EXPLORING THE EFFECT OF USING DIFFERENT EMOTIONAL DESIGN APPROACHES ON POSITIVE EMOTION, MENTAL EFFORT AND LEARNING ACHIEVEMENT: A MULTIMEDIA STUDY

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submitted by **AHMET MURAT UZUN** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Computer Education and Instructional Technology Department, Middle East Technical University** by,

Prof. Dr. Gülbin Dural Ünver
Dean, Graduate School of **Natural and Applied Sciences** _____

Prof. Dr. Soner Yıldırım
Head of Department, **Computer Education and Inst. Tech.** _____

Prof. Dr. Zahide Yıldırım
Supervisor, **Computer Education and Inst. Tech., METU** _____

Examining Committee Members:

Prof. Dr. Özgül Yılmaz Tüzün
Department of Elementary Education, METU _____

Prof. Dr. Zahide Yıldırım
Computer Education and Inst. Tech., METU _____

Assoc. Prof. Dr. Ömer Delialioğlu
Computer Education and Inst. Tech., METU _____

Assoc. Prof. Dr. Erman Yükseltürk
Computer Education and Inst. Tech., Kırıkkale Uni. _____

Assoc. Prof. Dr. Hasan Çakır
Computer Education and Inst. Tech., Gazi Uni. _____

Date: January 3, 2017

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: AHMET MURAT UZUN

Signature

ABSTRACT

EXPLORING THE EFFECT OF USING DIFFERENT EMOTIONAL DESIGN APPROACHES ON POSITIVE EMOTION, MENTAL EFFORT AND LEARNING ACHIEVEMENT: A MULTIMEDIA STUDY

Uzun, Ahmet Murat
Ph.D., Department of Computer Education and Instructional Technology
Supervisor: Prof. Dr. Zahide Yıldırım

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This study aims to investigate the effect of using different emotional design approaches in multimedia on 7th grade middle school students' positive emotions, mental effort investments and learning achievements (recall and transfer). To this end, four different instructional materials were created. Each material was literally identical to each other but only the extent of emotional design differed. For Neutral Design, none of emotional design principles were used. For Colorful Design, attention grabbing colors were added to the material. For Emotional Design, expressive facial expressions were added to characters. Finally, for Emotional Design and Sound Effects, interesting sound effects were used. The study was conducted at a middle school with 106 students. Students' positive emotions were measured by Emwave emotion detection device.

Results showed that students' positive emotions generally tended to increase as the amount of emotional design features increased. However, while students who used Colorful Design exerted more mental effort compared to students who used Neutral Design, students who used Emotional Design and Sound Effects exerted less mental effort compared to students who used Colorful Design. In addition, students who used Colorful Design outperformed students who used Neutral Design in terms of their recall scores. The results also indicated statistically non-significant transfer scores across groups. The qualitative analysis of the interview data revealed the different views of students regarding to the use of emotional design in multimedia. The results were discussed with respect to different views in the literature regarding the use of emotional design in multimedia.

Keywords: Emotional Design, Affect, Heart Rate Variability, Multimedia Science Learning, Emotion Detection

ÖZ

FARKLI DUYGUSAL TASARIM YAKLAŞIMLARININ KULLANILMASININ POZİTİF DUYGU, BİLİŞSEL ÇABA VE ÖĞRENME BAŞARISINA ETKİSİNİN İNCELENMESİ: BİR ÇOKLUORTAM ÇALIŞMASI

Uzun, Ahmet Murat
Doktora, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü
Tez Yöneticisi: Prof. Dr. Zahide Yıldırım

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Bu çalışma farklı duygusal tasarım yaklaşımlarının çoklu ortam öğretim materyallerinde kullanılmasının 7. sınıf ortaokul öğrencilerinin pozitif duygu durumlarına, bilişsel çabalarına ve öğrenme başarılarına (hatırlama ve transfer) etkisinin incelenmesini amaçlamaktadır. Bu amaçla, dört farklı öğretim materyali oluşturulmuştur. Her bir materyal tam anlamıyla birbirinin aynı olup, sadece duygusal tasarımın kapsamı farklılaşmıştır. Yansız Tasarım için hiçbir duygusal tasarım yaklaşımı kullanılmamıştır. Renkli Tasarım için materyale dikkat çekici renkler eklenmiştir. Duygusal Tasarım için karakterlere anlatımsal yüz ifadeleri eklenmiştir. Son olarak, Duygusal Tasarım ve Ses Efektleri için ilginç ses efektleri kullanılmıştır. Çalışma bir ortaokulda 106 öğrenci ile yürütülmüştür. Pozitif duygu durumları Emwave duygu tanılama cihazı ile ölçülmüştür.

Sonuçlar, kullanılan duygusal tasarım unsurlarının miktarı arttıkça öğrencilerin pozitif duygu durumlarının genellikle artma eğiliminde olduğunu göstermiştir. Bununla birlikte, Renkli Tasarım kullanan öğrenciler Yansız Tasarım kullanan öğrencilere göre daha fazla bilişsel çaba sarf etmiş, Duygusal Tasarım ve Ses Efektleri Tasarımını kullanan öğrenciler ise Renkli Tasarımı kullanan öğrencilere göre daha az bilişsel çaba sarf etmişlerdir. Buna ek olarak, Renkli Tasarımı kullanan öğrenciler, Yansız Tasarımı kullanan öğrencilere göre hatırlama puanları bakımından daha iyi performans göstermişlerdir. Görüşme verilerinin nitel analizi, öğrencilerin duygusal tasarımın çoklu ortamda kullanımı ile ilgili farklı görüşlere sahip olduğunu göstermiştir. Sonuçlar alanyazında duygusal tasarım unsurlarının çoklu ortamda kullanımı ile ilgili farklı görüşlere göre tartışılmıştır.

Anahtar Kelimeler: Duygusal Tasarım, Duygulanım, Kalp Atım Hızı Çeşitliliği, Çoklu Ortam Fen Öğrenmesi, Duygu Tanılama

To My Family

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CHAPTER 1

INTRODUCTION

This section includes background for the study which discusses different approaches that have been used so far in multimedia research to augment learners' emotion in an effort to enhance learning. Based on these different approaches and latest improvements regarding the issue in the literature, the problem statement is presented. In parallel with the problem, the purpose and the research questions are formulated and significance of the study is stated. Finally, the key terms and concepts are explained.

1.1 Background of the Study

For years, research on multimedia learning has focused on how effective and efficient multimedia materials can be designed and developed. This research has widely used Cognitive Load Theory (CLT) (Paas & Sweller, 2014) and Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2009) as theoretical frameworks. Although CLT and CTML have together affected the issues of design and development of technology-driven environments dramatically and have been the dominant theoretical frameworks directing multimedia research, these theories have some limitations in the sense that they have focused merely on the cognitive aspects of learning (Leutner, 2014). Although affective factors such as emotion and motivation have a long history in educational research and play important roles in supporting learning, they have been ignored in research on multimedia learning (Astleitner & Wiesner, 2004; Leutner, 2014; Mayer, 2014a).

The literature has sufficient knowledge about multimedia learning theories and models through which we can understand cognitive issues associated with multimedia learning. However, only a limited amount of information is provided about how to use emotional and motivational factors in multimedia learning in an effective and efficient manner (Leutner, 2014). In this regard, Brünken, Plass and Moreno (2010) stated that "although it is well known that metacognitive, affective, and motivational constructs are central to learning, they have not been the focus of cognitive load research" (p. 262). Similarly, Astleitner and Wiesner (2004) argued that research on multimedia learning produced inconclusive results, since some of non-cognitive parameters of learning were not taken into consideration. Emphasizing the importance of motivation, Astleitner and Wiesner criticized "traditional multimedia theory" for focusing mostly on the cognitive factors and ignoring motivational ones.

According to Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2009), there are three distinct cognitive processing during multimedia learning. The first kind of cognitive processing is extraneous processing which refers to unnecessary processing demands caused by poor instructional design. The second kind of cognitive processing is essential processing which is necessary for comprehension of the essential elements of the material. Essential processing is related to the complexity or difficulty of the material. The third kind of cognitive processing is generative processing which refers to learner's level of effort and motivation to engage in deeper learning processes (Mayer, 2009). Based on the cognitive processing limitations, Mayer (2009) suggested that instructional designers should minimize extraneous processing, manage essential processing and foster generative processing. So far, in the field of multimedia learning, most of the research has focused on reducing extraneous processing and managing essential processing. However, little attention has been given to fostering generative processing caused by learner's effort and motivation to make sense of the material (Mayer, 2014a). There are different reasons why research on multimedia did not deal sufficiently with generative processing. First, although motivation is an important factor which

stimulates and maintains generative processing (Mayer & Estrella, 2014), Mayer (2011) indicates that it is a challenge for researchers to entirely consider the benefits of motivational issues in multimedia learning as the question of "what motivates learners?" is not clear (as cited in Mayer, 2014a, p. 172). Second, former efforts for making multimedia materials more effective in terms of motivation has always become a matter of debate in the literature. For example, research about using affective design elements in multimedia in order to motivate students has mostly concentrated on the concept of "seductive details" which are defined as interesting, entertaining but irrelevant information that are not directly related to the learning objective (Mayer, 2009). According to seductive details research, additional information presented by seductive details may necessitate extra processing demands in limited working memory capacity which may force students to waste their precious resources on processing irrelevant extraneous information (Harp & Mayer, 1997, 1998). Additionally, using seductive details in order to "spice up" otherwise a boring lesson may distract students' attention away from learning the essential parts of materials (Clark & Lyons, 2010). For this reason, according to coherence principle of CTML, despite seductive design adjuncts may increase learners' emotional attachment to the learning material, they also have a risk of depressing learning. Accordingly, based on this view, instructional designers should minimize extraneous processing by eliminating "interesting but irrelevant" design features from the learning material and they should highlight the essential material (Harp & Mayer, 1998; Mayer, 2009). On the other hand, it was claimed that although use of seductive ingredients is not encouraged by the literature due to their negative effects, Park, Flowerday and Brünken (2015) argued that their potential motivational benefits cannot be underestimated. What's more, limited studies on the use of affective design elements in multimedia has dealt with interesting but irrelevant design features (i.e., seductive details). From this research, it has been concluded that interesting but irrelevant design elements should be excluded from the multimedia instruction rather than included, since they are not directly related to learning objective and may have a potential of decreasing learning performance (Mayer, 2009). However, it is not clear whether the irrelevance or interestingness of seductive details impair learning.

For this reason, suggestions about excluding seductive details may not be completely true (Crocker, 2008). Besides, can a specific design feature be both interesting and relevant to the learning objective at the same time? Mayer (2014a) indicated that "to the extent that motivational features create extraneous processing or distract the learner from essential processing, they are unwelcomed" (p. 172). However, the limit of "extent" is not clear. Seductive details are "details", if they interfere with learning. Further research is needed to clarify "conditions under which motivational features in multimedia lessons can engage learners in deeper processing during learning without overloading them or distracting them from the core material" (Mayer, 2014a, p. 173).

Limited information regarding the potential benefits of using affect in multimedia instruction prompted researchers to reconsider Mayer's CTML. Accordingly, Moreno (2006) offered the "Cognitive-Affective Theory of Learning with Media" (CATLM). The theory expands Mayer's CTML by considering affective, motivational, self-regulatory and individual factors as well as cognitive ones. One of the most important assumption of CATLM is "affective mediation assumption". According to this assumption, motivational factors may mediate learning by affecting the internal state of the learner which stimulate and sustain learner's attempt to be engaged in learning processes (Mayer & Estrella, 2014; Moreno, 2006). Specifically, Moreno and Mayer (2007) argued that "motivational factors mediate learning by increasing or decreasing cognitive engagement" and "metacognitive factors mediate learning by regulating cognitive processing and affect" (p. 313). Moreover, individual differences such as learners' prior knowledge, cognitive styles, personal traits and abilities may affect how much people learn with multimedia (Moreno, 2006). In short, Moreno's CATLM was formulated around the idea that motivational processing, metacognitive factors and individual differences may affect the level of learner's engagement in cognitive processing during learning in multimedia (Mayer, 2014a; Moreno, 2006). Considering Moreno's CATLM, currently emotional design in multimedia learning has been offered by the researchers in the hopes of improving learners' motivation to learn (Heidig, Müller

& Reichelt, 2015; Mayer & Estrella, 2014; Park, Knörzer, Plass, & Brünken, 2015; Plass, Heidig, Hayward, Homer, & Um, 2014; Um, Plass, Hayward, & Homer, 2012). In line with CATLM, it was shown by those studies that if affective design elements are used in accordance with cognitive theories of learning, they may mediate learning by increasing cognitive engagement (Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012). Although use of affect in multimedia in this way provides a means for understanding the benefits of using affective design features in multimedia learning, Mayer and Estrella (2014) indicate that "research on the emotional design of graphics in multimedia lessons is in its infancy" (p. 12). Likewise, Heidig et al. (2015) indicate that "we are only beginning to understand the role emotions may play in multimedia learning" (p. 81).

