

THE EFFECT OF APPLYING ELEMENTS OF INSTRUCTIONAL DESIGN ON TEACHING MATERIAL FOR THE SUBJECT OF CLASSIFICATION OF MATTER*

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ABSTRACT

The aim of this study was to examine the effect of instructional materials for the subject of classification of matter as solids, liquids and gases that were developed using a holistic instructional design model on student achievement. In the study a pre-test/post-test with control group experimental design was used. The study was conducted in the 2004-2005 school year using a sample of 120 students in the 7th grade (Experimental group 1=30, Experimental group 2=30, Control group 1=30, and Control group 2=30). At the beginning of the study a prior knowledge test, science attitude scale and Multiple Intelligence Fields Determination Scale were completed by the students. At the end of the study an achievement determination questionnaire was completed by the students in the experimental and control groups. Instructional material including student worksheets, student practice questions and a teacher guide were prepared by the researchers on the Freehand MXa program. In teaching the subject to the experimental groups, a holistic instructional approach was used that combined reliance on multiple intelligence theory, a constructivist approach, deliberate use of analogies and an emphasis on science process skills. In addition, concept maps and an animation were used. The data were analyzed using descriptive statistics, one-way analysis of variance, Cohen's size effect, and the Scheffe Test with the SPSS 11.00 program at the .05 significance level. At the beginning of the study, it was found that while there was no statistically significant difference between the students of the experimental and control groups, at the end of the study levels of achievement of the students on this subject in the two experimental groups were higher than both control groups.

Key Words: Instructional Design, Design Principles, Holistic Approach, Matter, Animations, learners' characteristics

INTRODUCTION

Instructional design is a systematic process aimed at helping students learn more easily. McArdle (1991) reported that an efficient instructional design greatly increases students' success. Up to the present several instructional design models have been developed by different researchers. In general, the processes of instructional design models consist of analysis, designing, development, implementation, and evaluation steps (Dooley, 2005). When undertaking instructional design it is possible to apply a single model, or it is also possible to combine more than one model (Işman, Çağlar, Dabaj, & Ersözlü, 2005). In the current study a combination of instructional design models were used to develop instructional materials. These include the models described by Dick, Carey, and Carey (2005), Kemp, Morrison, and Ross (2005), Smith and Ragan (1998), and ADDIE (cited in Zheng & Smaldino, 2003; Dooley, 2005). These models have common steps, which were emphasized by Dooley (2005), and four common components that were pointed out by Zheng and Smaldino (2003); learner considerations, content organization, instructional strategies, and evaluation. Within the framework of these common points we will examine how we can develop an effective instructional design that holistically integrates various attributes.

Various studies have shown that to be effective, instructional design must consider the learners' characteristics. Moallem (2007) emphasized that learners' individual differences are very important in learning and instruction. Similarly, Carnie (1997) suggested that the potential cause of students' low achievement level is that their learning characteristics do not match the design of instructional materials and teaching practices. Therefore, it would be very important to consider learners' needs when organizing the content in ways that increase the likelihood of students achieving learning objectives (Zheng and Smaldino, 2003). The instructional objectives describe skills and knowledge that the learners will have developed, upon completion of the instructional unit (Hashim, 1999). Dick, Carey, and Carey (2005) state that:

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The most important aspect of an instructional goal is the description of what learners will be able to do, that description is not complete without an indication of (1) who the learners are, (2) the content in which they will use the skills, and (3) the tools that will be available. (p.25)

Many researchers pointed out that efficient teaching and learning of any topic depends on the teaching methods, and that students learn better where more than one teaching method was used (Mahajan and Singh, 2003). Joseph and Gayle (1998) reported that using multiple teaching strategies and methods during instruction increased the cognitive learning of students with different learning styles. Powell and Wells (2002) proposed that using multiple methods provided teachers with flexibility, and enhanced activities to be appropriate for different learning styles.

Also, using media such as computer animations and visualizations has a positive effect on students' answers to conceptual questions about particular phenomena (Kelly & Jones, 2007). Russomanno and Goodwin (2007) suggested that animation and visualization tools make the learning more exciting than the traditional paper-pencil techniques. However, Sanger (2000) found that when computer animations were applied alone they were not sufficient in answering either the students' verbal or visual questions in instruction. Kelly and Jones (2007) found that after the teaching with animations learners' explanations increased in quality. However, some prior misconceptions were retained and new misconceptions emerged. The researchers implied that when using an animation for teaching a topic, instructors should plan class discussions to augment the visual media.

