio-visual attachments. This mobile phone feature allows for more comprehensive content to be sent to students.

The literature review also revealed that no studies in the field of science education have used mobile phones as educational tools. N. Zan, B. U. Zan, and Morgil (2014) conducted the first study to use smartphone applications in the field of chemistry. This research is seen as a continuation of previous work. Similar results were taken from previous educational studies that examined the use of advanced communication tools.

In the field of science education, chemistry was chosen as the subject through which to examine student learning via mobile phones features. To engage the different senses of students, the multimedia features of mobile phones have been used, and WhatsApp (free software) has been used to avoid any additional expenses for students.

Method

The fundamental purpose of this study is to examine the effects of mobile phone use in teaching environments. Mobile phones have recently enjoyed widespread use by secondary school students. Text and multimedia messages have been sent to students' mobile phones with the names, formulas, pronunciations, and usage areas of organic chemical compounds. These messages have been accompanied and supported by visual contents to make the information more permanent. To evaluate the students' levels of understanding of the symbolic language of chemistry (i.e., naming and writing compounds), questions have been sent to students as interactive text messages. Students' attitudes were examined before and after the study. This section includes information about the participants, research patterns, and methods.

Sampling Group

The sample group of this study consisted of 9th grade students from a commercial high school (N = 62). This school is located in the central district of Ankara. Experimental and control groups have been defined to carry out this experiment.

To define the experimental and control groups, the students completed a questionnaire. The questionnaire was distributed to all 9th grade students who had attendance records in this school. This questionnaire was distributed to learn about students' personal information and social conditions. On the basis of the questionnaire results, classes were chosen as experimental and control groups, and students in these classes had multimedia-supported mobile phones. Table 1 presents the sampling group's gender information.

Table 1
Gender Analysis of Students

	Experiment group		Control group		Total	
	N	%	*N*	%	*N*	%
Female	18	58	15	48	33	53
Male	13	42	16	52	29	47
Total	31	100	31	100	62	100

Research Pattern

Gathered quantitative and qualitative data have been analyzed by using hybrid methods. Multivariate Analysis of Variance (MANOVA) has been used to evaluate results. Research pattern, which has been used in this study, has been given in Table 2.

Table 2
Research Pattern of the Study

Gathering quantitative data	Questionary (personal information)
	Pre-test
	Application phase
	Final test
	Permanent test (two weeks later)
Gathering qualitative data	Semi-structured meetings after application

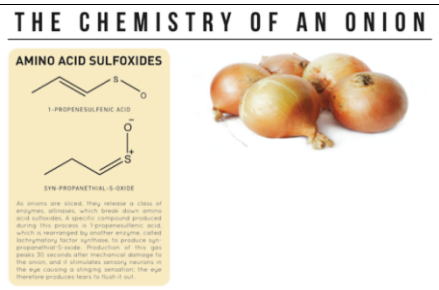
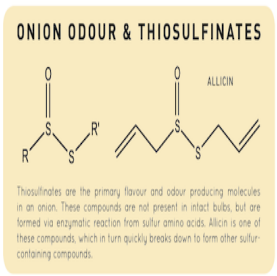
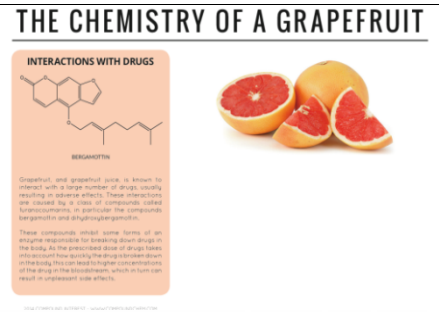
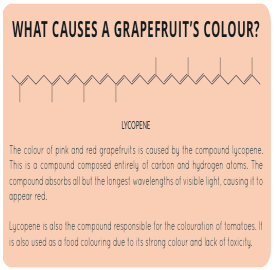
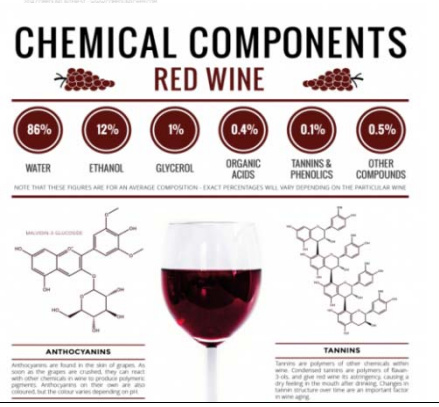
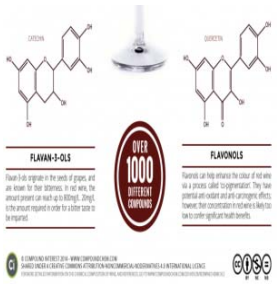
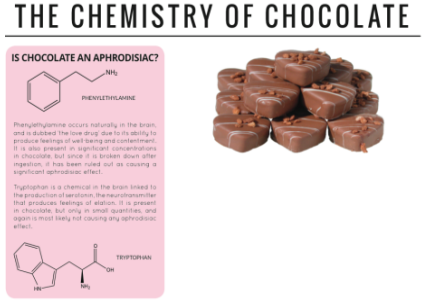
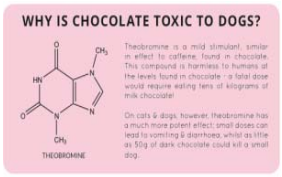
Used Materials and Applications