1.2 Problem Statement

Research on using affective design elements in multimedia remains insufficient. In addition, most of the research on using affective design elements in multimedia learning has concentrated on the "interesting but irrelevant", "additional" design elements (i.e., seductive details) to increase learners' emotional interest in effort to enhance learning. Use of such ingredients in multimedia design is a complicated issue. To Sitzmann and Johnson (2014), seductive details serve as a "double edged sword". On the one hand, they may induce emotional arousal in learners which in turn results in a better learning performance. On the other hand, they may pose additional loads in limited memory resources which may impair learning (Sitzmann & Johnson, 2014). According to coherence principle of CTML, adding seductive details to multimedia instruction may hamper learning. For this reason, it is suggested from this research that seductive details should be excluded from multimedia rather than included (Harp & Mayer, 1998). But, what about "interesting and relevant" design features? Can a multimedia learning material be both interesting and relevant to learning objective at the same time? Is it possible to incorporate emotion and motivation into multimedia learning, while at the same time not overwhelming limited working memory resources of the learners? Do using appealing design features in multimedia and the effectiveness of learning contradict

to each other? (Heidig et al., 2015). What works for whom? Recent research showed that if interesting design elements are used in accordance with the principles of CTML, they may induce emotional arousal in learners and thereby they may increase learning performance (Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012). However, research about this issue is not at the desired level. Clearly, there is a need to clarify the relationships among emotion, cognition, individual differences and learning in multimedia.

One of the problems in multimedia learning regarding the use of motivational and emotional issues is that different results have been obtained for different individuals who possess different levels of aptitudes (e.g., spatial ability, cognitive load, prior knowledge, working memory capacity) (Magner, Schwonke, Aleven, Popescu, & Renkl, 2014; Park, Moreno, Seufert, & Brünken, 2011; Sanchez & Wiley, 2006; Sitzmann & Johnson, 2014; Towler et al., 2008). What is more, most of the previous studies on the use of affect in multimedia did not consider contextual factors into account. For example, most of the studies were conducted with college students, although it is well known that motivational and emotional perception may be different for younger populations (Lohr, 2007; Mayer & Estrella, 2014). Furthermore, experiment times of the previous studies (e.g., an average of 5 minutes) on testing the effect of using affective features in multimedia were quite short (Thalheimer, 2004). In order to increase the ecological validity of the experiments, longer overall learning times in more authentic environments are needed (Mayer & Estrella, 2014; Rey, 2012). Finally, in most of the previous research, self-report paper-pencil based measures (e.g., Positive Affect Scale) were used to detect students' emotional reaction to certain environments (Plass et al., 2014; Um et al., 2012). For further studies, it was suggested that a more direct and better measures of emotion detection methods should be used as alternative measurement tools to detect emotions (Dong, 2007; Mayer & Estrella, 2014).

1.3 Purpose of the Study

The purpose of this study is to explore the effect of incorporating emotional design into multimedia learning on the students' positive emotions, mental effort investments and academic achievements (as measured by recall and transfer of learning scores). Being consistent with the assumptions of CATLM that individual differences may also affect how much people learn with specific multimedia and methods, another purpose of this study is to explore the confounding effects of individual differences such as prior knowledge and working memory capacity on academic achievement across treatment groups. In addition, this study aimed to understand students' views about using emotional design in multimedia learning. In order to attain the desired goal, four multimedia instructional materials were developed, each of which differed in terms of the extent and complexity of emotional design. The first group of students were taught by multimedia with Neutral Design (ND). For the design of this group's multimedia instructional material, colorless (grayscale), simple animated drawings with narration were used. The second group of students were taught by multimedia with Colorful Design (CD). This multimedia instructional material was exactly the same with the material designed for the ND group, except that only the grayscale colors were exchanged with bright, saturated, attention grabbing colors. The third group of students were taught by multimedia with Emotional Design (ED). This multimedia instructional material was exactly the same with the material designed for the CD group except that expressive anthropomorphism (personification of inanimate, lifeless objects) was used for this material. Additionally, for this group, positive exaggerated facial expressions were added for living characters (humans). The last group of students were taught by multimedia with Emotional Design and Sound Effects (EDSE). This multimedia instruction was exactly the same with the material designed for the ED group except that interesting cartoon sounds effects were added to the characters which change in accordance with their certain movements and activities.

1.4 Research Questions and Hypothesis

There are four main research questions directing the research which are given as follows:

- How do use of different levels and complexity of affective design elements in multimedia instructional materials (i.e., emotional design) affect students' positive emotion?

- How do use of different levels and complexity of affective design elements in multimedia instructional materials (i.e., emotional design) affect students' mental effort ratings?

- How do use of different levels and complexity of affective design elements in multimedia instructional materials (i.e., emotional design) affect students' learning achievement after controlling for the effect of confounding variables?

- What are the students' views of using emotional design in multimedia learning?

Based on the main research questions, the following null hypothesis are formulated:

Hypothesis 1: Students' positive emotions are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)

Hypothesis 2: Students' mental effort ratings are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)

Hypothesis 3: Students' achievement scores (as measured by recall and transfer of learning) are not significantly affected by use of different levels and complexity of

emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of prior knowledge and working memory capacity.

Hypothesis 3a: Students' recall of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest recall and working memory capacity.

Hypothesis 3b: Students' transfer of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest transfer and working memory capacity.

1.5 Variables of the Study

The dependent variables of the study are students' positive emotion scores, mental effort ratings and posttest achievement scores (as measured by posttest recall and posttest transfer scores). The independent variable is the treatment condition (ND, CD, ED and EDSE groups). Pretest achievement (as measured by pretest recall and pretest transfer scores) and working memory capacity are selected as control variables (covariates).

1.6 Significance of the Study

One important reason to conduct this study is to clarify how use of different levels and complexity of affective design elements in multimedia instructional materials affect learning. Limited studies on the issue concentrated on interesting but irrelevant design features (i.e., seductive details) and concluded that interesting but irrelevant design elements should be excluded from the multimedia instruction. However, it is not clear whether the irrelevance or interestingness of seductive details impair learning. For this reason, suggestions about excluding seductive details may not be completely true (Crocker, 2008). A specific design feature can be both interesting and relevant to the learning objective at the same time. Recent research has shown

that it may be possible to incorporate motivation and emotion into multimedia learning, while at the same time not overwhelming limited working memory resources of the learners and not distracting learners from processing essential elements of the instruction. However, there are only few studies dealing with the relationship between use of emotional design in multimedia and students' learning achievements (Heidig et al., 2015; Mayer & Estrella, 2014). As Brünken et al. (2010) stated "there is great potential to test specific hypotheses about the relation among motivation, cognition, cognitive load, and learning to advance CLT" (p. 262). The current study is planned to make contributions to the researchers' calls to reconsider the role of "affect" in multimedia learning by conducting further research in this area. In addition, affective mediation hypothesis of CATLM postulates that "motivational factors mediate learning by increasing or decreasing cognitive engagement" (Moreno, 2006, p. 151). By using different levels and complexity of affective design elements in multimedia, it is expected that the present study could contribute to the test of affective mediation hypothesis of CATLM.

Most of the studies on the seductive details did not focus on the effect of confounding (e.g., prior knowledge, working memory capacity) variables in detail (Rey, 2012). One of the concern of the current study was to investigate the confounding effect of individual differences such as prior knowledge and working memory capacity on the relationship between emotional design and multimedia learning. By this way, it was planned to make a new contribution to the test of "individual difference assumption" of CATLM.

Previous studies on using affective features in multimedia instruction were criticized for the following reasons: having short overall learning times, selecting college or university students as study groups, paper-pencil based measures of emotions. Additional research was needed within more authentic environments rather than laboratory conditions using longer overall experiment times with younger populations (Mayer & Estrella, 2014; Rey, 2012). The current study was implemented in its own authentic environment and adopted a longer overall

experiment time (for three weeks) with 7th grade elementary students. Hence, it could be said that the current study is compatible with researchers' call given above. In addition, instead of self-report measures, the current study used Emwave Pro emotion detection system, a kind of device used for measuring emotion.

The outcomes of the present study could also be beneficial in terms of its practical implications. First, the outcomes may inform multimedia designers and practitioners under which circumstances use of different levels and complexity of emotional design elements in multimedia would be more effective and efficient. Second, the study may reveal the potential benefits and pitfalls of using such design elements in multimedia. Third, the outcomes of the study may inform policy makers and teachers as they ask what kinds of multimedia materials should be selected to be used in schools.

1.7 Definition of Terms and Concepts

Multimedia Learning: Learning from words (e.g., narration or on screen text) and graphics (e.g., illustrations, photos, animation, or video) rather than words alone (Mayer, 2009).

CLT: Cognitive Load Theory (Paas & Sweller, 2014).

CATLM: Cognitive Affective Theory of Learning with Media (Moreno, 2006, 2007).

CTML: Cognitive Theory of Multimedia Learning (Mayer, 2009).

Emotional Design: "Trying to make the core elements in a lesson more emotionally appealing through giving them human-like features (for example, symmetrical faces with facial expressions) and rendering them in enjoyable colors" (Clark & Mayer, 2016, p. 224).

ND: Neutral Design of multimedia material including black and white (grayscale) representations with narrated audio.

CD: Colorful Design of multimedia which is exactly the same with ND, except that this material consists attention grabbing, saturated and bright colors.

ED: Emotional Design of multimedia which is exactly the same with CD in terms of learning content but different in the sense that this design includes anthropomorphism (personification of inanimate, lifeless objects). Additionally, for this group, positive exaggerated facial expressions are added for living characters (humans).

EDSE: Emotional Design and Sound Effects which is exactly the same with the material designed for the ED group except that interesting sounds effects are added to the characters which change in accordance with their certain movements and activities.

Coherence State: The coherence state is defined as the psychophysiological state "reflected by a smooth, sine wave-like (coherent) pattern in the heart rhythms" (Rozman, McCraty, & Tomasino, 2008, p. 197).

HRV (Hearth Rate Variability): A measure which is defined as "the variation over time of the period between consecutive heartbeats" (Acharya, Joseph, Kannathal, Lim, & Suri, 2006, p. 1031).

WMC: Working Memory Capacity

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In education, “cognitive”, “motivational” and “emotional” processes relate to the world differently both in terms of meanings and functioning. Cognitive processes deal with the acquisition and representation of knowledge which have a representative relation to the objects and facts. Emotional processes evaluate the objects and facts with regard to personal values and significance and decide to adopt or refuse them. Thus, emotional processes have an evaluative relation to the world. Finally, motivational processes deal with the goal states of people having intention of producing desired changes. Thus, motivational processes have an actional relation to the world (Kuhl, 1986).

Emotion, motivation and cognition are all related to learning (Schiefele, 1987). The limitation of pure cognitivist approaches is that they do not consider the regulatory role of motivation and emotion on cognition sufficiently. For pure cognitivist approaches, “computer” metaphor is used because of the fact that the mind and thinking are considered as entirely objective, cold, mechanical and rationale (Dai & Sternberg, 2004). “When the mind is reduced to merely a symbolic processing device, we get a lopsided image of how the mind functions” (Dai & Sternberg, 2004, p. 4). Based on this argument, one can argue that similar problem exists for multimedia learning. Traditional cognitive theories of multimedia learning did not sufficiently deal with emotion and motivation that are thought to have an influence in multimedia learning.

There is a need to reconsider traditional cold cognition approach, and adopt a more integrative approach of multimedia learning by considering relationship between affect, cognition, motivation and emotion (Astleitner & Wiesner, 2004; Park, Flowerday, et al., 2015). In this chapter, in order to better understand the roles of cognitive, motivational and emotional aspects of multimedia learning, first, cognitive aspect of multimedia learning will be discussed. Second, theories dealing with motivational and emotional aspects of multimedia learning will be addressed. Third, related studies regarding the use of cognitive-affective factors in multimedia will be reviewed. Fourth, the effect of individual differences on the relationship between motivation, emotion and learning will be discussed. As a last, the literature review will be ended with discussing the methods for measuring learning emotion.

2.2 Cognitive Theory of Multimedia Learning

Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2009, 2014b) has effected design and development of multimedia instructional messages significantly (Leutner, 2014). The underlying rationale behind CTML is that students learn more deeply from instructional material containing words and pictures than the instructional material containing words only (Mayer, 2009, 2014b). However, only use of words and pictures does not necessarily guarantee meaningful learning. The design decisions of the multimedia instruction should be compatible with cognitive theories of human learning (Mayer, 2009, 2014b).

CTML is grounded on the three cognitive assumptions of learning: dual channels, limited capacity and active processing (Mayer, 2009, 2014b). Dual channel assumption argues that people have two distinct channels for processing visual and auditory information (Paivio, 1986). Visual channel is reserved for processing visually presented information and auditory channel is reserved for processing auditorily presented information (Mayer, 2009). Limited capacity assumption argues that people can process only a limited amount of information in each channel at a time (Baddeley, 1992). According to this assumption, learners can hold only a few words or images in working memory rather than the exact whole copy of the

incoming stimuli (Mayer, 2009). Finally, active processing assumption argues that people actively engage in cognitive processes during learning. The cognitive processes involved in active learning are selecting, organizing and integrating. Selecting refers to paying attention to relevant parts of the words and pictures of a multimedia instructional material. Organizing refers to mentally organizing the selected words and pictures as new coherent cognitive forms in the working memory. Integrating refers to establishing cognitive connections among organized verbal and pictorial models and prior knowledge activated from long-term memory (Mayer, 2009; Wittrock, 1989). According to Mayer (2009), meaningful learning occurs if learners engage in five cognitive steps:

> (1) selecting relevant words for processing in verbal working memory, (2) selecting relevant images for processing in visual working memory, (3) organizing selected words into a verbal mental model, (4) organizing selected images into a visual mental model, and (5) integrating verbal and visual representations (p. 70).