Stein, Stuen, Carnine, and Long (2001), proposed that better design of instructional materials has a positive impact on low performing students. The quality of instructional designs may be improved to a large extent when considering the design principles being used. For this reason we can say that one of the most important steps in teaching is deliberately designing the instructional methods and materials. Rotter (2006) stated that:

Rules of graphic design can help teachers prepare their instructional materials to make them easier for students to read, to organize information more clearly, and to improve comprehension (p.273)

The basic principles of design contain numerous dimensions, such as balance, alignment, repetition, emphasis, proximity, focus, organization, movement of the reader's eye, contrast, alignment, spacing, simplicity, proportion, rhythm, variety, unity, organization and image. In addition to this, various sub-dimensions including font choice, highlighting, position of information, graphics, and use of color are contained in these dimensions (Rotter, 2006).

Chambliss and Calfae (1989) suggested that if the instructional materials such as science textbooks are well developed, the level of students' understanding of the concepts can improve. However, the principles of instructional design of teaching materials that are used in developing science instructional materials are not always beneficial for learners. For example, in the authors' country, Turkey, it has been found that ineffective features are present in instructional materials. The language of the instructional material is not clear and understandable, and the resources do not include new technologies and developments (Bakaç and Kesercioğlu, 2000). As well, the materials are not sufficient in terms of visual items such as graphics, pictures and figures (Bakaç and Kesercioğlu, 2000; Gökdere and Keleş, 2004; Dökme, 2004).

There are a very limited number of experimental studies on instructional design in science education in Turkey. For this reason, principles of instructional design were used to prepare material to support teaching on the subject of classification of matters as solids, liquids and gases. The concepts of classification of matter and particulate nature of matter are fundamental ideas of science and chemistry courses. Furthermore, numerous studies have been reported that many elementary school students and pre-service teachers have important difficulties related to understanding the structure of matter. When these studies are examined together, the common difficulties given below can be identified:

A gas is composed of invisible particles
There is empty space between the particles in a gas (Vos & Verdonk, 1996, p.658)

Air is everywhere, fills all space. Solid, liquid and gas are three types of some substance. One disappears as the other appears. Matter is continuous, but contains particles" (Swackhamer, 2001)

Solids can be only hard
All liquids contain water (Jarvis, McKeon, & Taylor, 2005, p.22)

For this reason in the current study a holistic instructional design, using design principles and integrating multiple teaching methods, was used to design materials, which were also supplemented with a computer animation.

Purpose of the Study

The purpose of this study was to examine the effect of the design of instructional material for the subject of classification of matter as solids, liquids and gases on 7th grade students' achievement in a science course. In this study the following research questions were investigated:

1. Is there any difference between the pretest scores of the experimental (holistic design) group and the control group?
2. Is there any difference between the experimental group and control group with respect to the achievement level gained through the holistic instructional design versus the current traditional science curriculum?
3. The teacher guide effective for the application of the instructional design by different instructors?

METHOD

In this study, a pre-test/post-test with control group experimental design was used. The study was conducted in the fall semester of the 2004-2005 academic year. The participants of this study were 120 seventh grade students in four classes. There were 30 students in each of the two control groups. Each of the first and second experimental groups were also made of 30 students. The overall gender division of the participants was 51% girls (n=61) and 49% boys (n=59).

In order to investigate the effectiveness of instructional design when the materials were used by the different instructors and to eliminate the bias of the researchers in the current study, a researcher taught the topic to the first control group (I) and second experimental group (IV). A science teacher in the school taught the topic to second control group (II). A different science teacher in the school taught the topic to the first experimental group (III).

Development of Instructional Design

Various models of instructional design have been described. It has been suggested that these models tend to have four common components (Zheng & Smaldino, 2003).

Learner Considerations: In this area, a multiple intelligence determination scale, prior knowledge test and a science attitude scale were used to identify the learners' needs and characteristics in terms of a multiple intelligence fields profile, success level and attitudes towards the science course. Also, after the examination of science teaching programs used previously in Turkey, the challenges in this area were examined in a related subject. Then, the likely incorrect understandings of the students were determined through discussions with teachers and a literature review.

