

A new web designed material approach on learning and assessment in science education

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Abstract

There are a lot of classic learning tools and measurement techniques in science education. However, there are not web designed materials and measurement tools based on educational criteria such as program development, learning pedagogies, assessment techniques and advanced software knowledge. The purpose of this study was to investigate the effectiveness on students' achievement, acquisition and permanency of a new web designed material developed by means of multimedia design programs in Matter and Heat Unit, combining a diagnostic branched tree technique from alternative assessment techniques and vision development technique from contemporary learning approaches. The study was carried out by the participation of 64 primary school students and two experienced science and technology teachers at the city center in Samsun-Turkey. With an experimental research design, two classrooms were assigned randomly, named with experiment group (n=31) and control group (n=33). The study was carried out during 2009-2010 spring semester, covering four weeks. Concept achievement test (CAT) and science and technology attitude scale (STAS) were applied as both pre-tests and post-tests. The test scores obtained from these data collecting tools were compared by using a t-test technique in SPSS 17.0 statistic package program. The results from this study showed that students' concept achievement increased by 53% in favor of experiment group at ($p<.05$) through branched vision development material (BVDM). It was seen that student' acquisitions increase by 51% in all acquisition categories after the study. However, student' attitudes developed positively in the experiment group.

Keywords: Web designed learning and assessment; Matter and heat; Achievement; Attitude
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1. Introduction

Recently, technology-supported science education has been widely used in the learning environments. As it is known, there are many dimensions of learning and teaching. For more effective science education research has been through many investigations by scientists and

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science educators in the different subjects of technology-supported science education. Web-supported science materials and assessment tools are of great importance in technology-supported science education. But, studies have been focused on technology supported material development. It has been reported that these types of materials have positive effects on learning [1-5]. However, some researchers argued that these types of materials have ineffective or negative effects on learning [6-9].

Science and technology curriculum mainly consists of these basic categories. Which are goals and objectives, content, method, teacher's roles, and evaluation aspects. In the curriculum development process, the basic philosophy of one or more learning theories is taken into consideration. Generally, three central learning theories have often been discussed on learning in web supported science education: behaviorist, cognitive and constructivist approaches [10-12]. In 2004, Turkish primary curricula was renewed and modified radically according to the requirements of the current age and community's needs. The renewed curriculum was developed in terms of the main philosophy of the constructivist learning and multiple intelligent theories [13-14].

There is a complementary relationship between technology and constructivism. Positive effects of them to each other in applications are observed [15]. According to constructivism, an individual does not accept the knowledge without any qualification, but constructs discussive, defending opinions, hypothesizing and questioningly [16-17]. Meanwhile, he experiences a process in which he learns thinking, learning, how and with what purpose the knowledge is being constructed [18]. Constructivist learning predicts a rich and interactive learning environment. To achieve this, students requires reaching the knowledge, getting and analyzing it, arranging and using it in order to solve the problems by the way of cooperative learning activities. They are expected to produce own product by searching, doing decisions, collaborating, using high level thinking skills and using own creativeness. In this regard, constructivist learning theory encourages the students doing about something instead of learning about something [19]. This learning approach is consistent with alternative assessment techniques (AAT). Alternative assessment is called performance assessment, appropriate assessment, or direct assessment; authentic assessment includes a variety of techniques.

According to Herrington and Herrington [20] alternative assessment occurs within the context of an authentic activity with complex challenge, and centers on an active learner that produces refined results or products, and is associated with multiple learning indicators. It includes the development of tests and projects [21]. Therefore, Turkish Ministry of National Education, [22] suggested that science and technology teachers use alternative assessment techniques such as performance development, portfolios, projects, concept maps, branched tree and structured grids. But, it is known that Turkish science and technology teachers do not have enough knowledge and skills about AAT [23-27]. However, Schurr [28] stated that a disadvantage of alternative assessment is the difficulty may be even the impossibility, of obtaining consistency, objectivity, and/or standardization in its results. Science and technology teachers do not have sufficient knowledge and skills and can not use enough AAT in science class. One of the most important of these techniques is branched tree.