The five cognitive processing steps mentioned above are all subject to capacity limitations of working memory. Instructional designers are challenged to design and develop effective and efficient multimedia instructional material due to this capacity limitation. On the one hand, they are supposed to guide the cognitive processes of selection, organization and integration. On the other hand, they are supposed not to overwhelm the limited cognitive capacity of the learners' working memory so that the precious working memory resources are mainly devoted to learning (Mayer, 2014b).

According to Cognitive Theory of Multimedia Learning (CTML) and Cognitive Load Theory (CLT), three types of processing demands occur when people learn: extraneous processing, essential processing and generative processing (Mayer, 2014b). These three cognitive processing demands are also conceptualized as "triarchic model of cognitive load" by DeLeeuw and Mayer (2008).

2.2.1 Extraneous Cognitive Processing

Extraneous cognitive processing is parallel to extraneous cognitive load in cognitive load theory (Mayer, 2014b). Extraneous cognitive processing is unnecessary cognitive processing demands caused by the poor design of an instructional material. For example, it was found by the research that if a visual is located on one page and the corresponding text is located on another page, learners exert extra effort to make sense of the visual and corresponding text by looking back and forth between materials in different pages which results in wasting precious limited working memory capacity (Mayer, 2009). The ideal way of eliminating this unnecessary load is that the corresponding text should be placed next to the visual it describes. If extraneous cognitive processing uses up much of the available cognitive capacity, learners cannot involve in cognitive processing such as selecting, organizing and integrating (Mayer, 2009).

2.2.2 Essential Cognitive Processing

Essential cognitive processing is parallel to intrinsic cognitive load in cognitive load theory (Mayer, 2014b) and refers to representing the essential elements of the presented materials in working memory during learning (Mayer, 2009). Essential cognitive processing is caused by the intrinsic complexity or difficulty of the material (Mayer, 2014b). For example, if an instructional material consists of complicated information that is difficult to understand, the levels of the essential processing in order to understand the material may increase (Paas & Sweller, 2014). Essential cognitive processing corresponds to “selecting” phase of selecting, organizing and integrating, since learners mentally form new representations of materials as they are presented (Mayer, 2014b). If learners are only involved in essential processing during learning, the outcome is more likely to be rote learning as indicated by good retention but poor transfer scores (Mayer, 2009).

2.2.3 Generative Cognitive Processing

Generative cognitive processing is parallel to germane cognitive load in cognitive load theory and refers to learner’s effort to make sense of the presented materials

(Mayer, 2014b). The source of generative processing is learner's levels of motivation to learn (Mayer, 2014b). For instance, when the instruction is given by learner's favorite instructor, the learner may devote more effort to understand the presented material (Mayer, 2014b). Generative cognitive processing corresponds to "organizing" and "integrating" phases of selecting, organizing and integrating (Mayer, 2009). Learners who engage in generative processing reorganize the selected words and pictures as new forms of coherent metal models (verbal and pictorial model) and integrate them with each other and with prior knowledge activated from long-term memory (Mayer, 2014b). If learners are mostly involved in essential and generative processing during learning, the outcome is more likely to be meaningful learning as indicated by good retention and good transfer scores (Mayer, 2009).

2.3 Instructional Implications of Triarchic Model of Cognitive Processing

According to limited capacity assumption of CTML, human cognitive capacity is limited (Baddeley, 1992). So, there is only limited amount of capacity for extraneous, essential and generative processing which is an important challenge for instructional design (Mayer, 2009). Based on the capacity limitations of human cognitive system, Mayer (2014b) suggested that instructional designers should eliminate extraneous processing, manage essential processing and foster generative processing. In order to eliminate extraneous processing caused by poorly designed instruction, coherence, signaling, redundancy, spatial contiguity and temporal contiguity principles are offered (Mayer, 2009, 2014b). According to coherence principle, "people learn better when extraneous material is excluded rather than included" (Mayer, 2009, p. 89). Research showed that interesting, entertaining but irrelevant design adjuncts should be excluded from multimedia rather than included so that cognitive capacity is used mostly for learning (Harp & Mayer, 1997, 1998). Signaling principle assumes that people learn better when signaling cues are added to multimedia instruction that direct learners' attention to the essential parts of the material (Mayer, 2009, 2014b). Signaling can be either visual or verbal. Visual signaling techniques include arrows, distinctive colors, flashing, pointing gestures and graying out, while verbal signaling

techniques include outline, headings, vocal emphasis and pointer words (Mayer, 2009). Redundancy principle posits that people learn more deeply from audio narration and graphics than audio narration, on-screen text and graphics. Based on the dual channel and limited capacity assumption, on-screen text is seen as "redundant" information. It was shown by the research that excluding this redundant material gave better results in terms of learning (Mayer, Heiser, & Lonn, 2001). Spatial contiguity and temporal contiguity principles are subsets of split-attention principle of cognitive load theory. Split-attention is defined by Ayres and Sweller (2005) as "avoiding formats that require learners to split their attention between, and mentally integrate, multiple sources of information" (as cited in Mayer, 2009, p. 148). Spatial contiguity principle assumes that better learning outcomes are achieved, when graphics and corresponding texts are presented near rather than far from each other (Mayer, 2009). For example, as noted before, if a picture is located on one page and the text that describes the picture is located on the other page, students perform task irrelevant processing to make sense of the materials being presented separately. The result will be poor or no learning (Mayer, 2009). Temporal contiguity principle argues that students learn better if visuals and narrated words are presented simultaneously rather than consecutively. If visuals and narrated words are not simultaneous with each other, learners' attention may be split to make sense of each material (Mayer, 2009)

In order to manage essential processing, pre-training, modality and segmenting principles are used (Mayer, 2014b). Pre-training principle refers to making learners familiar with the names and characteristics of the key concepts before the actual lesson starts. Such an approach helps reduce the burden on cognitive capacity during learning process (Mayer, 2009). Modality principle posits that people learn better if pictures are supported with spoken words rather on-screen words (Mayer, 2009). Words and pictures should be presented in a manner that is compatible with separate channels assumption of CTML. According to this assumption, words are processed in verbal channel while pictures are processed in visual channel. Presenting on-screen words instead of spoken words with pictures may lead to overloading of

working memory, since they are both initially processed in visual channel. The ideal way of eliminating this negative effect is using spoken words with pictures rather than on-screen words (Mayer, 2009). Segmenting principle assumes that people learn better when complex multimedia instruction is broken into manageable segments rather than a whole continues unit (Mayer, 2009). Segmenting principle is most effective when the material is complex to learn, the pace of the presentation is fast and the learners are novice to the content (Mayer, 2009).

In order to foster generative processing only a few techniques were used. Multimedia, personalization, voice and image principle are some examples of techniques used for fostering generative processing. According to multimedia principle, people learn better with pictures and words than words alone (Mayer, 2009). Meaningful learning occurs during generative processing. Hence, use of words together with pictures results in facilitation of building visual and mental models and making connections between them (Mayer, 2009). According to personalization principle, students learn better from multimedia instructional materials if words are presented in a more conversational way rather than formal way (Mayer, 2009). The rationale behind this principle is to create an intimate environment between the learner and the material so that learner feels herself as if she is talking with the material and exert more effort to learn the material. According to voice principle, people learn more deeply if the words in a multimedia instruction are narrated by a friendly human voice. Finally, image principle supposes that using instructor image in the multimedia screen does not necessarily result in better learning outcomes (Mayer, 2009). The triarchic model of cognitive processing and related design techniques are summarized in Table 1:

Table 1 Triarchic Model of Cognitive Processing and Related Design Techniques (Mayer, 2014b)

Goal	Design principle	Description of principle
Eliminate extraneous processing	Coherence principle	• Remove extraneous details
	Signaling principle	• Highlight essential materials
	Redundancy principle	• Do not use on-screen text together with audio narration
	Spatial contiguity principle	• Locate on-screen text next to the corresponding graphic
	Temporal contiguity principle	• Present narration and graphics in a simultaneous manner
Manage essential processing	Pre-training principle	• Introduce the names and characteristics of key concepts before the instruction starts
	Modality principle	• Use spoken text rather than on screen text
	Segmenting principle	• Break instruction into segments
Foster generative processing	Multimedia principle	• Present words and pictures together rather than words alone
	Personalization, voice and image principle	• Use more conversational communication style, friendly human voice. Do not use instructor image on the screen

2.4 Motivational and Emotional Issues in Multimedia Learning

Motivation is defined as "learner's cognitive state that initiates, energizes, and maintains goal directed behavior" (Mayer & Estrella, 2014). Specifically, motivation is the triggering force which directs learners' attention to engage in cognitive processes (Mayer & Estrella, 2014). To stress the role of motivation in multimedia learning, Mayer (2014b) addressed three types of learning scenario during multimedia learning based on the triarchic model of cognitive processing. First, if the material is poorly designed, the extraneous unnecessary elements may waste cognitive capacity, so there will be not enough space for engaging in essential and generative processing. In the second scenario, a multimedia material may be well designed which may not lead to unnecessary cognitive loads. However, this time

there may be a probability that the complexity or the difficulty of the material may exceed the capacity of the working memory, leaving insufficient space for engaging in essential processing. In the third scenario, Mayer (2014b) referred to "generative underutilization" problem. In this scenario multimedia material may be well designed, difficulty or complexity of the material may be moderate so there is enough space for learning. However, this time, even if extraneous processing is limited and essential processing is managed, students may not exert adequate efforts so as to make sense of the material being taught. This problem in multimedia could be attributed to lack of learning motivation (Mayer, 2014b). As cited by Clark and Lyons (2010, p.154), "instructional manipulations to optimize the cognitive load have little effect unless learners are motivated and actually invest mental effort in processing the instructions" (Paas, Tuovinen, van Merrienboer, & Darabi, 2005).

Most of the previous research on multimedia focused on cognitive factors such as minimizing extraneous processing and managing essential processing. However, little is known about how to foster generative processing, since traditional cognitive theories underestimated the motivational aspects of multimedia learning (Mayer, 2009, 2014a, 2014b; Mayer & Estrella, 2014).

2.5 An Integrated Model of Multimedia Learning and Motivation (IMMM) (Astleitner & Wiesner, 2004)

Astleitner and Wiesner (2004) were one of the first researchers to indicate the importance of the motivation in multimedia learning. They offered a new model called "An Integrated Model of Multimedia Learning and Motivation" (IMMM). The model introduced additional parameters in addition to Mayer's CTML such as "mental resources management" (e.g., attention, engagement, and monitoring) and "motivational processing" (e.g., goal setting and action control). Elements of mental resource management are defined as follows: (a) attention is referred to working memory capacity that is reserved to process a certain stimulus; (b) engagement is referred to one's number of mental activities devoted to certain task; (c) monitoring means changing processing capacities between attention and engagement based on

the assessments of successful mental activities. Elements of motivational processing are defined as follows: (a) goal setting is one's intention to achieve a specific task related to his/her expectancies and values; (b) action control acts as a "shield" in order to protect goal directed intention from other unrelated intentions (Astleitner & Wiesner, 2004). According to IMMM, mental resources management (e.g., attention, engagement, and monitoring) and motivational processing (e.g., goal setting and action control) may affect cognitive processes of mental activities (e.g., selecting relevant stimuli, organizing it into a coherent form in working memory and integrating it with prior knowledge activated from long term memory) and mental models (verbal and pictorial) involved in multimedia learning (Astleitner & Wiesner, 2004).

2.6 Cognitive Affective Theory of Learning with Media (CATLM) (Moreno, 2006, 2007)

Another prominent theory dealing with motivation is "Cognitive Affective Theory of Learning with Media" (CATLM). The theory has been proposed by Moreno (2006, 2007) and extends Mayer's CTML by incorporating new assumptions in an effort to clarify the relationship between cognition, metacognition, motivation and affect. For this purpose, the following new assumptions were added to CTML: (a) affective mediation assumption which argues that "motivational factors media learning by increasing or decreasing cognitive engagement"; (b) metacognitive mediation assumption which argues that "metacognitive factors mediate learning by regulating cognitive processing and affect"; finally, (c) individual differences assumption which argues that "differences in learners' prior knowledge and traits such as cognitive styles and abilities may affect how much is learned with specific methods and media" (Moreno, 2006, p. 151). Figure 1 illustrates the CATLM.