Content organization: The objective was defined as “(The student) classifies the matter by giving examples and describing the differences between them”, which was found in the 2000 Turkish science teaching program, was considered on the focus topic. Teaching materials relating to this topic were developed, including a student worksheet, student practice questions, and teacher guide. These were prepared by the first author using a process of instructional design that holistically integrated approaches focused on several student considerations. The teaching materials consisted of questions asking students' prior knowledge, the theoretical framework to form the foundation of the teaching, hands-on activities to be used and detailed information regarding visual elements such as photographs, tables and figures. Photographs of experimental set ups were taken by the first author and then edited on Photoshop 8.0. For preparing the text-based instructional materials Macromedia Freehand Mx were used, and animations were prepared using Macromedia Flash Mx. These were prepared to be consistent with the design principles under study, such as providing emphasis of key ideas, effective use of colors, and use of contrast and line balance. The animation that was used in instruction and text-based material examples can be seen in Figure 1 and Figure 2.

Instructional strategies: Because of the reasons discussed earlier, varied methods were integrated into a holistic approach to instruction. The materials were designed to support a teaching approach that synthesized elements from multiple intelligence theory (Armstrong, 2000) and a constructivist approach. Strategies that were used include a learning cycle (Bevevino & Dengel, 1999; Marek, 2000; Wilder & Shuttleworth, 2005; Lindgren & Bleicher, 2005), hands-on activities, instructional analogies (Bosak, 2000), an emphasis on science process skills (Gabel, 1993), concept mapping (Novak & Gowin, 1984) and an animation. This multi-faceted teaching

approach was used for teaching the subject to the experimental groups while the control groups received the instruction as is typically done in the school. With regards to the teaching material for the control group, four of the activities that were found in science textbook were done with the learners. The students were divided into groups of 4-5 and the textbook instructions were followed by the researcher and science course teacher of the school. Questions in the book were assigned as homework for the students. Teaching of the subject was carried out in three lessons just as it was defined in the annual plan.

The experimental groups, however, were taught using the holistic instructional design developed by the researchers. Application of the instructional design to the experimental groups was conducted so that all teaching methods mentioned for the three lessons were combined and used together at the same time as follows:

Engagement Phase: Students are presented with several real-world questions such as; “How can we classify different examples of matter considering their states?”, “What are the properties of solids, liquids and gases?”, “What are the differences and similarities among solids, liquids and gases?” These questions served to interest students in the topic so that they were motivated to continue the exploration. In this phase, the aim was to determine the students’ prior knowledge and motivate them to engage with learning the topic.

Exploration Phase: Learners were clustered into groups composed of four or five. They participated in two hands-on activities directly related to the questions of engagement. Explanations about the concepts were not given to students during in this phase. Also, the activities were meant to elicit the use of science process skills such as observing, measuring, classifying, inferring, predicting, communicating, defining operationally and collecting data during hands-on activities. Then students took part in an analogy activity in which students role-played molecules in solids, liquids and gases (Bosak, 2000). Additionally, students were taken into a computer laboratory to watch “States of matter” animation, which can be found on an Internet website (http://www.harcourtschool.com/activity/states_of_matter/). It was revised using Macromedia Flash Player, translating it into Turkish. Students viewed the action, pattern and arrangement of molecules in the solid, liquid and gas state according to the changes of the temperature in the animation. Thus, the instructional approach actualized multiple intelligence theory in the classroom including the intelligences referred to as interpersonal (by doing hands-on activities together), bodily-kinesthetic (by dramatizing solids, liquids and gas particles), verbal-linguistic (by discussing animations in ways that operationally defined the terms of solids, liquids and gases) logical-mathematical (by doing science experiments, applying science process skills like observing, predicting and inferring) and visual-spatial intelligence (by presenting an animation).

Explanation Phase: Students were given study questions to discuss with each other. The students were asked to share similarities and differences between solids, liquids and gases. Then students were asked to classify various examples of matter as solids, liquids and gases, using the criteria that they studied in the previous lesson phase. So, the verbal/linguistic area (analyzing and organizing information by communicating and defining operationally), logical/mathematical intelligence (by inferring, classifying) and interpersonal intelligence (by discuss the topic collaboratively) were actualized as part of developing an explanation of states of matter.