Branched tree technique (BTT) is widely used in science education. These graphic drawings are very convenient to check student's acquisition in present science and technology curriculum. Also, it is used to find out misconceptions and learning difficulties of students. In this technique, correct and incorrect answers developed by science and technology teachers are used together in the form of graphics. Starting from the first question, students give all answers. According to right or wrong answers, students pass 2. or 3. question. If they give wrong answer the first question, they try to answer the other question, with similar difficulty to the first question. Thus, the incorrect information and misconceptions of students can be revealed. Considering each student in class, science and technology teachers have difficulty in implementation of this technique [23].

Vision development technique (VDT) is a teaching - learning technique allowing the defense and the development of the students' opinions by taking advantage of the other student's views on a specific subject in classroom discussions. Besides, students can change by adopting contrast ideas of other students. VDT can be defined as a discussion method covering the polarized attitudes of the

students in the science and technology subjects. VDT is carried out with the participation of the whole class.

One of the main objects of science education is to help students learn concepts meaningfully. Learning basic concepts during the primary and secondary education is very crucial for the learning of advanced concepts. There are many abstract, difficulties in understanding subjects and concepts in science and technology lessons. Considering the mental development level in primary school students, this situation is of great importance [29]. Matter and heat unit is one of these units in 6th. grade science and technology curriculum. Students and teachers have great difficulties in both learning and teaching [30-33]

Tasdemir and Demirbas [34] reported that students have a lot of difficulty in understanding the concept of Matter and Heat, the 4th unit of 6th grade science and technology lessons. These are condensation, changing states of matter, matter, expansion, chemical change, physical change, dissolution, heterogeneous solution, homogeneous solution, gas. Hence, the writers stated that students have difficulties in correlating them with daily life. Again, it has been noted that, within the subject of dissolution, students suffer from contradiction of terms such as solution; the effect of the type of solvent and solute on solution; the effect of pressure; the effect of temperature etc. [33,35,36]. Also, it was argued that students constituted many misconceptions due to having difficulties in correlating these scientific concepts with their daily lives. [37-38]. As it is known, because of the importance and the difficulty of the subject, science teachers seek for alternative teaching approaches and effective science materials in their teaching activities.

Undergraduate science teachers have some difficulties especially in alternative assessment methods. Also, in-service teachers have difficulty in the application of the alternative assessment methods [39-41]. Student acquisitions for each unit are of great importance in science curriculum. Science teachers prepare alternative measurement tools according to these student gains. But, there are difficulties in the effective use of alternative assessment tools such as project, performance task, portfolio, concept map, structured grid, branched tree, idea development peer/self assessment, rubric, interview.

To overcome present problems, these different teaching and assessment approaches were used by the investigator in this study. These are branched tree and vision development techniques. In this direction, BTT and VDT were combined in a virtual environment by using web design programs. Besides, the activities with relation to student acquisitions in Matter and Heat Unit were included into the material. Thus, present material was known as branched vision development (BVD). Thus, the effects of a new web designed material including teaching and assessment were investigated on student' achievement, permanency and attitudes towards science education. In the literature by the research, there has not been any study on this subject.

2. Material and Method

The research was carried out in a primary school in Samsun, in the spring semester of 2009-2010. The sample of this study consisted of a total of 64 students and two experienced science teachers in Seyfi Demirsoy Primary School in the city center of Samsun.

The study was designed according to experimental method. The study lasted for a total of 4 weeks 16 hours. BVD developed by the research was enriched with interactive activities in accordance to student acquisitions. Science teachers participated in the unit by using BVD in the experiment group. In addition, the teachers used other usual learning and teaching methods during the study. The teacher used to check students' pre-knowledge via BVD at the beginning of the study. In addition, BVD was used as a measurement tool during both course processes and at the end of the study. On the other hand, The Unit was taught by traditional learning and teaching methods in the control group during the course such as class and group discussion, answer-question, brain storm. The matter and heat unit is found in the 6th grade science and technology textbook.

Content analysis of the unit at sixth grade level was made by science teachers, biologists and science educators. A detailed plan of the unit was done by taking into account abstract and hardly understandable concepts which related to matter and heat topics through reviewing the current literature and the researchers' experiences. While the BVD was prepared by the researchers, the main concepts in matter and heat unit, connections with other subjects and the behavioral objectives belongs to students' acquisition in the Turkish science and technology curriculum.



