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DEVELOPMENT AND EFFICIENCY OF SMART MOBILE DEVICE APPLICATION: EXAMPLE OF HEAT AND TEMPERATURE INSTRUCTION

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ABSTRACT: The versatility of mobile devices, such as availability, portability, adaptability, and the ability to personalize individual experiences, makes them valuable and makes their use mandatory. Rapid developments in mobile devices have had an impact on the field of education as well as in all areas. This situation has revealed mobile learning in the education system. Mobile learning is seen as a field of research that attracts practitioners at different stages of education to facilitate learning. The use of mobile technologies in learning has a number of advantages in terms of providing learning opportunities anywhere and anytime. This superiority, more mobility and expanded functionality, allows for faster, student-faculty interactions in flexible times and locations. In addition, when mobile technologies are used as part of active learning, they can increase students' motivation and satisfaction, and contribute to the learning of the taught content. The aim of this study is to develop mobile applications for the subject of heat and temperature, which students find hard to understand, and to use the developed applications in the lecture and to measure their impact on learning. For this purpose, mobile applications of the planned scenarios were created using Crazy Talk Animator and Adobe Flash CS6. Mobile applications were applied to the students as pre-test-post-test with control group and as half-experimental in the lessons. When the results were evaluated, it was observed that educational materials consisting of mobile applications were significantly more effective in increasing students' level of knowledge on the subject compared to normal lectures.

Keywords: Mobile Application Development, Mobile Learning, Content Design, Heat and Temperature.

1. INTRODUCTION

Today, as a result of efforts to integrate rapidly developing technology into almost every field, use of mobile technologies has become indispensable in our lives. The expansion of mobile device use has introduced the concept of mobile learning as a new dimension to distance learning. In mobile learning, a person can flexibly and quickly reach the needed information, regardless of time and space. [23].

Mobile learning is an educational approach that aims to close the individual's deficiencies in education with mobile devices. It has become very popular as a result of the widespread use of mobile devices [2]. In the use of mobile training tools and applications in some studies, many users find the teaching technique with mobile devices interesting [3]. In addition, parallel with the development of mobile devices with students whose use is widespread, it is seen that the

level of attitude towards mobile learning is high. [11]. The benefits of mobile learning are listed as follow:

- The ability to continue the learning activity outside the classroom without interruption,
- The prediction that education systems can be expanded by making them suitable for mobile devices,
- Providing equal opportunity for disabled students,
- Increasing the audio and visual interaction between students, academicians, and other users,
- Increasing the student's interest and motivation.

Physics teaching is perceived as a lesson full of formulae among learners. This attitude towards the lesson, makes physics lesson difficult in the eyes of the learner. Students, in their minds, try to revive these concepts and incidences in physics in their own way. Because of the wrong perception created, this situation causes great misconceptions on students. [23].
The biggest reason for misconceptions about heat and temperature, definition of heat and temperature, used in daily life or as a result of individual observation, consists of wrong terms. What is the difference between heat and temperature? A student who thinks about questions from his/her experiences in life enters a confusion of concepts when he/she evaluates these questions with their interpretation. If theoretical knowledge is supported by practical training, the student will be able to get rid of this conceptual confusion.[6]

The biggest deficiency of applied training is the inability of experiments that are difficult and expensive to be done at any time. Also, while doing the experiment, dangerous situations that may occur with the test materials used are among the challenges of practical training.

For this reason, computer-aided virtual experiments, applied with animation and simulations, can be done more effectively. With mobile applications prepared on the subject, students will be able to learn the cases that cannot be concluded with observations. With simulations prepared, broader learning experiences will be provided. Training using computer animations can be as functional as activity-assisted teaching. [13]. This study is aimed to produce interactive contents for mobile devices and to measure teaching effectiveness on physics lesson heat and temperature where confusion of concepts and difficulty of perception is experienced.

2. METHODS AND EXPERIMENTAL

2.1. Research Pattern

This study is a semi-experimental study examining the effectiveness of educational materials developed based on computer and instructional technologies in relation to heat and temperature in ninth grade high school students in physics lesson. Pre-test, post-test and quasi-experimental design with control group were used in the study. Pre-test, post-test and quasi-experimental design with control group are considered as one of the most effective quasi-experimental designs used to ensure internal reliability. Also, it provides a high level of statistical power to the researcher regarding testing the effect of the experimental procedure on the dependent variable, allowing the conclusions to be interpreted in the context of cause and effect. It is known as a powerful pattern that is frequently used in both educational sciences and computer and educational technologies [4,5,7,8,14,15,21,22].