Elaboration Phase: Students used their new knowledge in a different situation. Several questions were asked such as, “In that sugar takes the shape of container, they are like liquids, so sugar is a liquid?”, “You can compress a sponge, which is like gases, so is a sponge a gas?”, and “Describe the properties of the cornstarch and water mixture”. These questions encouraged students to analyze and explain the attributes of the states of matter as shown in the examples. In the last question it must be noted that the cornstarch and water mixture is referred to as a non-Newtonian liquid, in that it has properties that cross the characteristics of solids and liquids. In this hands-on activity students, are asked, “Is your new matter solid or liquid? Why?”

Evaluation phase: The students constructed individually a concept map using the words *matter, solid, liquid, gas, ice, water, water vapor, compressible, keep the volume, flow, spread out, regular pattern, irregular pattern, move rapidly*. As well, students were given homework in which they were given the choice to prepare a topic-related story, song lyrics, picture or billboard. This was in keeping with the premises of multiple intelligence theory.

Formal Evaluation

After the intervention a formal evaluation in the form of an achievement test was applied to both experimental and control groups at the same time. The findings from these tests will be discussed below in the Results section.

Measurement Tools

Four data collection tools were used in this research. Detailed information about each data collection tool is presented below.

Prior knowledge test: The test developed by Özdilek and Özkan (2005), was applied to determine the students' level of past science achievement and whether or not there was a difference between the prior knowledge of the experimental and control groups. Average item difficulty of the test was measured as .43 and the average item discrimination index was established as .46. Also, Cronbach's alpha reliability coefficient of the test was found to be .71 (see Özdilek & Özkan, 2005).

Science Attitude Scale: The survey developed by Özdilek and Özkan (2005) was used to determine the students' science attitude and whether or not there was a difference between the science attitude of experimental and control groups. Cronbach's alpha reliability coefficient of the survey was found to be .88.

Multiple Intelligence Fields Determination Survey: This survey, which was suggested by Saban (2004), was applied to determine the students' multiple intelligence fields and whether or not there was a difference between the multiple intelligence fields of the experimental and control groups. Cronbach's alpha reliability coefficient of the survey was calculated as .94.

Achievement Test: This test was developed by the researchers in order to determine whether or not there is a difference between the achievement level of students in both experimental and control groups. First, the opinions of two science teachers and a science education professor were taken into consideration to ensure the content validity of 17 questions. The science teachers had 23 years and 25 years of experience, while the science professor had 32 years of teaching experience. This study was piloted on 32 seventh grade students who attended a different school than that used in the study. The test consisted of 10 multiple choice items and 7 open-ended questions. For the calculation of the reliability of this test, item analyses on the multiple choice questions was conducted, and the inter-rater agreement on open-ended questions was assessed. After the pilot study, two questions that have item discrimination index values less than $d < .02$ were eliminated. The average item difficulty level was measured as .44; average item discrimination index .58 and a Cronbach's alpha reliability coefficient as .74 was found.

A rubric was prepared to evaluate the results of each open-ended question. Each question was evaluated using a scale of 0-3 (0=completely wrong or unanswered, 1=mixture of correct and incorrect information given, 2=correct but incomplete, 3= completely correct). Open ended questions were coded by two judges. The first author and the science teacher scored the answers of 73 students (61% of the participants) on the achievement test. The achievement tests that each scorer assessed were randomly selected. The percentage of the agreement between their scores for each of the 2 questions and four dimensions ranged from 82% to 91%. Thus, the post-test consisted of 15 questions, 8 of which are multiple choice items, and 7 are open-ended questions. In the assessment of the test students were awarded 1 point for each correct answer in the multiple choice questions, and they were scored 0-3 points for each open-ended question. Consequently possible achievement scores of the participants ranged from 0 to 29.

Data Analysis

The data were analyzed with descriptive statistics, one way ANOVA, variance homogeneity, Cohen's effect size, and Scheffe Tests using the SPSS 11.00 program at .05 significant levels.