Fig. 1. Flow diagram and a web interface of BVD.

This unit has a total of 17 student acquisitions under three main gains. The main categories are gains with relation to granular structure of matter and heat, propagation paths of heat, technological measures of heat insulation. In this direction, the researcher developed a total of 48 questions online, by taking into consideration scientists, science and technology teachers. Three different questions at each categories ranging from hard to easy (such as 1.1, 1.2, 1.3,) were asked and two options were presented to the students in the form of agree and disagree (Figs. 1 and 2). If the student answers the first question he passes to the next question. Otherwise, he passes to sub-question (1.2). If also this question (1.2) is not answered correctly he moves to the other sub-question (1.3). With the aim of giving sample, data table obtained from BVD via ASP are given under sample table after the study for the first three acquisitions.

After the online exam, students can see their scores and the road map of the online test (Fig. 1). In addition, science and technology teachers can view the individual status of each student and overall status of the whole class by means of Active Server Pages (ASP). If students failed to achieve the predicted acquisitions at each question category, they would redirect interactive activities prepared according to constructivist learning theory. After the activities, they can continue to answer the questions in BVD.

BVD was designed in the light of the principles and strategies of constructive learning theory. To reflect the main philosophy and properties of the constructivist learning theory, many educational activities were developed and integrated into the BVD by the researcher. In addition, there were many activities student's self-made in the BVD. All graphical learning tools and interactive activities with related to the unit provide meaningful learning to the students and covers with constructive learning theory.

An achievement test was used in order to collect data. The test was a multiple choice exam with 25 questions. The achievement test, was designed to evaluate the progress of students in the matter and heat units, it was worked through a pilot study. Item analysis was used to check the validity of the achievement test.

Sample data table from ASP with related to the distribution of student' acquisitions

Students	The distribution of acquisition and percentages								
	1_1	1_2	1_3	2_1	2_2	2_3	3_1	3_2	3_3
1	X			X				X	
2		X		x			X		
3			X		x				
4		X			x				
5						X		X	
6	X		X						X
7		X			X			X	
8				X					X
9				X					X
10		X			X			x	
11		X			X		X		
12	X						X		
13			X			X		X	
14			X		X				
15	X						X		
16		X							X
17				X					X
18			X	X				X	
19		X			X			X	
20									
21			X		X		X		
22	X				X			X	
23		X							
24	X			X				X	
25	x			x				x	
	28%	32%	24%	32%	36%	8%	20%	40%	20%
	1_1	1_2	1_3	2_1	2_2	2_3	3_1	3_2	3_3

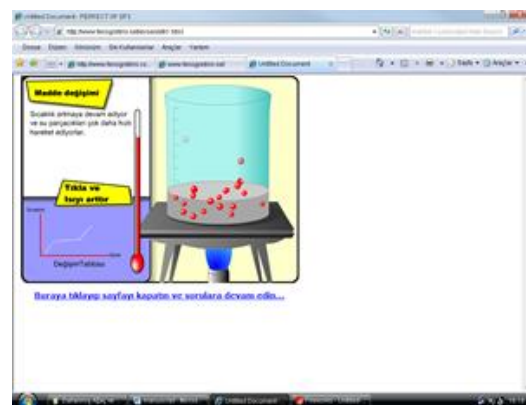
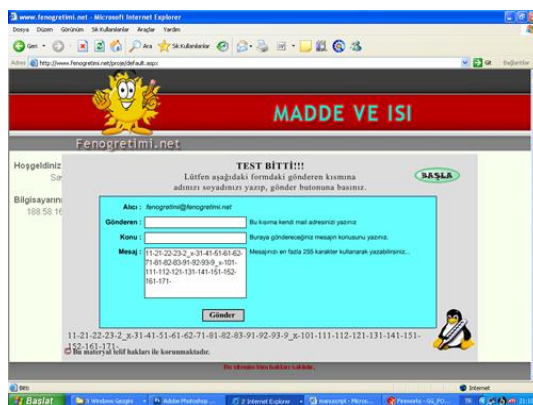