The view for this pattern is shown in Table 1.

Tablo 1. Research Pattern

Groups	Pre-test	Process	Post-test
Experimental Group	Personel Information Form Heat and Temperature Achievement Test	Heat and Temperature Lecture Based on Computer and Instructional Technologies	Personel Information Form Heat and Temperature Achievement Test
Control Group	Personel Information Form Heat and Temperature Achievement Test	Classical Heat and Temperature Lecture	Personel Information Form Heat and Temperature Achievement Test

As seen in Table 1, ninth grade students in the experimental group and the control group, before teaching the subject of Heat and Temperature, a Personal Information Form, an achievement test on Heat and Temperature was applied to both groups. While lecturing heat and temperature based on computer and instructional technologies to students in the experimental group by the same teacher, classical lectures were made to the students in the control group. While there is no difference in the pre-test scores of both groups, an increase in the post-test scores is expected in both groups after the lecture. However, if the increase in the posttest scores is statistically higher in the individuals in the experimental group than the individuals in the control group, this will show that the program developed based on computer and instructional technologies is more effective in increasing the academic achievement than the classical lecture method in the teaching of heat and temperature.

2.2. Working Group

The study group of the study consists of 58 ninth grade students who are attending a multi-program high school, selected through appropriate sampling. In this high school, ninth grade students are taught in two grades. Students studying in these classes are assigned to the control or experimental group by lot. 34.5% of the students are women and 65.5% are men. The average age range of students varies between 14 and 16 years old, with an average age of 14.71. More detailed information about the students in the experimental and control groups can be seen in Table 2.

Table 2. Descriptive statistics for students in the experimental and control groups.

Variable	experiment		Control		χ^2	p
	n	%	n	%		
Gender					.31	.581
Girl	11	37.9	9	31		
Male	18	62.1	20	69		
Mother Education Level					3.70	.158
İlliterate	6	20.7	2	6.9		
only literate	5	17.2	10	34.5		
elementary school graduate and above	18	62.1	17	58.6		
Father Education Level					.09	.760
İlliterate	0	0	1	3.4		
only literate	5	17.2	4	13.8		

elementary school graduate and above	24	82.8	24	82.8		
	Ort	S.s	Ort	S.s	z	p
Age	14.76	.64	14.66	.61	.62	.535
Income	1151.72	1075.58	981.03	1032.63	.60	.551
Teog Score	253.27	56.28	244.98	56.76	.55	.581

Note:The number of students who were illiterate at the father's education level was not included in the analysis since there was only one person in the experimental group. The assumptions of the tests are met. z: Mann-Whitney test result statistics, χ2: Chi-Square test result statistics.

As seen in Table 2, 37.9% of the students in the experimental group are women and 62.1% are men. While the mothers of 20.7% of the students in the experimental group were illiterate, 17.2% were only literate, 62.1% had a primary or higher education level. When the students in the experimental group were examined in terms of the education level of their fathers, 17.2% were only literate, while 82.8% had a primary education or higher education level. While the average age of students in the experimental group is 14.76, their average income level is 1151.72 Turkish lira. Finally, the average Teog score of the students in the experimental group is 253.27. On the other hand, 31% of the students in the control group are women and 61% are men. While the mothers of 6.9% of the students in the control group were illiterate, 34.5% were only literate, 58.6% had a primary or higher education level. When the fathers were examined in terms of education level, 3.4% of the fathers of the students in the control group were illiterate, 13.8% were only literate and 82.8% had primary education and higher education level. While the average age of the students in the control group is 14.66, their average income level is 981.03 Turkish lira. Finally, the average Teog score of the students in the control group is 244.98. The number of women and men in the control and experimental groups are similar in terms of mother's education level, father's education level, and transition score from basic education to secondary education, average monthly income level of the family and average age (Table 2).

2.3. Data Collection Tools

2.3.1. Personal Information Form

It was developed by the researcher to gather information about the students' name, surname, gender, age, mother-education level, father's education level, and average monthly income. Information on students' TEOG placement scores, was obtained from the e-School Management Information System of the Ministry of National Education by the researchers with the help of a school administrator, after obtaining permission from the students and the school administration.