RESULTS

Prior to the study, a one way ANOVA test was used to determine whether there was a statistically significant difference between the experimental and control groups on pretest scores. No statistically significant difference between the four groups was found with respect to prior knowledge level ($F_{(3;116)}=2.481$ and $p=.064$), attitudes toward science ($F_{(3;116)}=2.036$ and $p=.113$), verbal-linguistic intelligence fields ($F_{(3;116)}=2.401$ and $p=.071$), mathematical/logical intelligence fields ($F_{(3;116)}=.762$ and $p=.518$), visual/spatial intelligence fields ($F_{(3;116)}=1.404$ and $p=.245$), bodily/kinesthetic intelligence fields ($F_{(3;116)}=.513$ and $p=.674$), musical intelligence fields ($F_{(3;116)}=.391$ and $p=.760$), inter-personal intelligence fields ($F_{(3;116)}=.400$ and $p=.753$), intra-personal intelligence fields ($F_{(3;116)}=2.434$ and $p=.068$) and naturalist intelligence fields ($F_{(3;116)}=.829$ and $p=.481$). These results indicated that students in both experimental and control groups were similar regarding the pretest scores (see Table 1).

Table 1. One Way ANOVA Pretest Results between Experimental and Control Groups

Test	Group	N	Means	SS	F	p
Prior Knowledge	I	30	44.0	14.65	2.481	.064
	II	30	48.0	19.55		
	III	30	42.83	17.10		
	IV	30	54.17	19.39		
Attitudes towards science Scale	I	30	80.23	11.71	2.036	.113
	II	30	86.67	12.06		
	III	30	83.70	8.71		
	IV	30	85.60	10.58		
Verbal-linguistic intelligence field	I	30	21.10	6.04	2.401	.071
	II	30	24.56	5.55		
	III	30	23.23	4.60		
	IV	30	22.07	4.63		
mathematical/logical intelligence field	I	30	24.90	6.48	.762	.518
	II	30	26.73	7.13		
	III	30	25.00	4.32		
	IV	30	26.43	5.59		
visual/spatial intelligence field	I	30	28.40	7.93	1.404	.245
	II	30	27.13	7.11		
	III	30	25.20	6.32		
	IV	30	25.67	5.25		
bodily/kinesthetic intelligence field	I	30	25.93	7.42	.513	.674
	II	30	27.27	6.09		
	III	30	25.80	5.78		
	IV	30	27.40	6.61		
musical intelligence field	I	30	22.60	8.51	.391	.760
	II	30	22.87	8.01		
	III	30	24.40	5.81		
	IV	30	23.97	7.62		
inter-personal intelligence field	I	30	23.13	6.72	.400	.753
	II	30	22.97	6.94		
	III	30	22.13	6.28		
	IV	30	24.07	7.45		
intra-personal intelligence field	I	30	22.53	7.44	2.434	.068
	II	30	25.97	6.76		
	III	30	21.67	5.21		
	IV	30	23.37	6.47		
naturalist intelligence field	I	30	26.07	6.94	.829	.481
	II	30	27.17	6.61		
	III	30	24.53	6.66		
	IV	30	25.53	6.18		

First Control Group=I, Second Control Group=II, First Experimental Group=III, Second Experimental Group=IV

After the study, it was found that there were significance differences between the achievement test scores of students in the two experimental groups when compared with the two control groups using the one way ANOVA test ($F_{(3-116)}=27.912$ and $p<.05$). Following the ANOVA test (because of the homogeneity of variance tests p values $>.05$) a Scheffe test was conducted in order to determine which groups have significance differences. The test results revealed that levels of achievement of the learners in the two experimental groups were higher than both of the control groups. However, there were no statistically significant differences among the two experimental groups and among the two control groups.

Cohen's effect size and average percentages were also calculated in order to compare the mean average scores of experimental groups (III and IV) with those of the control groups (I and II). Average percentages of the four groups indicated that experimental groups scores (III=23.13/29=80%; IV=22.13/29=76%) were much higher than the control groups (I=9.90/29=34%, II=13.96/29=45%). Cohen's effect size was found to be 1.614, which is very high. An effect size of 1.614 means that the score of the average person in the experimental groups is

1.614 standard deviations above the average person in the control groups. Hence an average person in the experimental groups would score higher than 95% of all students in the control groups (Coe, 2002). Using the mean achievement score, it is possible to say that the instructional design is more effective than the current science teaching program at the elementary school level. Also, it appears that the teacher guide is effective in terms of establishing consistent instruction irrespective of the individual teachers, since there is no significance difference among the two experimental groups. The results are presented in Table 2.