Fig. 2. A web interface related to student' points and acquisitions for the database and a web

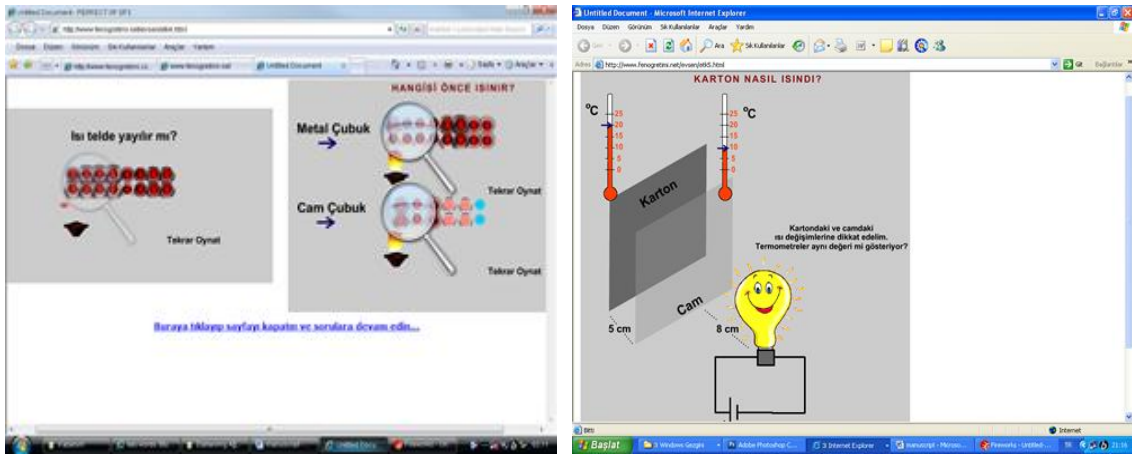


Fig. 3. Web interfaces from interactive activities in BVD.

Sample questions		
Knowledge level		
<p>What name is given to the prevention of propagation of heat emitted from the earth in the atmosphere ?</p> <ol style="list-style-type: none"> Greenhouse effect Thermal insulation Spread via radiation Convection 	<p>What name is given to heat propagation resulting from descent of cooled particles and rising of heated particles?</p> <ol style="list-style-type: none"> Convection Radiation Radiation Transmission 	
Comprehension level		
<p>Which of the following is the reason for wearing dark-colored clothes during cold days?</p> <ol style="list-style-type: none"> Dark-colored clothes hold the light better. Reflecting surfaces heat up more quickly. Dark-colored clothes are made from materials that reflect heat well. These dresses provide more aeration. 	<p>Which of the following is an example of heat propagation through radiation?</p> <ol style="list-style-type: none"> The melting of the ice thrown into cola The burning of the hands by a spoon inserted into the saucepan The putting pasta into hot water The warming up of a car in the sun 	
Application level		
<p>Which of the following ranking is true for the spreading type of heat in the above matters (I, II, III)?</p>		
<p>I</p>	<p>II</p>	<p>III</p>
<p>A. Radiation</p>	<p>Conduction</p>	<p>Convection</p>
<p>B. Conduction</p>	<p>Convection</p>	<p>Radiation</p>
<p>C. Convection</p>	<p>Radiation</p>	<p>Transmission</p>
<p>D. Conduction</p>	<p>Convection</p>	<p>Radiation</p>

In addition, STAS developed by Tas [4] was used in order to analyze the attitude of students towards science and technology lessons. The existing scale was put through another pilot study. After the data was gathered, analysis were made with the help of SPSS 17.0 package program and the reliability factor cronbach- α was measured as 0, 82. This attitude scale is made up of 15 items and is a 3 point likert type scale. Each item was evaluated in three categories; “agree”, “don’t agree”, “can’t decide”. Positive items were graded 2, 1, 0 respectively; and, negative items were graded 2, 1, 0 , starting from the categories “don’t agree”.