2.3.2. Heat and Temperature Subject Achievement Test

Heat and Temperature subject success test has been developed in order to determine the level of knowledge students have about heat and temperature. The test development stages proposed by DeVellis [10] were followed in the development of the test. First, the heat and temperature subject curriculum in the ninth-grade textbook was examined by the Ministry of National Education and the achievements that students should have, were determined.

In accordance with these achievements in the second stage, a 25-question success test from the auxiliary textbooks recommended by the Ministry of National Education was prepared by two different physics teachers working at the school where one of the researchers was working. This form was examined by a faculty member with experience in physical education and the final form of the success test was given. The success test was then applied as part of the pilot

study to five students attending ninth grade outside the school where the application was performed. As a result of the pilot study, students stated that there was no expression that they had difficulty understanding.

Here is a sample question in the success test.

Question: On hot days, the environment cools if the places are frequently watered. According to this;

I- Cooling of water in water tests
II- If the cut watermelon is kept in the sun for a short time, the watermelon cools down.
III- If ice is put in the lemonade glass on a hot day, the outside of the glass sweats.

Which of its events can be explained by the same principle?

a) Only I b) Only III c) I and II d) II and III e) I, II, III

Students were given 1 point for each correct answer given in the test; wrong answers were ignored. For this reason, the scores that can be obtained from the achievement test vary between 1 and 25. The increase in the scores of the students in the achievement test indicates that the level of knowledge about heat and temperature has increased.

2.4. Mobile Application Preparation Process

2.4.1. Storyboard

Storyboard is the form of the stream (animation, video) that will be used in the prepared e-content, which has been cast into the picture. Animation or video montage are structures that require difficult processes, and the animator or video editor "Does the scenario give the desired effect?" searches for an answer to the question on the storyboard. After the fiction is put into a picture, to what extent the story to be told or the information to be given is effective, whether there is any disconnection in the fiction, and the integrity of the animation tests are also examined on the storyboard. The animation or video is then brought to life. Storyboard preparation is used in the design phase of e-content creation. [13]

2.4.2. User Interface

Application user interface screen has been prepared using Adobe Flash CS 5.5 and Action Script 3.0 (Figure 1). The interface is designed to link all documents to be used by the student as separate files from the program background using the extensible markup language (XML). In this way it plays by calling the animation file and the sound file from the database file and depending on whether the user is on, the program provides a lecture about the subject. As a result, the application developed within the scope of the study does not occupy much space in the memory of the user's mobile device, and its performance is high and it can work comfortably on devices that are not powerful in terms of hardware.

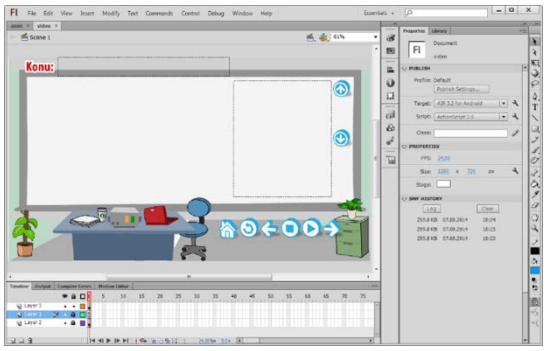

Figure 1. Adobe flash CS 5.5 application screen

The application is designed to work horizontally in full screen on mobile devices. In order to be user friendly, other educational software prepared in the Google market were examined and according to the results, application control buttons, text area, animation area were placed on the stage. The application has been prepared to be very colorful to attract attention.

The stage consists of 6 main parts (Figure 2);
1. Subject title section,
2. Animation section,
3. Summary lectures section,
4. Summary subject checks section,
5. Application controls section,
6. Volume controls section.