Table 2. One Way ANOVA and Scheffe Posttest Results between Experimental and Control Groups

Group	N	Means	Standard Deviations	F	p	Scheffe Test
I	30	9.90	6.34	27.912	.000*	I, II< III, IV
II	30	13.96	6.44			
III	30	23.13	7.31			
IV	30	22.13	6.43			

*p<0.05

CONCLUSIONS AND DISCUSSION

In the previous study it was found that an instructional design based on a holistic approach used in a science unit entitled “*Travel to the Inner Structure of Matter*” was effective on supporting students’ achievement, retention and attitudes towards science course when we compared this design with the traditional approach (Özdilek, 2006).

In the current study the aim has been to examine the effect on learners’ achievement of the holistic instructional design material, using design principles and integrating multiple teaching methods, which were also supplemented with a computer animation on the classification of matter. It was revealed that materials developed to support a holistic approach to instructional design (including a student worksheet, student practice questions and teacher guide) that synthesized several elements of effective instructional design were more successful at supporting student achievement, when compared to the previous program being used in the school, which helped the students in reaching the instructional objectives. It was also found that the teacher guide is effective for the of application the instructional design by different instructors.

These results showed that the instructional design is highly effective since, as suggested by McArdle (1991), an efficient instructional design greatly increases students’ success. The holistic instructional design approach included deliberate integration of multiple teaching methods to improve the success, multi-faceted instructional materials prepared for the topic and supporting the instruction further by the use a computer animation. The result that we attained in our study is consistent with the suggestions of Joseph and Gayle (1998), Powell and Wells (2002), and Mahajan and Singh (2003) that more than one teaching method should be used in instruction. It resonates, too, with researchers who argue that learners’ characteristics and needs must be considered in instruction (Carnie, 1997; Hashim, 1999; Zheng & Smaldino, 2003; Dick, Carey, and Carey, 2005; Moellem, 2007), that media such as computer animations should be used in instruction (Kelly & Jones, 2007; Russomanno & Goodwin, 2007), and that instruction should be designed according to design principles (Stein et.al, 2001). This study indicates that the holistic instructional design approach, which addressed all of these dimensions, supported the students in the experimental group to be more successful compared to the ones in the control group.

Summerville and Reid-Griffin (2007) stated that the use of instructional design models to deliver technology-enhanced instruction can lead to effective teaching and there are few models for developing design skills that integrate technology within the education curriculum. Marriage of technology integration and the use of technology as a tool through instructional design offers the students numerous opportunities to engage in lesson-building activities. As it was mentioned before using media such as computer animations and visualizations has a positive effect on students’ achievement (Kelly & Jones, 2007) and motivation to learn (Russomanno & Goodwin 2007). It is thought that using animation with integrated multiple teaching methods helped students learn the topic more successfully than other approaches. Also this method eliminated the challenges indicated before by Sanger (2000) and Kelly and Jones (2007) when computer animations and visualizations were applied alone. Additional to the fact that there is a tendency to use multiple teaching methods together to improve the success in education, the instructional design prepared for the topic, using these methods in a way that they are integrated and supported by an animation is also a new attempt.

In sum, it can be said that if instructional materials on other topics in science were prepared in a way that integrates elements of multiple effective teaching methods and according to the design principles such as emphasis, effective colors, use contrast and lines balance the teaching is likely to be more effective.

IMPLICATIONS

It is hoped that this study will be helpful for researchers who study the instructional design of science materials and also will be beneficial for elementary school students and pre-service teachers in order to provide them with much more understanding of effective instruction on the structure of matter and related topics in science. The animation that was used in instruction and text based material examples can be seen in Figure 1 and Figure 2. This is so that instructional designers and researchers can have some idea of the design principles that were implemented.

Also, the effectiveness of the instructional designs as in our study should be investigated by being applied by different science teachers, because persons who apply instructional designs in the schools are science teachers rather than professors at universities, as was the case for some of the students in this study. Besides, researchers' bias can be diminished if someone other than the researcher implements the instruction.

However, among of these factors and especially teaching methods and strategies have been used in instruction in a holistic way such as multiple intelligence theory, a constructivist approach, a learning cycle, science process skills, inquiry teaching method, an analogy, concept mapping, and a computer-based animation. Thus, it is not possible to say that each teaching method contributed individually to student achievement. This limitation needs to be taken into account when considering the contributions of the study. It may be that for the sake of efficiency some smaller group of instructional methods could be employed with the same (or, conceivably, even greater) student achievement gains. The implications of this study are clear that a combined, holistic approach to instructional design, which makes use of multiple teaching methods, is beneficial. Determining just which combination of teaching methods might be most efficient and effective will require further research. The approach of using multiple teaching methods so as to increase the likelihood of matching with learner characteristics and teaching strategies seems warranted by this study. For this reason planning the instruction based on holistic approach and implementation of this accordingly by teachers is very important to ensure an effective instruction. Corresponding to this it seems important to holistically modify both the student materials and the teacher materials so as to develop a coherent approach to integrating the different methods used.