Before the research, CAT developed by the researcher was applied to the experiment and the control groups. Data obtained from data collecting tools is suitable for parametric analysis techniques. According to Kolmogorov-Smirnov test, the universe has a normal distribution. Levene F test shows that variance was homogeneous. The sample was selected randomly from the universe. The sample size is more than 30. The data was collected by means of measurements. Parametric tests were used in the study because of this feature of the data. For the two groups which were selected from the universe randomly. Therefore, parametric independent t-tests were used in the study. [This test](#) gives an indication of the separateness of two sets of measurements .The independent t-test is used to test for a difference between two independent groups on the means of a continuous variable. For these statistics analysis was performed SPSS 17.0 package program.

3. Results

With the aim of determining whether there’s any difference between the control group and the experiment group regarding science and technology achievement, CAT was applied to each group as pre-test and post test.

Table 1. t-test Analysis results of the Scores of Experiment and Control Groups in Pre-test and Post-Test.

Tests	Groups	Number of students	Averages	Standard Deviation	t-test results	significance
Pre-test	EG	31	31.45	8,13	0,753	P=0,478
	CG	33	32.82	6.46		
Post-Test	EG	31	84.24	15,382	3,562	P=0,000
	CG	33	63,43	15,137		

The results obtained from CAT were given in the Table 1. According to this, achievement averages were 31.35 and 32.82 of each group. After the study these averages were 84.24 and 63.43 respectively.

As it is seen in Table 2, the average difference for the first acquisition category was at a ratio of 41.5% in the experiment group and at a ratio of 18% in the control group. The average difference in the Second category acquisitions changed at a ratio of 58.2% in the experiment group. This difference was at a ratio of 34.2% in the control group. Also, the average difference in the third category acquisitions was at a ratio of 53.1% the experiment group. This difference was at a ratio of 27.2% in the control group.

Table 2. The results of the students' acquisition according to pre and post-test data

Main categories and students' acquisition in matter and heat unit	Pre-test		Post-test		Differences (%)		Average Difference (%)	
	EG	CG	EG	CG	EG	CG	EG	CG
1. Gains with related to the molecule structure of matter and heat	%	%	%	%	%	%	%	%
a. They observed that when matter is heated the particles increase in speed	45	47	84	63	39	16	41.5	18
b. They establish a relation between collisions of atoms-molecules by means of heat transfer within substances.	32	42	76	62	44	20		
2. Gains with related to propagation paths of heat								
a. They show heat conduction in solids via Experiments.	26	32	80	65	54	33	58.2	34.2
b. They act as heat conductors in heat conducting in solids.	21	27	87	57	66	30		
c. They act as heat insulators because they are not good conductors of heat.	42	43	93	74	51	31		
d. From daily observations and experiments, they can conclude that there is no heat transfer without direct contact.	34	43	84	54	50	11		
e They know that heat will able be conducted through radiation.	34	29	86	65	52	42		
f. They explain by questioning why the earth cools at night.	17	23	65	45	48	22		
g. They explain why dark-colored objects warm up faster as compared to light-colored objects.	21	14	90	75	69	61		
h They explain why the surface of heat insulating containers glaze bright.	16	22	86	54	70	32		
I They show the spread of heat through convection in liquids by the use of experiments.	23	19	81	59	58	40		
k. They diagnose propagation by means of conduction, convection and radiation of heat.	17	13	82	59	65	46		
3. Gains with relation to technological measures of heat insulation								
a. They can estimate what is needed in situations of isolation	23	32	84	65	61	33	53.1	27.2
b. They give examples of preferred situations of transmission instead of insulation	35	45	95	67	60	22		
c. They give examples of common insulating materials	46	52	96	79	50	27		
d. They discuss other features in addition to insulation features of the selection of thermal insulation materials used in different aims.	45	33	81	62	36	29		
e. They explain relation of energy consumption with insulation.	35	45	93	69	58	24		

Table 3. t-test analysis results of the attitude of experiment and control groups towards science and technology lesson between the groups

Tests	Groups	Number of students	Averages	Standard Deviation	t-test results	significance
Pre-test	EG	31	35,56	9,357	1,245	P=0,538
	CG	33	36.78	10,564		
Post-test	EG	31	53,67	12,453	2,432	P=0,00

Table 3 demonstrates the t-test analysis results concerning the attitude of students during the experiment and control group towards science and technology lesson. While the average attitude of the experiment group students towards science lesson in pre-test was 35, 56, the average attitude of the control group students was 36, 78. There were no significant differences in terms of the Pre-test data between the control and the experiment groups before the study ($t_{(62)} = 1.245$, $p > 0.05$). Post-test results show that the average attitude of the experiment group students is 53, 67, whereas the average attitude of control group students is 46, 92. The post-test average of STAS show that there was a significant difference between the groups ($t_{(62)} = 2,432$, $p < 0.05$).