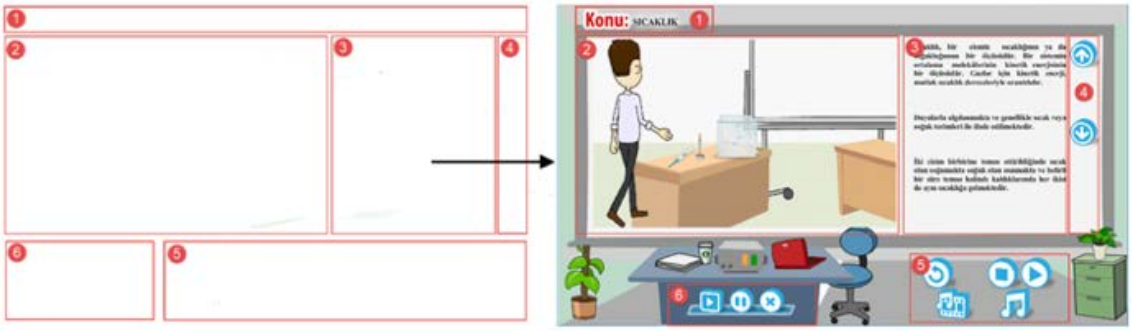

Figure 2. Scene parts

2.4.3. Animation Preparation Process

Animations were prepared using Crazy Talk Animator (Figure 3) program. Crazy Talk Animator is a program developed on character animation. With this application, modeling, dressing, and animating the character, and creating harmonious animations between scenes can be easily done. In the application, the objects placed on the stage, where they should be in the flow of the animation with the timeline, they perform the desired behaviors (Figure 4). For each object, individual change, visibility, transparency, and motion properties can be adjusted in this section to provide interaction between objects. While animating characters, the 2 and 3 dimensional properties to be used can also be adjusted over the timeline.

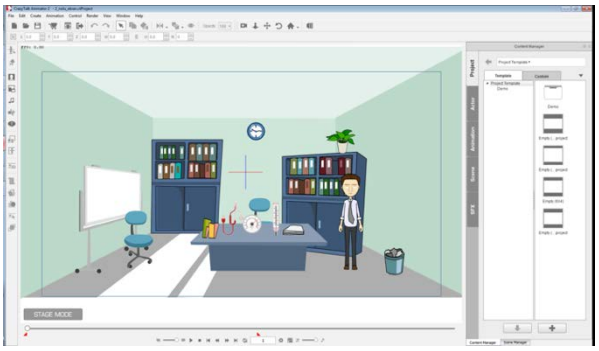

Figure 3. Crazy talk animation program application screen

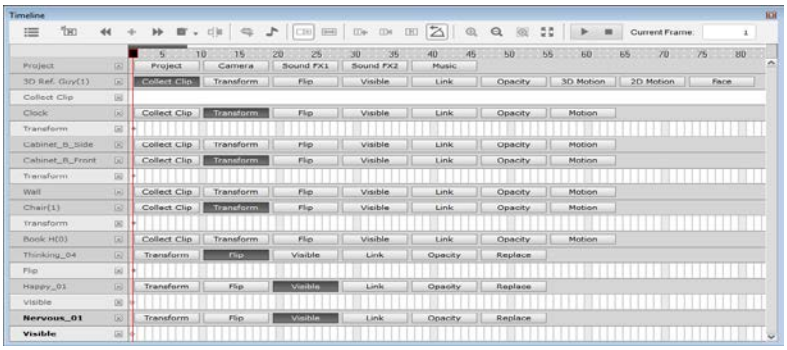

Figure 4. Timeline panel

3D motion Key editor panel, it enables the animation to be viewed from every angle by allowing the created character to be examined in three-dimensional plane (Figure 5).

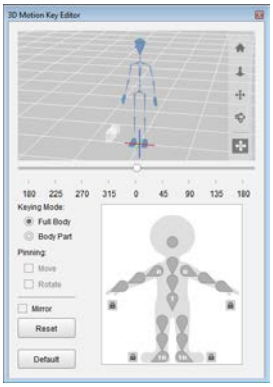

Figure 5. 3d Motion key editor

2.4.4. Packaging of the Application

In order to enable the completed training software to run on android-based mobile devices, using the publish button from the file menu in the animation software, a dialog window with the necessary settings is opened (Figure 6). After the publishing window approval, the created Apk file will be ready for use.

Figure 6. Apk publishing screen

Apk is a short form for Android Package Kit and is the equivalent of executable EXE (Executable File Format) files in the Windows operating system in the android operating system. Apk files are used to install applications on mobile devices using the Android operating system without using the Play market. Manually installing applications in this way is called "sideloading" [1]

2.4.5. Application Examples

The scene in Figure 7 shows the melting of some ice and the freezing of the water. During the process, heat was given to the ice to melt the ice, and heat was taken from the water to freeze the water. At the end of this section, it is aimed that students learn how heat exchange occurs in melting and freezing.