The study was also limited to the topic of classification of matter, a typical topic at 7th grade in Turkey and elsewhere. For this reason it is recommended that researchers prepare and investigate other instructional designs at different grades, topics and units using a similar holistic approach.

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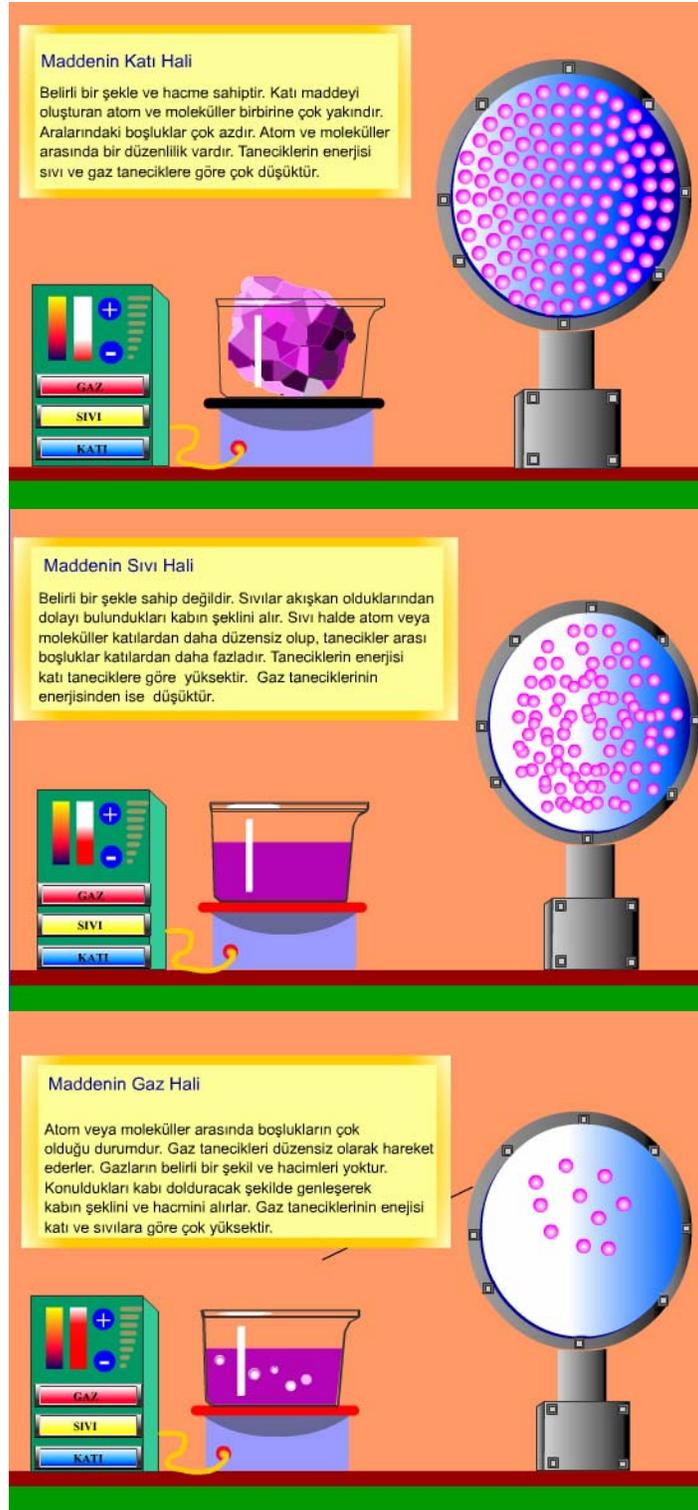


Figure 1. Animation of Solids, Liquids, and Gases Pictures

Etkinlik: Çeşitli Maddelerin Katı, Sıvı ve Gaz Olarak Sınıflandırılması

Amaç: Çeşitli maddeleri katı, sıvı ve gaz olarak sınıflayabilme

Etkinlik Öncesi Sorular:

1. Toz şeker, bulunduğu kabın şeklini aldığına göre sıvı mıdır?

2. Sünger sıkıştırılabildiğine göre gaz mıdır?

3. Mürekkep su içinde tanecikler halinde yayılabildiğine göre gaz mıdır?

Gerekli Malzemeler: Kesme şeker, toz şeker, sünger, mürekkep, bardak, su, saat camı

Etkinliğin Yapılışı:

1. Kesme şekerini cam kaba koyarak gözlem yapınız.

2. Toz şekerini cam kaba koyarak gözlem yapınız.

3. Süngeri elinizle sıkarak gözlem yapınız.

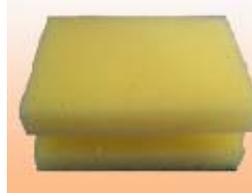
4. İçi su dolu olan bir bardağa birkaç damla mürekkep damlatarak gözlem yapınız.



Kesme Şeker



Toz Şeker



Sünger



Sıkıştırılmış sünger



Mürekkep



Suya damlatılan mürekkep

Sonuçlar:

1. Toz şeker, bulunduğu kabın şeklini aldığına göre katı veya sıvı olduğuna nasıl karar verirsiniz?

2. Sünger, gazlar gibi sıkıştırılabildiğine göre katı veya gaz olduğuna nasıl karar verirsiniz?

3. Mürekkep, su içinde gazlar gibi yayıldığına göre sıvı veya gaz olduğuna nasıl karar verirsiniz?

Etkinlik: Katı, Sıvı ve Gaz Halindeki Maddeleri Öğrenelim

Amaç: Maddelerin yapısını öğrenmek

Etkinlik Öncesi Sorular: Katı, sıvı ve gaz halindeki maddelerin yapısı nasıldır?

Katı:

Sıvı:

Gaz:

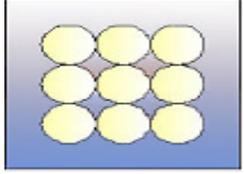
Gerekli Malzemeler: Tebeşir ve dokuz öğrenci

Etkinliğin Yapılışı:

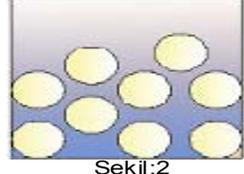
Şekil: 1'deki gibi kare çizilen bir alan içinde birbirinize çok yakın bir şekilde durarak olduğunuz yerde titreşim hareketi yapınız. Sizler katı bir maddenin taneciklerisiniz. Şimdi size ısı enerjisi veriyoruz. Isındığınızı hissediyorsunuz. İleri ve geri doğru sallanmaya başladınız. Biraz daha fazla sallaniyorsunuz. Eriyorsunuz. Sıvı olmaya başladınız.

Şekil:2'deki gibi durunuz. Şimdi sıvı hale geçtiniz. Yavaş bir şekilde sallanmaya devam edin. İleri ve geri doğru yürüyün ve çizgi içinde kalın. Çünkü siz bir kavanozun içindeki sıvı taneciklerisiniz.

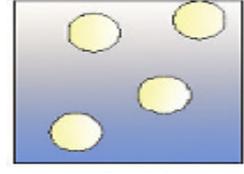
Şekil:3'te size biraz daha fazla ısı enerjisi veriyoruz. Şimdi karenin içini hızla terk etmeye başlayın. Şu anda çok sıcak ve siz karenin içinde duramıyorsunuz. İşte şimdi gaz tanecikleri oldunuz.



Şekil:1



Şekil:2



Şekil:3

Sonuçlar:

- Bir maddenin katı, sıvı ve gaz halinin tanecik düzeni nasıldır?
- Bir maddenin katı, sıvı ve gaz halinin hangisinde tanecik enerjisinin daha fazla olduğunu düşünüyorsunuz? Neden?

Üç etkinlik sonucunda elde ettiğiniz verileri aşağıdaki tabloya yazınız.

Madde	Kütle	Hacim	Şekil	Akışkanlık	Sıkıştırılma	Tanecik Düzeni	Tanecik Enerjisi	Arayüz
Katı								
Sıvı								
Gaz								

Yukarıdaki tabloya göre katı, sıvı ve gaz halinde bulunan maddelerin özelliklerini yazınız.

Katı:

Sıvı:

Gaz:

Figure 2. Text Based Material Examples