Chemical formulas and compound names, which were given to students in this study, were shown in Table 3. The same method and techniques were used to the control and experimental groups in the classroom

while teaching symbolic language of the chemistry subject. The experimental group students were supported with SMS, which were sent to students' mobile phones, while no SMS was sent to the control group students, but written materials were given to the control group students. The materials which were given to students were shown in Table 3.

Table 3

Chemistry-Related Multimedia Messages for Students

The first message: object from daily life	The second message: formula of compound	The third message: sound file	The fourth message: structure of organic matter	The fifth message: continuation property of the fourth message
Onion		A reading of compounds and usage fields are sent as sound files	Amino acid sulphoxides	
Grapefruit			Bergamottin and lycopene	
Wine			Tannins, anthocyanins, and flavones	
Chocolate			Phenylethylamine and tryptophan	

Multimedia Messages

Table 3 shows an example of the text and multimedia messages that have been implemented in this study. The messages in Table 3 were sent to students via mobile phones. Each message was sent one minute after the previous one. Chemistry-related information was sent in five different messages. The first message included the compound's name; the second one included the compound's formula; the third message included a sound file with the compound's pronunciation; the fourth message included usage field information about the compound; and the fifth message was the continuation property of the fourth message and included multimedia content about the usage fields of the compound. Table 3 displays a list of the text and multimedia messages that relates to the chosen chemistry topic.

Short Exam Questions

Short exam questions were sent as multiple-choice test questions in multimedia messages. Questions were presented with four answer choices. An example of a short exam question is shown in Figure 1. The students were expected to answer the multiple-choice questions by sending messages from their phones with the right answer codes. They sent answers to the related phone number. They were given two minutes to answer the questions. After they answered (or did not answer) the question and the time expired for the related question, evaluation results were sent to them via messages. The participants volunteered to use this application. In addition, they did not pay for this application.

What causes a grapefruit's colours?

(a) Tryptophan (b) Lycopene (c) Tannin (d) Glycerol

Figure 1. Example of a short exam question.

Server System

A system for smartphones is the basis of this study. WhatsApp Messenger is a proprietary, cross-platform instant messaging subscription service for smartphones and selected feature phones that uses the Internet for communication. In addition to text messaging, users can send images, video, and audio media messages, along with their locations through integrated mapping features (WhatsApp, 2014). With this system, multimedia messages were sent to the students, and delivery reports of multimedia messages were taken. Due to the capabilities of this system, students' answers were recorded. Figure 2 shows the user interface of this multimedia message sending system.

Application

This system for smartphones is the basis of this study. To sustain this study, all students used this server system. With this system, multimedia messages were sent to the students, and delivery reports of multimedia messages were taken. Due to the capabilities of this system, students' answers were recorded.

Practise lasted for three weeks. Multimedia messages were prepared before they were applied. Each day, five different messages were sent to the students for a particular compound. The time schedule was prepared for SMS. Between course hours and afterschool hours were chosen as the best time to send messages to the students. After 6:00 p.m., the examination questions were sent to students via SMS. These examination questions were sent via SMS to the experimental group, while the same questions were presented as course materials to the control group. There were no messages sent to the control group students, but they did receive written materials.