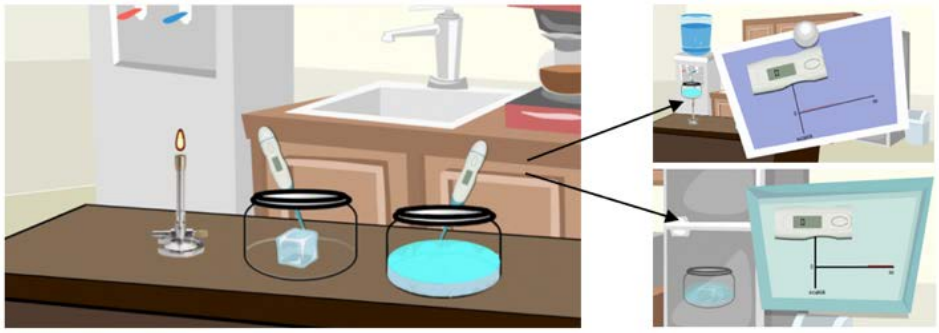

Figure 7. "Melting and freezing temperature" animation

In the scene shown in Figure 8, there are water and steam at 100 degrees Celsius in two containers. The pot with water in it is placed on the cooker and heat is given, and the temperature at which the water boiling does not change is shown on the temperature graph. The second container is put on ice and heat is taken from the water vapor. In this case, the temperature at which the water vapor condenses into a liquid does not change and again it is shown on the heat-temperature graph. At the end of this section, it is aimed that students comprehend the relationship between heat and temperature during boiling and condensation state changes.

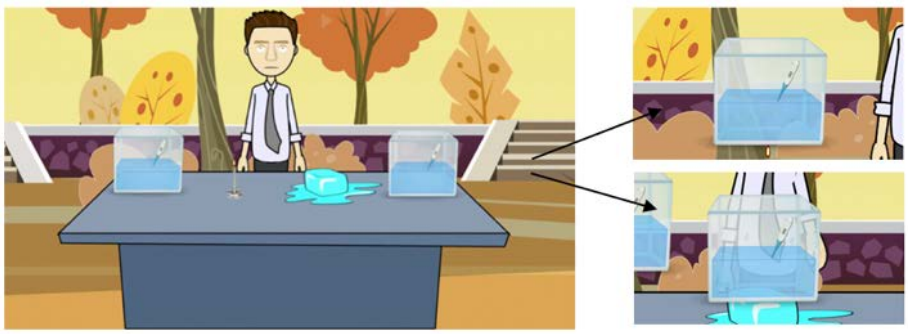

Figure 8. "Boiling and condensation temperature" animation

An animation screen shot prepared for the scenario is shown in Figure 9. In this scene, it has been shown that a heated sphere increases with the expansion of its volume and as a result, it cannot pass after heat is given from the ring through which it can pass before heat is given. In daily life, the volumes of the objects that receive heat generally increase in direct proportion to their temperatures. For example, inflated balls harden in hot environments and their volume increases as a result of this situation. At the end of this section, it is aimed that students learn the direct proportion between temperature increase and volumetric expansion.

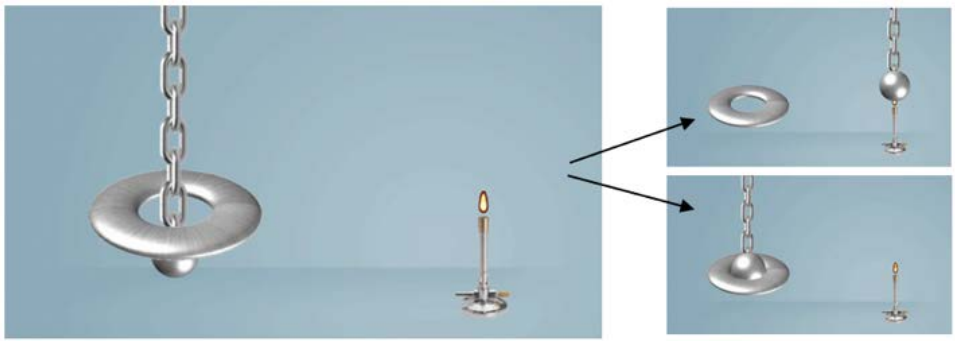

Figure 9. "Expansion by volume" animation

In this scene (Figure 10), the melting of the ice mass at -10 degrees by applying heat is shown. At the same time giving a graph of heat and temperature, the graphic relationship between state change and temperature was presented. While the temperature of the objects that are given heat increases in daily life, there is no increase in temperature even though heat is given during the process. The reason for this is that heat energy is spent on process change instead of temperature increase. At the end of this chapter, it is aimed that students learn the relationship between process and temperature.