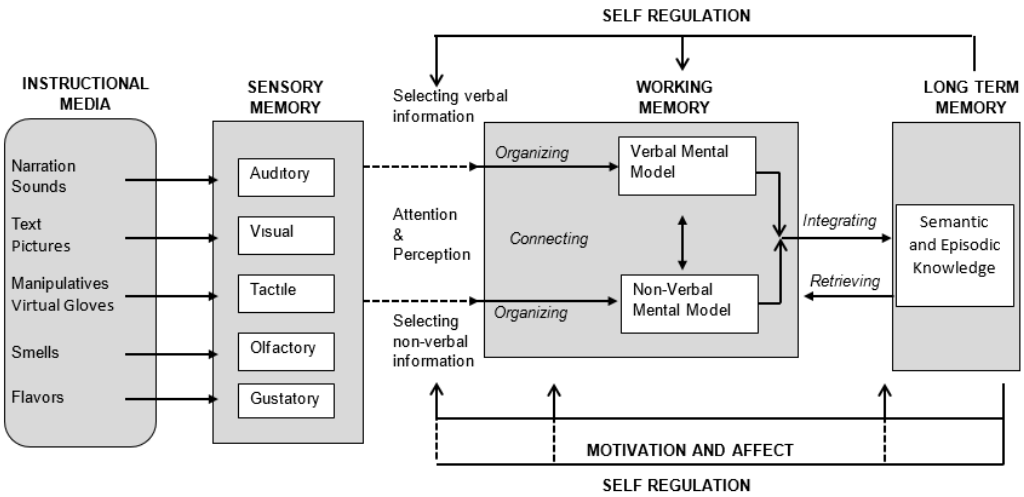


Figure 1 Cognitive Affective Theory of Learning with Media (Moreno, 2006)

If motivation is that important for students to make sense of the material being taught, then how can we incorporate motivation into multimedia learning? Specifically, how can we make students be more motivated to exert effort for engaging in generative processing? Recently, emotional design for multimedia learning has been presented which will be discussed in the next sections. First of all, it may be plausible to describe the term "emotion".

2.7 Defining Emotions

In order to understand the concept of emotional design, first, the term "emotion" should be defined. The literature provides a variety of definitions for the term of "emotion", and there is not a consensus among researchers in this area. In an effort to clarify the definition of the term, Kleinginna and Kleinginna (1981) compiled various definitions of "emotion" provided by the literature and suggested a formal definition of the term. According to Kleinginna and Kleinginna, emotion can be defined as:

> A complex set of interactions among subjective and objective factors, mediated by neural-hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual

> effects, appraisals, labeling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behavior that is often, but not always, expressive, goal- directed, and adaptive (p. 355).

Based on this comprehensive definition, one could argue that emotion is a predisposition to move forward or away from specific objects or facts (Astleitner, 2000; Kuhl, 1986; Plass & Kaplan, 2016). Emotions could also be defined as "individuals' judgments about the world that are evoked as a reaction to and an interaction with certain stimuli" (Park, Knörzer et al., 2015, p. 31) based on the previous studies. The current study adopted this definition in line with its scope.

The literature showed that the terms emotion, mood and affect have been used interchangeably without clear-cut definitions. As reported by Pekrun (2006), some researchers made a distinction between moods and emotions based on their intensity and duration. According to this classification, moods are lasting longer and they are less intense. On the other hand, emotions are lasting shorter and they are more intense. In addition, while moods don't have a specific object focus, emotions are aroused in response to a specific object. Affect, on the other hand is a general umbrella term encompassing moods and emotions and refer to experiences of valances, feelings, affective states, moods and emotions (Boekaerts, 2007).

Emotion can be classified based on different taxonomies. First, according to object focus, emotions can be activity or outcome related. For example, joy or pride could be given as an example of outcome related emotions experienced by students when they succeed. In the same manner, students may feel frustration, if they fail. Boredom or enjoyment experienced during learning could be given as examples of activity related emotions. Emotion can also be classified based on their (a) valence (positive vs. negative; or pleasant vs. unpleasant) and the degree of their (b) activation or arousal (activating vs. deactivating). Based on this distinction, for example, enjoyment is activating positive (pleasant) emotion, while relaxation is deactivating positive (pleasant) emotion. Similarly, anger is activating negative (unpleasant) emotion while boredom is deactivating negative (unpleasant) emotion (Pekrun,

Frenzel, Goetz, & Perry, 2007). Similar with the previous studies dealing with emotional design for multimedia (e.g., Chen & Wang, 2011; Mayer & Estrella, 2014; Park, Knörzer, et al., 2015; Plass et al., 2014; Um et al., 2012), this study did not focus on the specific types of emotions. Instead, the current study focused on the valence dimension of emotion, specifically positive learning emotions.

2.8 Emotion and Cognition

Previous research hypothesized that emotions and cognition are two distinct, different, partially independent separable systems of human perception (Barry, 1997). Based on the past research, emotions are regarded as being animalistic and irrational whereas cognition is logical and human (Norman, 2004). This approach is based on "cold cognition" approach which underestimates the power of emotion on human perception and behavior. However, as Norman (2004) argued, emotion cannot be separated from cognitive processing, since emotion and cognition interact with each other. "Everything we do, everything we think is tinged with emotion, much of it subconscious. In turn, our emotions change the way we think, and serve as constant guides to appropriate behavior, steering us away from the bad, guiding us toward the good" (Norman, 2004, p. 7).

The amygdala has an important role in our emotional reaction to the outer world. Emotional significance is attached to incoming data by the amygdala which prepares body before acting in severe situations by stimulating the hypothalamus to release hormones. It alerts automatic nervous systems for preparing muscles to be ready for movement, signaling brain to release chemicals to increase alertness. All these processes happen unconsciously (Barry, 1997). At first, emotional processing was believed to come after conscious thought processing. That is, cognitive appraisal is needed for emotional reaction. However, newer research has speculated that messages are first received by the amygdala, the center of our emotions, before being transmitted to the neocortex, the center of our intelligence. The implication of this finding is clear: we are not fully logical beings as we think and still dependent on

our emotions. We first react emotionally to situations before thinking about them (Barry, 1997).

If emotion and cognition interact with each other and are inseparable, then what kind of relationship exist between emotion and cognition? The effect of emotion on cognition could be addressed under two competing hypotheses: suppression hypothesis and facilitation hypothesis (Oaksford, Morris, Grainger, & Williams, 1996). Suppression hypothesis is based on the resource allocation theory. According to suppression hypothesis, moods may lead to extra-task-processing or task-irrelevant processing which may have a potential of suppressing cognitive reasoning (Ellis & Ashbrook, 1987, as cited in Oaksford et al., 1996). Suppression hypothesis posits that due to the capacity limitations of working memory, emotions -either positive or negative- may have deleterious effects on cognitive processing (Oaksford et al., 1996; Seibert & Ellis, 1991). On the other hand, facilitation hypothesis argues that positive emotions facilitate cognitive processing. According to Fredrickson's broaden and build theory, positive emotions broaden the degree of attention, cognition, and activity, which in turn expand physical, intellectual, and social resources (Fredrickson, 1998). Suppression and facilitation hypothesis are explained in detail next.

2.8.1 Suppression Hypothesis

Working memory does not only process words and pictures but also our beliefs, wishes, intentions are represented within the working memory (Kuhl, 1985, as cited in Astleitner & Wiesner, 2004). Since memory resources are limited, non-cognitive elements such as emotion may be seen as a source of extraneous cognitive load which interfere with learning (Astleitner & Wiesner, 2004; Park, Knörzer, et al., 2015).

Seibert and Ellis (1991) examined the interfering effect of emotion on cognition in two experiments by exploring the relationship between irrelevant thoughts, emotional mood states and cognitive task performance. Seibert and Ellis (1991) defined irrelevant thoughts as "thoughts that did not facilitate successful solution of

the criterion task" (p. 508). The purpose of their study was to examine whether induced emotional mood states impair cognitive task performance and whether these emotions increase irrelevant thoughts. To this end, totally 90 college students participated to the study, 45 students for the experiment 1 and 45 students for the experiment 2. Both of the two experiments were the same in that participants were randomly assigned to one of the three conditions (happy, neutral and sad), they received happy, neutral (control) and sad mood inductions and completed a memory task. However, only the procedure for gathering students' thoughts differed. In experiment 1, students stated their thoughts by means of thought listing procedure, whereas in experiment 2, they were supposed to state their thoughts by means of concurrent think-aloud procedure. The researchers used their own mood induction procedure including 25 self-referent statements presented at 20 second intervals. A sample positive statement to induce positive mood was "life's a blast, I can't remember when I've felt so good". A sample negative statement to induce negative mood was "I feel I am being suffocated by the weight of my past mistakes". A sample neutral statement was "there are 60 seconds in one minute" (p. 509). Results of both of the experiments showed that participants in the both happy and sad mood states produced more irrelevant thoughts than the participants in the neutral state. Moreover, participants in the happy and sad mood induction groups performed worse on the memory task than the participants in the neutral state. As a result, the researchers concluded that moods, either positive or negative, may lead to task-irrelevant thoughts which may impair cognitive performance.

In order to explore the relationship between working memory, affect and cognition, Oaksford et al. (1996) conducted a set of experiments. The main concern of the study was to test whether emotions act as suppresser or facilitator of cognitive processing. For the first experiment, 62 participants were randomly assigned to the one of the four conditions: positive mood induction, negative mood induction, neutral mood induction and no mood induction. As mood induction materials, participants watched brief video clips before the actual reasoning tasks begin. A comedy film, a television documentary about the topic of "stress", and the BBC nature program were used for

positive, negative and neutral mood inductions respectively. The control group did not watch any videos. After mood inductions, students were supposed to perform a cognitive reasoning task (Wason Selection Task). The results of the first experiment showed that participants who received positive and negative mood inductions both performed worse on reasoning task than participants who received neutral and no mood induction. However, in the first experiment, the researchers did not test whether induced emotions have a direct or indirect impact on working memory. To address this issue, a second experiment was conducted. The authors designed a contextually appropriate and concurrent attentional monitoring task to test whether this parallel task loaded working memory resources in the same way as negative and positive moods did. If so, this would have corroborated the authors' hypothesis that emotions suppress cognitive performance by depleting mental resources. The same cognitive reasoning task (Wason Selection Task) was used as in the experiment 1. 50 participants were randomly assigned to either monitoring (n=27) or control group (n=23). The results of the study showed that consisted with the prediction, concurrent task suppressed cognitive performance as negative and positive emotions did. In experiment 3, 49 students participated to the study. The same mood inducement procedures (video films) were used as in the experiment 1. Participants were randomly assigned to the one of the four conditions. The treatment conditions were exactly the same as was in the experiment 1. As an assessment of central executive component of working memory, the authors, this time the authors used the Tower of London task. The result of the experiment 3 revealed that positive but not negative mood suppressed "plan efficiency" in the Tower of London task. As a result, based on the results of the all 3 experiments, the authors concluded that positive mood depleted working memory resources and thereby suppressed central executive task performance.

2.8.2 Facilitation Hypothesis

The facilitation hypothesis posits that positive emotions facilitate cognitive processing. According to Fredrickson's (1998) broaden-and-build theory, positive

emotions broaden the scope of attention, cognition and action (actual behavior and behavioral intentions) which in turn builds physical, intellectual and social resources.

To test whether positive emotions broaden the scope of attention and thought-action repertoires, Fredrickson and Branigan (2005) tested 104 students in two experiments. For both experiments, five treatment conditions were created. Two of the treatment conditions were shown video films that elicited positive emotions such as (1) amusement and (2) contentment, two of the treatment conditions were shown video films that elicited negative emotions such as (3) anger and (4) anxiety, and one treatment condition was shown a video film that elicited neutrality (control group). In the experiment 1, the effect of emotional activity on the scope of attention was tested. As Plass and Kaplan (2016) argued, "the process by which emotional activity contributes to changes in attention may be a key mechanism to understand and facilitate the role of emotion in learning" (p. 135). In line with this statement, to assess participants' scope of attention, a global-local visual processing task was conducted. The results of the global-local visual processing task indicated that participants who watched video films that elicited positive emotions showed broader scopes of attention than the participants who watched video films that evoked neutrality. For the experiment 2, in order to assess participants' thought-action repertories which are related to their induced emotions, a Twenty Statements Test (TST) was used. First, participants were asked to state the strongest emotions they felt while they were watching the films. After that, given that feeling, they were asked to list all things they wanted to do right at that moment. Participants were supposed to fill 20 blank lines beginning with "I would like to _____" Number of responses on TST were counted. The scores ranged from 0 to 20 with higher scores indicating larger accounts of thought action repertories. The results of the analysis of experiment 2 showed that participants who experienced positive emotions demonstrated greater number of thought action urges than participants who did not experience a particular emotion. In both of the experiments, positive emotions group were compared to the neutral group. According to the authors "comparisons to neutral states provide more stringent tests of the broaden hypothesis and less

ambiguous results than do comparisons to negative states" (Fredrickson & Branigan, 2005, p. 326). Negative states were only used to test whether negative emotions narrow the scope of attention and thought action repertories. The results of the experiment 1 did not show any evidence indicating negative emotions narrowed the scope of attention. On the other hand, the results of the experiment 2 demonstrated that compared to neutral state, negative emotions narrowed the thought action repertories.

Isen, Daubman and Nowicki (1987) conducted four experiments to test whether positive affect facilitated creative problem solving. Positive affect was induced through comedy films or gifts including bags of candies given to the participants before the actual experiment started. Duncker's candle task and remote associates test (RAT) were used as creative problem solving tasks. Results showed that induced positive affect improved creative problem solving. "It has been proposed that a creative-problem-solving task is one involving the ability to see relatedness in diverse stimuli that normally seem unrelated" (Isen et al., p. 1128). Although creative problem solving is regarded as a stable personality trait, it could be facilitated by a positive affective state which leads to greater levels of cognitive interpretations and awareness.