Table 4. Independent t-test results of the experimental and control group’s permanency test scores

Tests	Number of students	Averages	Standard Deviation	t-test results	significance
Experiment Group	31	69,56	8,633	3.534	P=0,00
Control Group	33	56.78	7,881		

As shown in Table 4, there were a significant difference between the experiment and the control group in students’ permanency-test scores ($t_{(62)} = 3,534$, $p < 0.05$). The average of the experimental group’s permanency-test score was 69.56 whereas the average of the control group was found 56.78. The difference was in favor of the experimental group. When the difference was analyzed in terms of permanent learning, the use of BVD had significantly improved the student achievement in the experiment group as compared to the students in the control group.

4. Conclusion and discussion

Many researchers have studied the web-designed instruction [41-45]. These studies focused more on success, attitudes, and misconceptions and so on. According to these researchers web-designed instruction provides important contribution to science learning and teaching. The results obtained from the study showed that students’ achievement increase in the two groups after the educational sessions. However, this increase ratio was 53 % in the EG and 31 % in the CG (Table 1). The increase in science achievement was higher in EG than CG. This was probably due to BVD material. Because, the teacher revealed to the students’ prior knowledge related to the acquisitions at the beginning of the study, such as incorrect information, misconceptions and so on. He planned teaching and learning activities in terms of students' prior knowledge and practiced EG during the study. Our findings are similar to the results of other studies that use web supported material. [46-50].

In these investigations, Student’ acquisitions (behavioral objectives) are like a road map for teachers in terms of the Turkish science and technology curriculum. Learning and teaching processes is planned according to acquisitions. To achieve this, the mental state of the students according to constructivist pedagogy is of great importance for effective science education such as pre-knowledge, incorrect information, and misconceptions. As it is known, teachers use several methods with the aim to determine mental state of students' before the

start of the course such as class and group discussion, answer-question, brain storm. In addition, it is known that these approaches are insufficient to achieve these goals. Besides, other methods such as interview, conceptual change text, graphical illustrations are not preferred by science and technology teachers. But, these techniques take more time. Also, teachers not have sufficient knowledge and skills to apply these techniques. To overcome these difficulties,

BVD can provide great convenience and flexibility by means of Active Server Pages (ASP) concerning both individual and the whole class. As seen in table 2, student's acquisitions in relation to heat and granular structure of matter increased by 41.5% in EG and 18% in CG. Students' acquisitions in relation to propagation paths of heat matter increased by 58.2% in EG and 34.2% in CG. Also, student's acquisitions in related to technological measure of heat insulation increased by 53.1% in EG and 27.2% in CG. This result is similar to a previous study [50].

The attitude towards science and technology lessons directly affects the learning processes of the students. It gives direction to the students' future lives [51]. Selwyn and Ertepinar et al. [52] reported that technology designed materials develops a positive attitude towards science education. In contrast to this Shaw and Marlow [53] said that CAIM 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 [54-57]. In this study, however, BVD changed students' attitudes towards science lessons as much as expected (see Table 3). Attitude change can results from interactive activities in the material. The students who do not reach acquisitions used BVD material during the course. Thus, this could be caused by changes in attitude.

With the aim of determining the effects of permanency of BVD, the achievement test was applied to the two groups after three weeks and data obtained from this tool were performed independent t test. There were significant differences between the experiment and control group in terms of students' permanency-test scores ($t_{(62)} = 3,534$, $p < 0.05$). This result is similar to the results of earlier studies [58]. In conclusion, it can be concluded that BVD could improve student achievement, acquisitions and attitudes towards science and technology lessons.

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