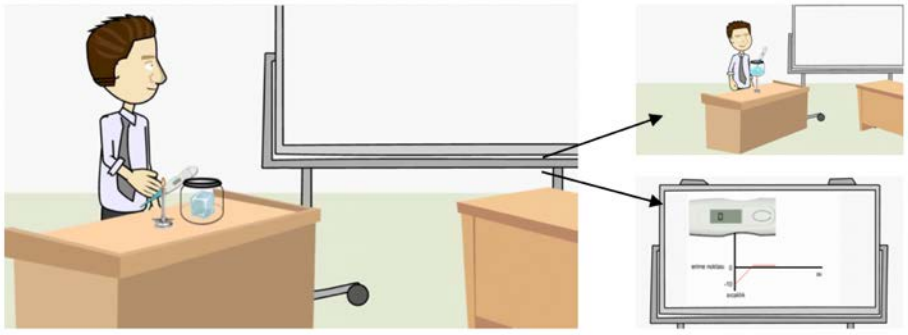

Figure 10. State change (melting and freezing) animation.

In this scene (Figure 11), there is an increase in the temperature of an object of mass m, given heat. The temperature rise of objects is the difference between their final temperature and their initial temperature. At the end of this section, it is aimed that students learn how to calculate temperature change.

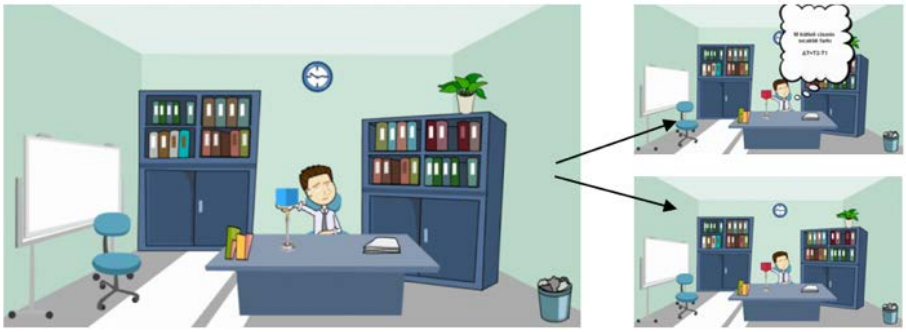

Figure 11. "Heat" animation

2.5. Process and Application

In research, the general purpose of researching information about the examination of the research, the principles of confidentiality and voluntarism have been explained and informed. The applications were carried out in a spacious and quiet classroom environment and the application was carried out in two groups by the physics teacher working at the school. While the physics teacher gave normal lectures to the class in the control group, he taught the class in the experimental group with the necessary materials in computer and instructional technologies and in accordance with the necessary acquisitions in the Physics Textbook of the Ministry of National Education. The students answered the pre-tests one week before the application, and the post-tests were carried out one day after the application.

2.6. Data Analysis

The data collected in accordance with the purpose of the research were scored and analyzed through the appropriate statistics program. The assumptions of the statistical techniques used before the analysis were examined. Firstly, normality assumption was examined in order to determine whether parametric or non-parametric statistics will be used in the analysis of data. In this study, the assumption of normality was evaluated by using Shapiro-Wilk test skewness and kurtosis values and graphical approaches. The Shapiro-Wilk test is used when the sample size in each group is 50 and below [12,17,19,20]. This test tests the hypothesis that sample data come from a normal distribution. While the test results show that the data are not from a normal distribution, the insignificant test results indicate that the data show a normal distribution. It was seen from the data that only the pre-test scores of the control group were not normally distributed. However, when the graphs of skewness and kurtosis values and control group pre-test scores were examined, it was decided to use parametric tests because the data showed a distribution close to normal [12,17,20]

Group differences between the pre-test before the application and the post-test scores after the application of the individuals in the control and experimental groups. T-test was used for independent samples for comparison, and t-test for dependent samples was used to compare the scores of individuals in each group before and after receiving education.