Ashby, Isen and Turken (1999) addressed many studies in the literature indicating that positive affect has an impact upon performance on various cognitive tasks. From a neurological point of view, they proposed that positive affect is related to increased levels of brain dopamine concentration. Based on their "A Neuropsychological Theory of Positive Affect and Its Influence on Cognition", they argued that "the elevated dopamine levels influence performance on a variety of cognitive tasks" (Ashby et al., 1999, p. 544).

Positive affect does not only facilitate information retrieval from long term memory, but it also influences the way information first processed. That is, emotion affects our encoding processes. The emotional quality of the information may capture our

attention, direct us for attaching importance to some details while ignoring others, affect how we detail the information once we attend it (Murray, Holland, & Kensinger, 2013). According to Isen, Shalker, Clark and Karp (1978), people in positive mood tend to see the "brighter sides of the things" and react in a more positive way than other to various stimuli. Isen et al. (1978) conducted a study in which affective states were induced by a computer game with an outcome of win or lose. The results indicated that participants who won the game were better able to recall positive material in the memory. The authors interpreted the findings in light of the accessibility hypothesis, assuming that "mood state serves as a cue by which positive material in memory is accessed" (p. 7).

A similar study conducted by Nasby and Yando (1982) in order to explore the effect of induced mood states on memory encoding and retrieval of affectively valent information. Apart from the most of the other studies which were conducted with adults (e.g., Isen et al., 1978), 108 children were selected as participants for this study. As learning and recall materials, a list of 24 positive and negative adjectives were used. Children were exposed to mood induction procedures twice, once before the encoding and once again before the retrieval. In terms of encoding, the results of the study indicated that a happy mood at the time of encoding facilitated the recall of positive adjectives, whereas a sad mood at time of encoding impeded the recall of positive adjectives compared to neutral mood. Selective encoding of negative adjectives was not observed. In terms of retrieval, results showed that a happy mood at the time of retrieval facilitated the recall of positive adjectives, whereas a sad mood did not impede the recall of positive adjectives. Again, selective retrieval of negative adjectives was not observed (Nasby & Yando, 1982).

Yang, Ji, Chen and Fu (2014) conducted a study to test whether positive affective learning has an effect on memory. A face learning task was used for the purpose of the study. The task involved showing photographs of various people to the participants. Each photo included a close-up face of a random character with a neutral expression on his or her face. Along with photographs, a positive or negative

verbal description was presented with a positive or negative affective tone. The verbal descriptions were sentences about characters in the photographs which included names, occupations, and residences of the characters. It was also presented whether the characters had good or evil personality. In the learning phase of the experiment, the photographs were shown to the participants sequentially. After that, participants performed an unrelated arithmetic task in order to prevent them using rehearsal techniques. In the memory phase, they were again presented a collection of photographs. This time, the task included novel photographs in addition to old photographs presented in the learning phase. Participants were asked to remember the photographs presented previously in the learning phase. The results of the study indicated that a neutral face paired with a positive information was recalled more than a neutral face paired with a negative information. That is, neutral stimulus paired with a positive information induces positive affect and thereby improves the memory. As a result, the authors concluded that contrary to suppression hypothesis, although neutral stimuli paired with an emotional sentence may lead to unnecessary processing demands and distract learners from processing the essential parts of the stimuli, induced positive affect may decrease or terminate these additional efforts. "Under affective context, the users may be more stimulated and engaged in the interaction, and can better understand and memorize information because the attention can be modulated by the affective context" (Yang et al., p. 298).

According to Pekrun (2006) emotions may deplete cognitive resources. That is, both positive and negative emotions may divert students' focus to the object of emotion which may lead to decrease in cognitive resources that should be normally focused on the task-relevant processing. However, as Pekrun et al. (2007) reported, positive emotions constitute an exception in some conditions. For example, if a positive emotion is directly relevant to the process of ongoing activity or task, then it may help students focus their attention to that activity allowing them fully make use the cognitive resources. Consistent with this hypothesis, it was found by research that learning enjoyment is positively correlated with flow experience and negatively correlated with task irrelevant thinking during learning. On the other hand, negative

emotions caused by negative achievement outcomes are found to be negatively correlated with flow experience and positively correlated with task irrelevant thinking (Pekrun et al., 2007).

Considering the relationship between affect and cognition, Isen (1999) suggested that researchers should be careful, while they are evaluating the difference between positive and negative affect. As noted earlier, based on the valence dimension, emotions can be categorized as positive and negative emotions. Based on the valence quality, one should not always assume that positive emotions simply function oppositely to negative emotions. In other words, positive and negative affect are not always inversely related to each other (Isen, 1999). One also should not assume that positive and negative emotions are symmetrical or parallel in their effects. Considering their effect on cognition, for example, it was found in many research that positive affect facilitates retrieval of positive material in memory. However, it was found in some studies that negative affect did not facilitate retrieval of negative material in the same way as positive affect did. Isen (1999) also indicated that most of the research, which found the facilitating effect of positive emotions on cognitive processing dealt with "mild positive affect". According to Isen (1999), the effect of intense or extreme positive affect on cognition is not known. However, it is plausible to argue that the influence of intense positive affect on cognition may be different than mild positive affect. The reason for this assumption may be that the facilitating influence of positive affect on cognitive processing appears best when the ongoing activity is not interrupted. Intense positive affect may be too distracting or demanding for attention and may lead to interruption of the existing activity. "From the standpoint of facilitating one's decision making or creative problem solving at the particular moment in time, it may be better to find $5.00 than to win $5,000,000 in the lottery" (Isen, 1999, p. 522).

2.9 Emotion and Motivation

Research showed that positive emotions also fostered intrinsic and extrinsic motivation. For example, Isen and Reeve (2005) conducted a study with 60

university students to investigate the effect of positive emotions on intrinsic motivation and extrinsic motivation. The source of students' intrinsic motivation was a funny, interesting and enjoyable puzzle task, whereas the source of their extrinsic motivation was their work responsibility: an uninteresting circulating the letter string task. The results of the study showed that students' initial task selection was effected significantly by the positive affect, when students were free to choose between an interesting puzzle and uninteresting letter string tasks. That is, students in the positive affect condition tended to start their free choice activity with the interesting puzzle task whereas students in the neutral condition tended to start with the uninteresting letter string task. The authors interpreted this finding as a fact that positive affect fostered intrinsic motivation. To test the effect of positive emotion on extrinsic motivation, students were told that they could play puzzle, do letter string task or both, but letter string task was a "work to be done". The results showed that students devoted more time to uninteresting letter string task when they were in a positive mood. According to the authors, this finding is an indicator of the fact that positive emotion also fosters extrinsic motivation.

Pekrun et al. (2007) indicated that positive activating emotions such as enjoyment of learning generally are thought to increase students' interest and thereby their motivation to learn. On the other hand, negative deactivating emotions such as boredom and hopelessness are considered to be harmful for learning motivation. Pekrun et al. (2007) warned, however that negative activating emotions function complicatedly. For example, although failure - related - anxiety negatively influences interest and intrinsic motivation, it may increase efforts exerted to certain task to avoid failure (Pekrun et al., 2007).

From the viewpoint of human-computer interaction, it is well known that human experience different emotions while they are interacting with any systems. For instance, human feels enjoyment of learning, if the system is perceived to be helpful, or disappointment, if the expectations are not met. Hence, emotional outcomes are regarded to be very important for performance. For instance, negative emotions

experienced during learning may affect users' perceptions of interface. If interface is not perceived to be helpful by the learners, they may not give their best to concentrate on and remember of the information presented by the system which may decrease motivation and learning (Yang et al., 2014).

2.10 Emotional Design for Multimedia Learning

The term emotional design has been primarily used for industrial design, but so far it has not been scientifically explored within the scope of educational studies (Mayer & Estrella, 2014). The rationale behind emotional design is that attractive things work better (Norman, 2004). Specifically, use of attractive, interesting and emotionally sound design elements in multimedia instruction may capture students' attention to the relevant parts of the material by fostering their interest and curiosity to the learning material. By this way, it is predicted that students' positive emotions such as enjoyment of learning will be increased. As Pekrun et al. (2007) indicated, enjoyment of learning and instruction is positively associated with intrinsic and extrinsic motivation which in turn promotes learning.

Having an interaction with a design initiates certain emotions among users. This interaction may please, annoy, attract or satisfy us (Dong, 2007; Norman, 2004). According to Norman (2004), there are three levels of cognitive and emotional processing related to the design of a particular product: visceral design, behavioral design and reflective design. Among these three levels, visceral level of design pertains to subconscious reaction to the physical appearance of any products. Thus, visceral level of design relates to the attractiveness of the design. At the level of visceral design, the main concern is on how things "feel, look and sound". For example, in order to make a good first impression on the customers, "a master chef concentrates on presentation, arranging food artfully on the plate" (Norman, 2004, p. 67). In a similar vein, when Apple computers put colorful iMacs to the market, they released that the sales of these products increased dramatically even though the new colorful Apple computers were almost same with the other Apple products in terms of hardware and software (Norman, 2004). In industrial design, it was revealed

by the literature that designs which are perceived as aesthetically pleasing also perceived to be more user friendly and attract more customers. In social psychology, attractive people believed to be more capable than other people. In sum, as Norman argued, attractive things work better since they induce positive emotions among users (Dong, 2007).

Recent research has shown that multimedia materials could be designed in a way that induce positive emotions (Chen & Wang, 2011; Plass et al., 2014; Um et al., 2012). The emotional response to an instruction delivered by a screen may be boring, confusing, fun, enjoyable or challenging. There will be always a certain instant emotional reaction, when learners first see a lesson, even if there is a white page with a plain text (Crocker, 2008). Emotion can affect to and can be affected from learning environment (Chen & Wang, 2011).

In an effort to explore the effect of inducing positive emotions in learners and thereby increase their motivation and learning, previous studies on multimedia mostly used interesting but irrelevant "details" which is also known as seductive "details". Seductive details are design features which are interesting and entertaining but irrelevant to the learning objective. Since seductive details contradict with the coherence principle of CTML, such design ingredients are not encouraged to use in multimedia learning (Mayer, 2009). On the other hand, as Sitzmann and Johnson, (2014) argued, research has not yielded consistent evidence that seductive details do in fact damage learning. In a review, Rey (2012) proved that some of the studies failed to show the detrimental effects of seductive details, some only found partial evidence about it. Research has shown that seductive details could be motivating and be beneficial in some situations (Sitzmann & Johnson, 2014; Towler et al., 2008).

With the introduction of CATLM (Moreno, 2006), recently, research on multimedia has tried to understand whether it is possible to incorporate emotion and motivation into multimedia learning, while at the same time not overwhelming limited working memory resources of the learners. Consistent with this approach, emotional design

for multimedia has been introduced (Plass et al., 2014; Um, 2008; Um et al., 2012). Emotional design for multimedia learning refers to using both interesting and relevant design features instead of interesting but irrelevant "details" (i.e., seductive details). Different from seductive details research, emotional design does not necessarily mean adding extraneous details to the multimedia but rather refers to manipulating the intrinsic design features of the multimedia material (Heidig et al., 2015). By this way, it is predicted that such affective design features could induce positive emotions in users. Positive emotions broaden the cognitive resources which facilitate learning achievement. The relationship between affective design, emotion, cognition and learning is depicted in the following figure:

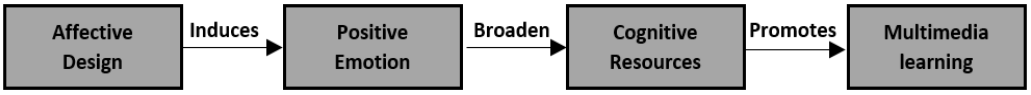


Figure 2 Conceptual Framework Depicted Emotional Design and Learning. Adapted From (Dong, 2009)

If emotional design has a potential to induce positive emotion in learners, then how can we evoke positive emotions? Different design techniques have been offered to increase positive emotion. According to Norman (2004), visceral level is the simplest and the most primitive part of the brain. However, a particular stimulus is simply recognized by the sensory level or visceral level. Norman (2004) argued that we, people are genetically programmed to seek for "food, warmth and protection". For this reason, certain situations related to "food, warmth and protection" give confidence to us and thereby evoke positive emotions. Norman, listed conditions that induce positive emotions as follows:

- Warm, comfortably lit places,
- Temperate climate,
- Sweet tastes and smells,
- Bright, highly saturated hues,

- “Soothing” sounds and simple melodies and rhythms,
- Harmonious music and sounds,
- Caresses,
- Smiling faces,
- Rhythmic beats,
- “Attractive” people,
- Symmetrical objects,
- Rounded, smooth objects,
- “Sensuous” feelings, sounds, and shapes (p. 29).