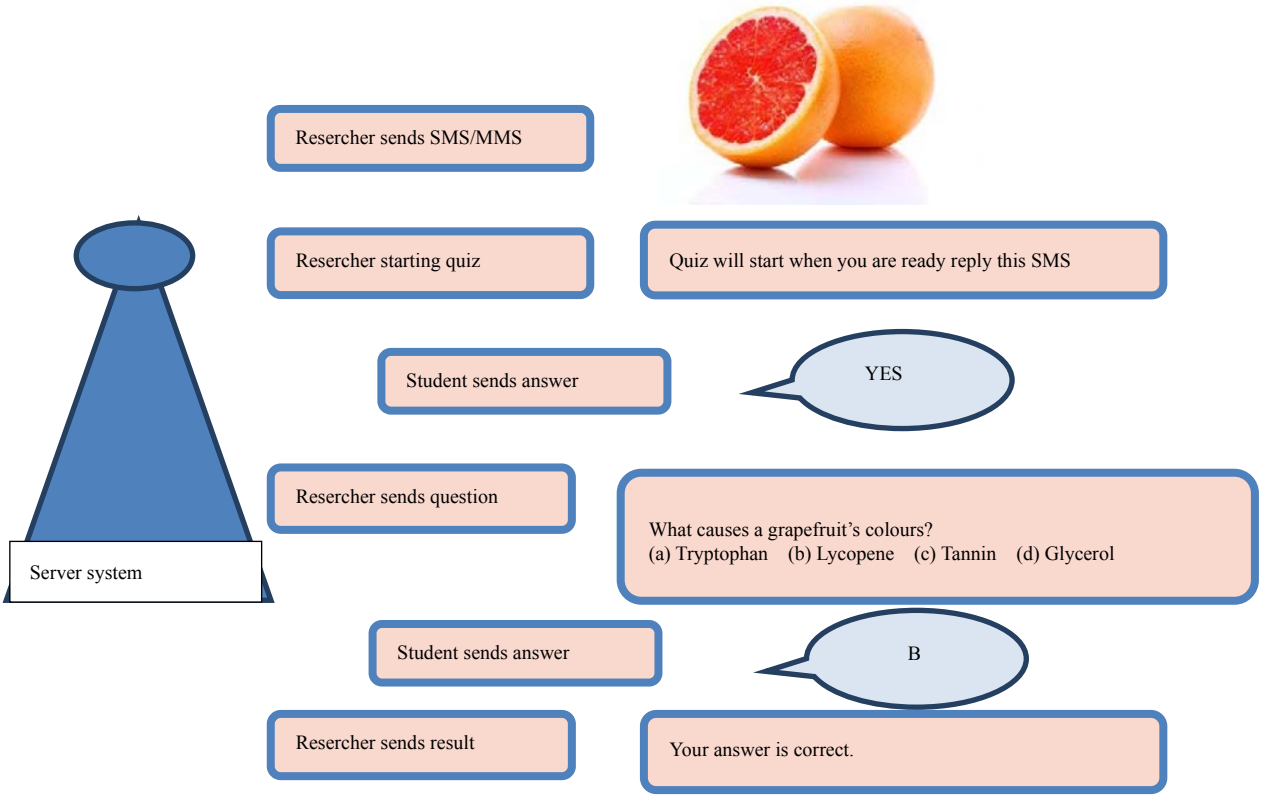


Figure 2. Multimedia message sending system.

Findings

As highlighted in the study's search pattern, in addition to traditional course methods, the students in the experimental group were supported with SMS from WhatsApp.

The experimental group's pre-test average was 50.83, while the control group's pre-test average was 47.69. These results show that the two groups were comparable with each other. The experimental group's final test average was 76.17, while the control group's final test average was 66.01. The experimental group's average test score increase was 26.33, while that of the control group was 18.32.

In compound and formula naming, the degree of learning was higher in the experimental group than in the control group.

To determine the permanence of this information, the students took a permanent test two weeks after the final test. The average permanent test score in the experimental group was 78.29, while the average score in the control group was 63.69. When these scores were compared with the final test scores, the experimental group's score increased by 1.12 points, while the control group's score decreased by 2.32 (see Table 4).