The t-test for independent samples has the assumption of homogeneity of variances as well as the assumption of normality. This assumption was checked by the Levine test and found to be met in all analyzes. Levine [18] suggests that statistical analysis results should be given together with effect size estimates. The effect size simply shows how meaningful the results obtained are in practice. The effect size classification proposed by Cohen [8] was used to interpret the differences between groups. When trying to compare the difference between averages, the most frequently used effect size statistic is Cohen's d. According to Cohen [8], the d value of 0.20 and below is low, the d value of around 0.50 is medium, and the d value of 0.80 and above indicates a high level of effect size. In all analyzes 0.05 margin of error was determined as the upper limit.

3. RESULTS AND DISCUSSION

Table 3 shows the mean and standard deviation values of the pre-test results and the t-test results for independent samples before the lectures to the students in the experimental and control groups.

Table 3. The achievement test pre-test results of the individuals in the experimental and control groups

Variable	Experiment		Control		sd	t	p	Cohen's d
	Avg.	S.s	Avg.	S.s				
Pretest Success Score	5.59	1.86	6.24	2.40	56	1.16	250*	.30

Note: *p > .05**

Table 3 shows that there is no statistically significant difference in the pre-test scores of the individuals in the experimental and control groups. However, as can be seen from the Cohen d effect size, the achievement test mean scores of the individuals in the control group are 0.30 standard deviations higher than the mean scores of the students in the experimental group. **Table 4** shows the average of achievement test scores and standard deviation values applied to the experimental and control groups before and after the training. In order to determine whether these score differences show a statistically significant difference, a series of dependent samples t-test was conducted. Table 4 shows the results for this test.

Table 4. t-test for dependent samples performed for pre-test-post-test scores

Variable	Pretest		Lasttest		sd	t	p	Cohen's d
	Avg.	S.s	Avg.	S.s				
Control Group	6.24	2.40	9.34	3.10	28	9.19	.000*	1.07
Experimental Group	5.59	1.86	11.14	2.72	28	11.82	.000*	2.36

Note: *p < .001**

Table 4 shows that there was a significant increase in the temperature and temperature knowledge levels of the individuals in the control and experimental groups. However, when the effect sizes are examined, there is an increase of approximately one standard deviation in the knowledge level of the individuals in the control group in the classroom where the normal lecture is given, there was an increase of approximately 2.4 standard deviations in the knowledge level of the individuals in the experimental group.

In other words, compared to normal lectures, the education in the experimental group with computer and instructional technology-based materials is more effective in teaching the information about heat and temperature than the education in the control group with normal lecture. **Table 5** shows the mean and standard deviation values for the test results after the lectures of the students in the experimental and control groups of the students and the t-test results for independent samples.

Table 5. The achievement test posttest results of the individuals in the experimental and control groups

	Experiment		Control		sd			
	Avg.	S.s	Avg.	S.s				
Post-Test Success Score	11.14	2.72	9.34	3.10	56	2.34	.023*	.65

Table 5 shows that while there is no significant difference between the pre-test results of the groups, there is a significant difference in favor of the individuals in the experimental group as a result of the post-tests.

4. CONCLUSIONS

This study consists of 2 parts. In the first part, physics lesson, in order to prevent confusion about heat and temperature, the subject was examined, scripted, and animated with Crazy Talk Animator and Flash CS 5.5 applications, audio narrations were created. The animations, the audio files containing the lectures and the lectures on the subject were packaged in 35 scenes to be controlled through the prepared interface and arranged to work on mobile devices using Android operating system. The mobile application prepared in the second part was applied to the control and experimental groups, and the results were evaluated with the tests. with the application prepared, students were able to understand the difference between the terms of heat and temperature, which they frequently used interchangeably in daily life, in visual and audio expressions, and get rid of the confusion of concepts. The prepared application is available for Android devices. If the interface is prepared for devices using the IOS operating system, it will be accessible by a wider user audience. Using the mobile application developed as a result of the study, animations of similar topics that are difficult to understand by students can be developed and their use in mobile devices can be expanded. In addition, when the results are evaluated as a whole, it shows that educational materials developed based on computer and instructional technologies are significantly more effective in increasing students' level of knowledge about the subject compared to normal lectures. This research was conducted only within the scope of ninth grade students and physics course. This situation can be considered as a limitation for this study. Therefore, the application developed within the scope of the research can be seen as a situation that may be important in terms of revealing the reliability of the application for different courses and at different grade levels. Subsequent studies can be conducted with a focus on these recommendations.

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