Norman also listed some conditions which automatically induce negative affect:

- Heights,
- Sudden, unexpected loud sounds or bright lights,
- "Looming" objects (objects that appear to be about to hit the observer),
- Extreme hot or cold,
- Darkness,
- Extremely bright lights or loud sounds,
- Empty, flat terrain (deserts),
- Crowded dense terrain (jungles or forests),
- Crowds of people,
- Rotting smells, decaying foods
- Bitter tastes,
- Sharp objects,
- Harsh, abrupt sounds,
- Grating and discordant sounds,
- Misshapen human bodies,
- Snakes and spiders,
- Human feces (and its smell),
- Other people's body fluids, vomit (p. 30)

In order to evoke positive emotions, research on multimedia learning adopted some design principles. For example, Astleitner and Leutner (2000) offered FEASP approach. The abbreviation of FEASP corresponds to the combination of first letters of negative emotions such as **F**ear, **E**nvy, **A**nger and positive emotions such as **S**ympathy and **P**leasure. According to this approach, instructional designers should analyze the emotional problems related to instruction and then they should eliminate negative emotions such as fear, envy and anger, while they should promote positive emotions such as sympathy and pleasure. Astleitner and Leutner proposed 20 principles of design for emotionally sound instruction. Within the scope of the current study, only some of the strategies for pleasure increase will be discussed. One strategy for pleasure increase is "enhancing well-being". This can be ensured by designing effective, efficient and user-friendly interfaces. Another strategy is establishing open learning opportunities. If learners have freedom and control over some elements of instruction, then they feel pleasure. Use of humor may also be used. This can be achieved by increasing students' level of exhilaration by using humor. Stories, comics and cartoon production systems may be used for this purpose. As a last design principle, play-like activities could be added to the instruction such as instructional computer games (Astleitner, 2000; Astleitner & Leutner, 2000).

Previous research on multimedia used various design techniques to elicit positive emotions. For example, use of warm, bright, saturated, attention grabbing color combinations (Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012), anthropomorphism or personification of inanimate objects (Mayer & Estrella, 2014; Park, Knörzer, et al., 2015; Plass et al., 2014; Um et al., 2012), baby-face bias, rounded objects and figures (Plass et al., 2014; Um et al., 2012), interesting sounds and background musics (Moreno & Mayer, 2000) could be given as examples to those design principles. Some of the techniques that have been used so far within the scope of emotional design in multimedia are discussed as follows:

2.10.1 Color Combinations

Research has shown that color combinations affect how people feel. Based on the previous research, different colors lead to different emotions (e.g., Boyatzis & Varghese, 1994; Kaya & Epps, 1998). In general, cool colors such as blue, green and purple regarded as “restful” and “quite”, while warm colors such as red, yellow and orange are considered to be “active” and “stimulating” (Ballast, 2002, as cited in Kaya & Epps, 1998, p. 397).

Lohr (2007) argued that children primarily preferred bright colors to dark colors. Boyatzis and Varghese (1994) explored children’s emotional association with colors and found that children attributed positive emotional meanings to bright colors and negative emotional meanings for dark colors. As Um et al. (2012) cited from various research on advertising, saturated colors affect customers’ excitements and relaxation and eventually result in positive attitude towards products and buying behaviors. In the context of learning, Lohr (2007) indicated that use of highly saturated colors make images easier to be perceived compared to the unsaturated colors. In addition, she suggested instructional designers to use warm colors in order to make certain elements more noticeable.

Although use of colors for learning is regarded to be beneficial in certain circumstances, instructional designers are advised to be careful about this issue. Because, the effect of color on learning is mixed. Some research found that colors promote cognitive processing in many ways like retrieving information, supporting memory and promoting learner-content interaction, while some of them reported that colors may be distracting in some situations (Shneiderman, 1992; Misanchuk, Schwier, Boling, as cited in Lohr, 2007). On the other hand, as Clark and Lyons (2010) reported, it was found by some of the research studies that colorful learning materials were not superior than black and white materials in terms of students’ learning achievement scores.

2.10.2 Anthropomorphism

Another design technique to elicit positive emotion is anthropomorphism or personification (Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012), which has been used successfully in a few studies dealing with emotional design in multimedia, and proved to be effective (Mayer & Estrella, 2014; Park, Knörzer, et al., 2015; Plass et al., 2014; Um et al., 2012). The technique includes incorporating humanoid features into lifeless objects (Clark & Mayer, 2016). According to Piaget (1929) the term animism is used for the tendency of children to attribute life characteristics to inanimate objects. On the other hand, anthropomorphism refers to attributing not only life but also human characteristics to inanimate objects. (as cited in Watts & Bentley, 1994). Although animistic thought and "mechanistic, orthodox view of science" conflict with each other, anthropomorphism and animism can be beneficial to promote students' science learning. They are seen as simply a pedagogic strategy, which can be used to help teachers explain abstract concepts in compatible with students' understandings of concrete physical world (Kallery & Psillos, 2004; Watts & Bentley, 1991, 1994). The following, examples of anthropomorphism could be seen:

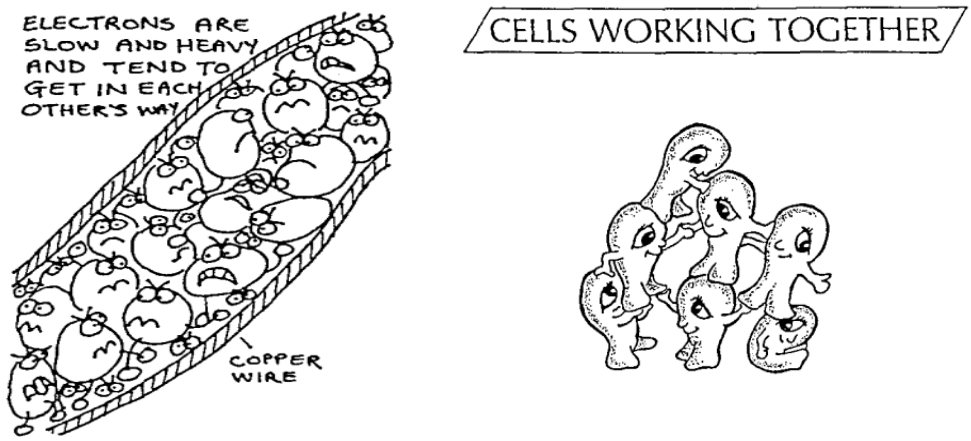


Figure 3 Examples of Anthropomorphism. From Dobson, K. (1987). *Coordinated Science: Introductory Book*. London, Collins Educational (as cited in Watts & Bentley, 1994).

2.10.3 Baby-Face Bias and Cartoon-Like Characters

This design approach refers to the tendency of perceiving things with baby faced features as more “cute” than other things that don’t have baby faced qualities. The cuteness of the things is based on the physical qualities such as having rounded features with large eyes, small noses, and high foreheads and so on. People and designs with such features receive more positive attention and are rated as more likeable than others (Lidwell, Holden, & Butler, 2003). Such baby-face cute characters are commonly used in children cartoon films providing a sense of humor by exaggerating of the characters’ actions. Cartoon-like characters initially draw children’s attention and interest to the material and provide enjoyment by stimulating their imaginations (Dalacosta, Kamariotaki-Paparrigopoulou, Palyvos, & Spyrellis, 2009).

2.10.4 Interesting Sounds and Music

Adding interesting sounds or music is another way of making multimedia more interesting. How can interesting sounds and music be used in multimedia? In previous research, interesting sounds and music were used in the form of background music or environmental sounds (Mayer, 2009; Thalheimer, 2004). Background music was added in order to provide a gentle instrumental background to the presentation of the material. On the other hand, environmental sound was used in an effort to support the visual messages being presented. For example, when the narration speaks about the ice crystals formation, the sound of cool wind or ice cubes crackling was heard (Mayer, 2009). Research on using interesting sounds and music showed that seductive details effect was found when background music was added to multimedia and no-seductive details effect was found when context appropriate sounds were added (Thalheimer, 2004).

2.11 Studies Regarding the Use of Emotion in Multimedia Learning

Regarding the use of affective design features in multimedia, Mayer (2014a) conceptualized three different approaches: The first approach is "less is more". Studies that adopted this approach argue that instructional designers should

concentrate on the techniques that minimize extraneous processing as much as possible (e.g., eliminating irrelevant design adjuncts) and manage essential processing (e.g., breaking a complex lesson into parts). According to this approach, use of interesting but irrelevant design adjuncts such as text, graphics and sounds should be avoided, and essential parts of the material should be highlighted (Harp & Mayer, 1998; Mayer, 2009, 2014a). The second approach is named as "more is more". This approach posits that instructional designers should use design features that motive learners to engage in generative processing. Based on this approach, interesting, appealing and entertaining design elements or challenging learning scenarios could be incorporated into multimedia learning materials despite the fact that they may lead to extraneous processing or extraneous cognitive load and distract learners from processing the essential parts of the learning material (Mayer, 2014a).

The last approach is named as “focused more is more”. According to this approach, instead of “interesting but irrelevant design adjuncts”, instructional designers should focus on using “interesting but relevant” design features in multimedia that motive learners to engage in generative processing. In addition, instructional designers should take necessary precautions in order not to overload learners with extraneous processing and distract learners from processing of the essential materials. Although CATLM suppose that motivation is an important parameter that needs to be considered while designing multimedia learning, both CATLM and CTML suppose that instructional designers should use design principles to ensure that limited capacity is not overloaded, essential processing is not distracted and generative processing is fostered (Mayer, 2014a).

As Chen and Wang (2011) cited from many studies on multimedia, a relationship exists between cognitive load, learning and affective parameters such as emotion and motivation. Considering CLT and CTML as theoretical background, most of the previous research about use of affective design elements in multimedia learning regarded emotionally interesting design elements as seductive “details”. These design elements were regarded as “details”, because, although they are rated by

students as being interesting and entertaining, they are not directly related to the learning objective (Harp & Mayer, 1997).

According to CLT, three types of cognitive load are experienced during learning: intrinsic, extraneous and germane cognitive loads. Intrinsic cognitive load refers to the inherent complexity or difficulty of a learning material. Extraneous cognitive load occurs when the instructional material includes poor instructional design which require learners to process unnecessary information that are not about knowledge acquisition. Finally, germane cognitive load is regarded as effective cognitive load, which refers to allocating working memory resources for intrinsic load rather than extraneous load (Paas & Sweller, 2014). Based on the types of loads proposed by CLT, one can assume that seductive details may impose extraneous cognitive load during cognitive processing, since these elements include irrelevant design elements that are not directly related to the learning objective. Extraneous cognitive load should be eliminated in order to free up memory resources for processing necessary information. From the view point of CTML, use of interesting but irrelevant design elements in multimedia contradicts with the coherence principle and limited working memory capacity assumption. Additional design elements, used in the hopes of making lesson more enjoyable, may pose additional mental load in working memory and increase extraneous cognitive load. This unnecessary load imposed by the extraneous materials may decrease learning, since precious working memory resources may be depleted by these unnecessary details and there may be not enough capacity for processing the essential material (Mayer, 2009). For this reason, it was suggested by Clark and Lyons (2010) that instructional designers should design their design elements at the lowest level of complexity which essentially aims to support the objective of the lesson. Simpler visuals may demand less mental load and freeing working memory for processing essential material. Hence, based on the limited capacity assumption, most of the time, “less is more”. Seductive visuals, on the other hand, are regarded as being “decorative”, “eye-candy” (Clark & Lyons, 2010) or “cosmetic” (Rieber, 2000), since they are mostly used to stimulate emotional interest rather than to support cognitive interest. According to Rieber (2000), graphics

sometimes used for cosmetic purposes. The reason for using cosmetic graphics is to make an instruction more attractive and aesthetically pleasing. However, graphics that are used for cosmetic purposes have both advantages and disadvantages. “At their best, cosmetic graphics help maintain student interest and perhaps regain student attention… “At their worst, cosmetic graphics distract student attention from other important material” (Rieber, 2000, p. 59). The functionality of an instructional visual is dependent on its effectiveness in conveying instructional message properly. However, for marketing and selling purposes designers prefer using embellishing designs which have capability to catch audience eye. This approach is not learner and learning centered and this type of visuals are mostly used for eye-candy (Lohr, 2007).