Table 4

The Experimental and Control Groups' Pre-, Final, and Permanent Test Averages

Groups	Pre-test X_1	Final test X_2	Permanent test X_3	Final-Pre X_2-X_1	Perm-Final X_3-X_2
Experimental	50.83	77.17	78.29	26.33	1.12
Control	47.69	66.01	63.69	18.32	-2.32

To determine whether the differences between applied test averages were significant, a two-way MANOVA test was applied. The results of MANOVA test are given in Table 5. The two-way MANOVA test was applied to examine the effects of two or more independent variables on more than one dependent variable (Green, Salkind, & Akey, 1999). The dependent variables of this study were pre-test, final test, and permanent test results. The independent variables were the control and experimental groups. Before variance analysis, the Shapiro-Wilk test was applied to ensure that the data were suitable for variance analysis. With a score distribution at the level of 0.01, the analyses results were found to be normal. The population and covariance between dependent variables were examined with Box's *M* test and Levene's test. The population tests were found to be homogeneous ($F = 2.523$, $p = 0.058$; for final test $F = 1.763$, $p = 0.164$). This result expresses an average level effect size. Using Bonferroni inequalities for dependent variables, the pre-, final, and permanent tests in the binary group were compared. These test results are shown in Table 5.

Table 5

Binary Group Comparison Based on Bonferroni Inequalities

Dependent variable	Practice group	Practice group	Average difference	*SH*	*p*
Pre-test	Experimental	Control	3.034	2.589	0.246
	Control	Experimental	-3.034	2.589	0.246
Final test	Experimental	Control	11.497	3.240	0.001
	Control	Experimental	-11.497	3.240	0.001
Permanent test	Experimental	Control	14.931	3.558	0.000
	Control	Experimental	-14.931	3.558	0.000

The students participated in face-to-face interviews. For example, the experimental group students were asked the following questions: "What did you think of this teaching method?" and "What were the positive and negative aspects of this method?".

Interviewees gave positive replies to all of these questions. When they were asked about the positive aspects of this application, they gave the following answers:

> Mobile phone applications should be used in geography and history courses.
>
> I saw the usefulness of this application in the examinations. I learned new things about compounds every day. I also learned the names and formulas of compounds and the usage areas of compounds.
>
> Multimedia messages are very useful for me. Seeing and understanding the usage areas of compounds was a very effective method for me.
>
> Our teacher sends us SMS messages every day. Because of this (daily attention), I feel myself learning from all SMS messages.
>
> My mobile phone is always with me. I can read the SMS messages wherever I am. These SMS messages have permanent features for me. I can also read the SMS messages to whomever is nearby. It is a really different course method. It is very useful for me.
>
> In my class, we do not have computers. However, all students have mobiles. We can use them for all of our lessons.

Results and Conclusion

Mobile phone use has become widespread among students. This study examines effective mobile phone use as a teaching method in a chemistry course that focuses on chemical formulas and naming compounds. The literature review has not identified any study that relates to mobile phone use in science and chemistry courses. However, the gathered results are compatible with results of other studies in the field of foreign language.

Mobile phone use for science learning has reached the point where it is beginning to move out of the classroom and into the real world. With mobile phones, educators have the potential to provide rich learning environments for their students, but there are still issues that must be considered before mobile phones can reach their full potential (Stockwell, 2010).

Students complained about small screens in a study by Jones and Marsden (2004). In the same study, students also complained about the extra budget requirements for the application used. In this study, students did not complain about screen scale or resolution, as technological advances develop daily. These advances make mobile phones preferable and easy to use. Because this study used a free application called WhatsApp, the students did not complain about additional expenses, which was one of the positive aspects of this study.

The *Vision 2023: Education and Human Resources* report of the Research and Scientific Committee of Turkey (TUBİTAK) (2005) highlights the importance of human beings' abilities to think critically, to pursue lifelong learning, and to integrate technology and information. These abilities characterise a person of the modern age. Data from this study show that adapting lessons to new technologies allow pupils to mature into adults who have lifelong learning capabilities. Great scientific and technological contributions are expected from these types of pupils in the future.

In face-to-face interviews, the study determined the advantages of this type of educational method (e.g., mobile phones are always with students). The students sometimes forget their textbooks, and this situation makes course progress difficult. However, with this application, they did not forget to take their mobile phones with them. They answered all messages simultaneously. During interviews, the students revealed that they were able to read the messages wherever they were. This accessibility encourages the students to work hard.

The results of this study show that mobile phone use has major effects on the educational system. Mobile phones also have great effects on chemistry courses that focus on naming compounds. These educational methods increase the quality of the lessons. The lesson's effectiveness increases with mobile phone use because students are really interested in new technologies.

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