Research provides evidence regarding the benefits of cognitive interest over emotional interest when it comes to using interesting but irrelevant details in multimedia learning (Harp & Mayer, 1997). For example, Harp and Mayer (1997) conducted two experiments in an effort to test the effectiveness of the emotionally interesting design adjuncts which are added to an otherwise boring lesson. The researchers used the concept of “seductive details” including seductive text and seductive illustrations to refer the entertaining and interesting design adjuncts. Based on the Kintsch's (1980) theory, the researchers made a distinction between emotional interest and cognitive interest (as cited in Harp & Mayer, 1997). According to emotional interest theory, interesting design elements may stimulate students’ curiosity and promote their enjoyment which in turn influence their affect. If emotional arousal is increased, then students may pay more attention to the task and learn more. As a result, based on the emotional interest theory, affect influences cognition. On the other hand, cognitive interest theory claims the opposite: students will be in a more positive emotional state and thereby will be motivated more to learn, only if they understand the lesson. Structural understanding of a process promotes a sense of a happy feeling. That is, cognition influences affect. In order to compare the effect of emotional interest and cognitive interest on learning, Harp and Mayer (1997) conducted two experiments. In experiment 1, students were randomly

assigned to the one of the four conditions: base text group, base text plus seductive text group, base text plus seductive illustrations group and base text plus seductive text and seductive illustrations group. Four different forms of booklets, including different forms of seductive details based on the treatment conditions, were created. All of the booklets included six paragraphs lesson about the "formation of lighting" and six captioned illustrations signaling the most important steps of the "lighting" process that are necessary to create a mental model about "how lighting occurs". Seductive text and illustrations were interspersed to the booklets based on the treatment conditions. Students read the booklets, performed the achievement tests and filled the interest questionnaire. Students read the passages only one time and no time limit was enforced to the students. The results of the experiment 1 showed that students in the no-seductive details group performed better both on the retention and transfer tests than those students who were in the base plus seductive text, base plus seductive illustrations and base plus seductive text and seductive illustrations groups. According to the researchers, the results of the experiment 1 indicated that interest scale was not successful in discriminating the emotional interest and cognitive interest. Hence, a second experiment was decided to be conducted. In the second experiment, the differentiation between emotional interest and cognitive interest was addressed in a more explicit manner with the help of the new survey designed by the researchers. A sample statement used for emotional interest was "How entertaining is this material?" For cognitive interest, the following sample item was used: "How much does this material help you to understand the process of lightning?" In order to better understand the distinction, the researchers asked students to read base plus seductive text and seductive illustrations booklet and rate the relevant portions of it. As expected, students rated the seductive text and seductive illustrations as being high on emotional interest and low in cognitive interest and they rated explanative summaries (illustrated captions) and base text as being low in emotional interest and high in cognitive interest. The researchers concluded that seductive details did not help students to remember the key points of the process and also, they did not help produce more solutions to the transfer problems, although they had a potential of promoting students' enjoyment while they are reading the passage. Instead, seductive

details depressed learning by shifting students' attention away from the important events in the explanative chain of the process and by disrupting building of cause-effect chains of the process. Based on the results of this study, it could be concluded that "the best way to help students enjoy a passage is to help them understand it" (Harp & Mayer, 1997, p. 100) not to add extraneous details. In other words, the best way to help students be motivated is to support their cognitive interest rather than emotional interest.

The harmful effects of seductive details were replicated by another study conducted by Harp and Mayer (1998). This study was originally conducted to clarify the underlying mechanism of seductive details. In four experiments, emotional interest induced by seductive details compared with cognitive interest. Seductive details were presented either in the form of seductive text and seductive visuals. Participants read a scientific passage regarding the lighting formation either with or without seductive details. The results of the all four experiments were similar to the previous experiments conducted by the same researchers (Harp & Mayer, 1997) indicating that participants who read the scientific passage without seductive details recalled more information than participants who read the passage with seductive details. In the same manner, participants who read the scientific passage without seductive details produced more solutions to the transfer problems compared to the participants who read the passage with seductive details.

The studies conducted by Harp and Mayer (1997, 1998) provided evidence that interesting design elements does not always result in enhanced learning, especially when they are only tangentially related to the learning objective. Clark and Lyons (2010) reported the comparative effects of "liking and learning". They argued that "liking" is not always indicator of learning. More specifically, it does not mean that materials which are positively rated by the students will eventually results in better learning. Based on the results of various research studies, Sitzmann, Brown, Casper, Ely and Zimmerman (2008) conducted a meta-analysis and found that there is a little correlation with students' perceptions regarding their classes and their learning. The

correlation is too small to argue that higher levels of students' satisfaction of lessons are related to better learning from that lesson.

Based on the coherence principle of CTML or "less is more" approach, it was suggested by the literature that instructional designers should focus on the simple drawings and concise text rather than complex pictures and detailed text in order not to overwhelm limited working memory resources. Working memory can hold extra-task processing or task - irrelevant processing which may interfere with cognitive processing and thereby leads to decreased performance outcomes (Oaksford et al., 1996). For this reason, in their book, Clark and Lyons (2010) suggested instructional designers to use less complex visuals rather more complex ones to eliminate "visual noise". Simple drawings are less complex and easy to understand than more realistic pictures. The details in complex illustrations could compete with user's limited attentional span. Simple drawings on the other hand, stress the key elements of the instructional message. As Lohr (2007) indicated, "extras" may obscure the important parts of the massage. Butcher (2006) compared the effects of different materials on learning about heart and circulatory system. Three conditions were created in which students learnt the subject with a material including only text, text with a simplified diagram and text with a detailed diagram including 3D representations. According to the researcher, the simplified illustration has two benefits in terms of freeing up working memory resources: first it may decrease visual search difficulty, second it only stresses the key elements of the process by providing a clearer representation of the process. The results of the study indicated that both simplified and detailed representations were superior in terms of learning compared to text-only condition. However, simplified drawings supported learning more than 3D representations.

Mayer et al. (2001) showed that when the amounts of materials are increased, less understandings is observed. They conducted a study in which students were shown a narrated animation on lighting formation either with or without interesting video clips. The video clips were not directly related to the cause-effect chain of the process of lighting formation but included emotionally interesting design adjuncts. The

results showed that use of interesting but irrelevant video clips depressed learning. In this regard, Clark and Lyons (2010) argued:

> Although visuals like these are added with the good intention of improving motivation, their negative effect on learning is counterproductive. Learners are better served by materials that use graphics that make the main lesson ideas more understandable than materials that add extraneous visuals for purposes of emotional interest (p. 59).

As previously noted, use of affective design elements in multimedia is based on the arousal theory (Mayer, 2009), which assumes that interesting design elements can be added to multimedia in order to increase students' enjoyment experienced during learning. However, students' enjoyment does not always guarantee their success in learning. For example, Clark (1982) summarized the research studies on the relationship between enjoyment and achievement and found a negative correlation between them in some conditions. An interesting finding of the study was that students often reported enjoyment when they learnt least. In the same manner, Salomon (1984) argued that the perceived difficulty of a learning material may affect the amount of mental effort invested on a task. More specifically, while students are studying with an enjoyable material, they may assume that less effort is necessary to learn the content of that material. That is, students may use shallow learning strategies, when they encounter a task that is perceived to be easy (Schommer, Crouse, & Rhodes, 1992; Winne & Hadwin, 1998, as cited in Sitzmann & Johnson, 2014). This hypothesis was partially validated by Sitzmann and Johnson (2014) who conducted a research study with 395 part-time and full-time workers. The purpose of the study was to test whether there was a relationship between seductive details and time on task. They found that trainees invested less time in reviewing modules which contain seductive details. According to the authors, time on task could be regarded as an indicator of the amount of mental effort invested, because their results also showed that learning performance increased, when students invested more time. In sum, perceived difficulty may affect the amount of effort that is devoted to a material. Bearing in mind that materials that contain emotionally interesting details could be regarded to be easy, students may exert less effort to achieve an easy task.

Seductive details may also be used in the forms of interesting sounds and music. The rationale for the use of interesting sounds and music is based on the arousal theory. The theory assumes that interesting sounds and music make multimedia more interesting and enjoyable, increase students' interest towards to the learning material and promote their understandings (Mayer, 2009). Given this rationale, Moreno and Mayer (2000) conducted two experiments to test this hypothesis. Interesting sounds and music were used as seductive details. Interesting sounds included environmental sounds which corresponds to the parts of cause-effect chain of the process of lighting formation (Experiment 1) and the operation of hydraulic braking systems (Experiment 2). For example, when the narrator referred to "cool wind" in the narration, a sound of "wind blowing" was heard. Interesting music was presented in the form of soft background music. Based on the purpose of the study, four types of multimedia materials were created for the treatment conditions: neutral group (N), sounds group (NS), music group (NM) or sounds and music group (NSM). Students' learning performance scores were measured by retention and transfer tests. Both experiments showed that students in the group NSM remember significantly less information than students in the other groups. In addition, they produced fewer solutions to the problem solving transfer tasks compared to other groups. The results were consistent with the coherence principle and limited capacity assumption of CTML. According to the dual channel assumption of CTML, multimedia messages are processed in two distinct channels, visual and auditory. Visual channel is reserved for processing visually presented information and auditory channel is reserved for processing auditorily presented information. Each channel is limited in the amount of information processing at a time. When interesting sounds or music are used along with the narrated animation, the narrated audio and interesting sounds or music compute for the limited resources of the auditory channel. Hence, little space may remain for attending to and processing for the important information delivered by the audio narration (Mayer, 2009).

In sum, previous studies on multimedia learning regarding the use of affective design elements argued that use of emotionally interesting design elements have beneficial

effects. They may induce positive emotions to increase learning motivation. However, these beneficial effects may remain insufficient to compensate for the damage caused by extra-task or task-irrelevant cognitive load imposed by these emotionally interesting design elements (Um et al., 2012). Although research showed the detrimental effects of seductive details, Harp and Mayer (1998) suggested that the power of the well-designed illustrations, rather than seductive ones, should not be dismissed. In addition, they argued that all interesting design elements should not be regarded as being detrimental, since previous research showed that students learn more, if they study with interesting materials rather than uninteresting ones. The detrimental effects of seductive details maybe due to the problematic means of presenting them (Harp & Mayer, 1998). Maybe, seductive details could be presented in a way that support both emotional interest and cognitive interest without imposing extra load and without depressing learning by this way. As Park, Flowerday, et al. (2015) indicated, the idea that interesting design elements should be excluded from multimedia rather than included is consisted with the "cold cognition approach" which regards seductive details as a source of extraneous cognitive load. They indicated that although seductive details contradict with the coherence principle of CTML, their beneficial effects in terms of learning by increasing emotion and motivation cannot be underestimated. Furthermore, Lohr (2007) indicated that instructional designers should be careful in their considerations of "less is more approach". "Advice to keep things simple and sayings such as "less is more" are often misinterpreted as advice to keep out some of the necessary detail" (p. 126). It was noted that details sometimes may be important, since some users are attracted and motivated by them.

It is interesting to note that most of the previous research on using emotions on multimedia dealt with "interesting but irrelevant" design elements. But, one can question that whether a specific design element would be both interesting and relevant to the learning objective at the same time. Bearing this in mind, recently, the concept of emotional design has been proposed. Unlike seductive details research, emotional design does not focus on the interesting but irrelevant details,

but it focuses on the design issues that are both interesting and relevant to the learning objective. Emotional design does not add extraneous details to the material but rather it manipulates the intrinsic elements of any designs (Heidig et al., 2015) by using a variety of techniques such as using warm, saturated, bright colors, anthropomorphism (personification), rounded designs with baby-faces (e.g., Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012).

Affective mediation hypothesis of Moreno's (2006, 2007) CATLM assumes that motivational factors may media learning by increasing or decreasing cognitive engagement. Students should be motivated in order to fully make use of their cognitive capacities. They should also be motivated to use their self-regulation skills in order to devote the necessary cognitive resources for the task (Park, Flowerday, et al., 2015).

Based on the affective mediation hypothesis of CATLM, Um et al. (2012) predicted that a multimedia learning material could be designed in a way that induces positive emotion. In order to induce certain moods, both internal and external mood inducement procedures were used in the study. External mood induction procedures consisted of 25 predetermined positive or neutral statements. Students read these statements before the actual experiment started. A sample positive item was "it's great to be alive!" A sample neutral statement was "there are sixty minutes in one hour". Internal mood induction procedures were implemented by the multimedia program itself that adopted emotional design principles. For internal mood inducement, no new extraneous elements were added to multimedia, but rather intrinsic design elements of the material were manipulated unlike seductive details research that used extraneous additional details. In order to check mood inducement, the Positive Affect Scale (PAS) from the Positive and Negative Affect Schedule was used (PANAS; Watson, Clark, & Tellegen, 1998, as cited in Um et al., 2012). Students rated their subjective feelings (e.g., interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive and active) on a 5-points Likert scale ranging from 1 (not at all) to 5 (very much). Two types of computer based

multimedia material on the topic of immunization were created for the purpose of the study. The materials were identical in terms of the content but they were different with respect to emotional design principles. The first multimedia material adopted neutral design in which no emotional design principles were used. That is, black and white (grayscale) colors were used for simple rectangular objects. The second multimedia material adopted emotional design principles. For this material, the same neutral images were replaced with anthropomorphic images (attributing human characteristics to non-human things), saturated bright warm color combinations and baby-like elements (large eyes, small noses, short chins). 118 American college students were randomly assigned to one of the four treatment conditions based on the two emotional inducement factors: externally induced emotions by means of emotional statements (positive and neutral emotions) and internally induced emotions by means of emotional design principles used for multimedia (positive and neutral emotions). The students worked with the multimedia materials for 15 minutes. The results of the study demonstrated that emotional design used for multimedia material induced positive emotions among users. More specifically, positive emotions induced by the multimedia material by means of emotional design maintained the learners' positive emotions induced externally at the beginning of the learning process. In addition, emotional design of multimedia increased positive emotions of learners who have a neutral emotional state at the beginning. Considering the achievement scores, the results also indicated that internally induced emotions by means of emotional design principles enhanced comprehension and transfer scores of the students, whereas externally induced emotions promoted transfer but not comprehension.

A similar study was conducted by Plass et al. (2014). The study had two purposes. First, the researchers wanted to replicate the results of the study conducted by Um et al. (2012) by using different external mood induction procedures (by means of video) and selecting a different population (German students instead of Americans). Second, it was aimed to explore the distinctive effects of color and shape separately, not in combination, by decomposing their effects from multimedia respectively.

German version of the same learning material about the topic of immunization was used. Students worked with the multimedia materials for 15 minutes as was in the study of Um et al. (2012). The result of the study 1 showed that the similar patterns of results were found as the study conducted by Um et al. (2012). The multimedia material which adopted emotional design principles induced positive emotions in users. That is, the multimedia material, in which emotional design principles were used helped maintain and increase the positive mood state induced through videos before the actual learning process started. Furthermore, the results demonstrated that positive emotions facilitated cognitive processing. Students who received multimedia instruction that was designed in accordance with emotional design performed better on comprehension test than those who received multimedia instruction without emotional design (neutral). However, no significant difference was observed in terms of knowledge transfer between emotional and neutral group. The results of the study 1 also indicated that positive emotions induced through emotional design resulted in low levels of perceived task difficulty and high levels of perceived motivation in students. However, no significant differences were observed in terms of satisfaction and perception of learning achievement scores. The purpose of the study 2 was to examine the separate effects of color and shape on achievement scores. For that aim, four different versions of the multimedia based on two factors were created. These factors were color (absence or presence of color) and shape (absence or presence of rounded face-like images). Totally, 103 university students participated to the study. Participants were assigned to one of the four treatment conditions randomly. In terms of learning materials' capability to induce positive emotions, the results showed that rounded human-face-like shapes induced positive emotions in users whereas colors did not. In terms of the effect of shape and color on retention and transfer, the results indicated that both shape and color affected comprehension independently. However, when it comes to transfer, it was found that shape significantly affected transfer while color did not. That is, shape of the elements was more effective when they were combined with neutral colors. Finally, it was found that shape and color did not have an influence on cognitive load, measures of satisfaction, motivation, or perception of learning. As a result, this

study suggested that positive mood inducement by means of emotional design was most effective, when warm colors were used together with human face- like rounded shapes. Regarding the contradictory results in terms of the effect of color among the studies conducted by the same research group, the authors of the study argued that the differences may be due to the different sample characteristics of the studies. German group was predominantly female while the American group was more balanced. They argued that further studies should also consider gender differences on color preferences. In addition, the studies mentioned above were conducted in western countries. The members of other countries might perceive the effect of colors differently than the western countries.

Mayer and Estrella (2014) conducted a similar study with 64 college students who viewed 8 PowerPoint slides on "how a virus causes a cold" either with a material with emotional design and with a material without emotional design. The authors referred emotional design as "redesigning the graphics in a multimedia lesson to enhance the level of personification and visual appeal of the essential elements in the lesson" (Mayer & Estrella, 2014, p. 12). Enhancing the appeal of the graphics included using attention grabbing colors such as red for the host cell, blue for the virus and yellow for the sac caused by the virus. Personification includes attributing human-like characteristics to the essential elements of the lesson which was similar to anthropomorphism approach used by Plass and his colleagues. For example, the host cell infected by a virus, was illustrated as having specific emotions on its face such as surprise, fear and sickness during the various stages of the process. The main hypothesis of the study was that students who received a multimedia instruction based on the emotional design principles (human- like features, appealing colors) would outperform those students who received the lesson without emotional design in terms of a learning performance score. The second hypothesis was that the emotional group would report less difficulty and more effort than the neutral group. Two experiments were designed to test the hypothesis. In experiment 1, the students received the lesson for 5 minutes and then completed the retention and transfer test. The Second Experiment was the same with experiment 1 except that students had no

time limit during learning. The results of the first experiment showed that emotional group performed significantly better than the neutral group on retention test. However, no-significant difference was observed in terms of the transfer of learning. In addition, the results showed that the groups did not differ significantly in terms of their ratings of the appeal and enjoyment of the lesson and desire for more similar lessons. Based on the predictions of CATLM, the emotional group was predicted to report higher levels of effort and lower levels of difficulty than the neutral group. Consisted with the prediction, results showed that emotional group reported a higher level of effort during learning than the control group. However, there was no significant difference between the groups in terms of difficulty ratings although the difference was in the predicted direction. The results of the second experiment were literally identical to the first experiment in terms of learning outcomes. As in the experiment 1, the groups did not differ in terms of the ratings of appeal of the lesson, enjoyment of the lesson desire for more similar lessons. Unlike experiment 1, the emotional group did not report higher levels of effort than the neutral group. However, consistent with the second hypothesis, the control group reported greater difficulty than the enhanced group although the difference did not reach statistical significance. The main finding of the study was that emotional design resulted in higher levels of student achievements. The authors of the study offered to replicate the study in more authentic learning environments. They also offered to test the hypothesis of CATLM with younger populations. Furthermore, the study used subjective measures of motivation, effort, and difficulty. For this reason, future research should focus on more direct measures. Considering learning performance, the study found a significant difference on retention but not on transfer. Further studies should also focus on the effects of transfer with delayed tests.

Park, Knörzer, et al. (2015) conducted an eye tracking study to explore the effect of using anthropomorphism on positive emotions and learning. 101 university students participated to the study. The study used 2 x 2 factorial experimental design with the following factors: (1) external emotions induced by external mood induction procedure (positive and neutral) and (2) internal emotions induced by the multimedia

material (the presence of absence of anthropomorphism). Students were randomly assigned to each group. As the external emotion induction procedure, Seibert and Ellis (1991)'s procedure was used. In this procedure, students read different statements before the actual experimentation started. For example, for positive emotion, they read the following sample statements: "It's great to be alive!" and "It doesn't get any better than this". For neutral emotion, the students read the following statements: "There are sixty minutes in one hour" and "Apples are harvested in the fall". As a manipulation check of mood induction, the Positive Affect Scale (PAS) was used as in the Um et al. (2012)'s study to confirm that the external manipulation was valid. Students eye gaze patterns were recorded by using an eye tracker device. Two types of multimedia environment on the topic of "immunization" either with anthropomorphism or without anthropomorphism with warm, bright and saturated colors were used as learning materials. Each student watched the multimedia material for 5 minutes. The results of the experiment showed that unlike previous studies on emotional design (Plass et al., 2014; Um et al., 2012), the design of the learning material did not affect learners' emotion. Regarding learning comprehension and learning transfer, only the main effect of external mood induction was significant. However, the main effect of emotional design and the interaction term were not significant. The eye-tracking data showed that learners in a positive emotional design showed longer fixations on the parts of the learning material which is an indicator that learners' attention was captured by the anthropomorphism. As recommended before by the some of the previous studies about the issue, the authors suggested to replicate the study in a more authentic learning environments with longer learning times in order to increase ecological validity. In addition, the authors suggested that individual differences of the learners should also be considered to draw a more accurate picture of the interplay between affect and learning.

Knörzer, Brünken and Park (2016a) conducted a study to test to what degree positive and negative emotions will affect learning outcomes. Two experimental groups were formed. 50 university students were randomly assigned to the experimental

conditions. The experimental groups were exposed to either negative or positive emotions before the actual learning started. Music and autobiographic recall were used as emotion induction procedures. Students used a multimedia material about ATP synthase. The experiment time for each participant was about 90 minutes. The participants were tested in the laboratory setting. Results showed that student who were exposed to negative emotions showed higher levels of learning outcomes than the students who were exposed to positive emotions. Knörzer et al. (2016a) attributed this finding to the fact that positive emotions distracted students from learning the material.

Knörzer, Brünken and Park (2016b) conducted a study to explore the effect of emotions (positive, neutral, negative) on learning with multimedia. 75 university students participated to the study. Apart from other studies on emotional design, this study only focused on externally induced emotions. In other words, the study did not focus on the internally induced emotions by means of emotional design principles used for multimedia. Three treatment groups were formed. The groups were exposed to either positive, neutral and negative emotions inducement procedures before the learning task started. Music and autobiographic recall were used to induce positive, neutral and negative emotions respectively. In addition to learning measures (retention, comprehension and transfer) motivational, attentional and cognitive load measures were also utilized. Results showed that emotions did not have any influences on the retention dimension of learning. On the other hand, emotions affected comprehension and transfer dimensions of learning. More specifically, while negative emotion which is related to sadness was found to facilitate learning, positive emotion which is related to happiness was found to suppress learning. According to Knörzer et al. (2016b), due to the negative emotion, a more detailed and focused cognitive processing occurred. On the other hand, positive emotions had a distracting effect for learning. These results were inconsistent with the previous research which found that positive emotions had a facilitating effect on learning (e.g., Park, Flowerday, et al., 2015; Park, Knörzer, et al., 2015; Plass et al., 2014; Um et al., 2012). Knörzer et al. (2016b) argued that the different results were obtained

between the current study and the previous studies because of using different mood inducement procedures and different learning materials.

Liew, Mat Zin, Sahari and Tan (2016) conducted a study to explore whether smiling facial expression of a talking pedagogical agent could affect learners' emotion, motivation and learning. Two virtual learning environments were created. The first one included a pedagogical agent with a smiling face, whereas the second one included a pedagogical agent with a neutral face. 107 freshmen business majors participated to the study. Results showed that there was no significant difference in terms of students' learning scores between smiling and neutral agent conditions. In addition, it was observed that participants in the smiling condition felt less positive emotions, joviality and self-assurance than the participants in the neutral condition. What is more, smiling agent was found to deteriorated students' perceptions of learning environment. Liew et al. (2016) attributed this surprising results to students' perception of smiling agent. According to the authors, the students might have perceived the virtual agent's smiling as "fake". To gather a further insight and test whether participants perceived agent's smiling as fake, the researchers conducted a second experiment. It was shown by the second experiment that most of the participants did not find smiling agent's face as enjoying. Qualitative responses indicated that there was a mismatch between agent's voice and his smiling face which made them perceive the agent as "fake".

Liew and Tan (2016) conducted two experiments to explore the effect of positive mood and negative mood on cognition and motivation. In the first experiment, the effect of positive mood on cognition and motivation was compared to the effect of neutral mood. In the second experiment, the effect of negative mood on cognition and motivation was compared to the effect of neutral mood. The study of Liew and Tan (2016) was different than the most of the previous research which only directly compared the effect of positive mood to negative mood. 172 business majors participated to the experiment 1. Students used a multimedia learning program about basic programming language. The results of the experiment 1 showed that positive

mood induction increased students' intrinsic motivation and mental effort, which could be evaluated as positive emotions had a facilitating effect on cognition and motivation. In addition, it was shown that positive mood decreased perceived task difficulty. Experiment 2 was literally same with experiment 1, but this time the effect of negative mood on cognition and motivation compared to the neutral mood was explored. 96 students participated to Experiment 2. The same learning material was used. Results indicated that negative mood increased intrinsic motivation and mental effort, whereas it was found to have a reducing effect for learning. Generally, this study confirmed Isen's (1999) admonishment that one also should not assume that positive and negative emotions are symmetrical or parallel in their effects. Both positive and negative mood increased students' intrinsic motivation.

Brom, Hannemann, Stárková, Bromová and Děchtěrenko (2016) conducted a study whether adding anthropomorphic faces and funny graphics to a black and white instructional animation affects students' learning achievement scores (as measured by retention and transfer), positive affect and flow levels. 41 high school students used the emotionally designed multimedia, whereas 37 students used the black and white version of the same material. The multimedia covered the topic of "biological wastewater treatment". Results showed that there were not significant differences between groups in terms of positive affect, flow and transfer domain of learning. However, there was a significant difference in terms of retention scores of the students between groups. Students in emotionally designed multimedia group outperformed the students in neutral design group. Qualitative analysis of the interview data showed that anthropomorphic graphics may serve as memory cues for students to remember the parts of the instruction.

2.12 Individual Differences and Emotional Design

One of the assumption of CATLM is individual differences assumption which posits that the differences in learners' prior knowledge, and traits such as cognitive styles and abilities may affect how much people learn from a specific method and media (Moreno, 2006). Hence, it has been argued by the research that different learning

characteristics should be taken into consideration when evaluating the effect of affective design issues on multimedia learning. The following, some of the individual differences that have been issued in the literature were given.

One of the most influential factors as an individual difference is prior knowledge. Research showed that differences in prior knowledge lead to different results in multimedia learning. That is, different results were obtained for participants who possessed different levels of prior knowledge. For example, decorative visuals are thought to be detrimental to learning (Clark & Lyons, 2010), since they are not directly related to the learning objective and are used only for cosmetic purposes (Rieber, 2000). However, Magner et al. (2014) found that interesting decorative visuals only hindered learning for learners who possessed lower levels of prior knowledge but did not have any negative effects for learners who possessed higher levels of prior knowledge. Rather, learners with higher levels of prior knowledge benefited from this kind of visuals. Considering emotional design, a similar pattern of results may be predicted. A material with emotional design includes more complex design elements than the material without emotional design. Hence, learners with high prior knowledge may benefit from emotional design, while learners with low prior knowledge may not. Rey (2012) argued that most of the previous research on the use of affective design elements in multimedia did not take prior knowledge into consideration. Prior knowledge was not included into analysis as control measures (e.g. covariate). But rather, it was only assessed by subjective self-assessment scores (e.g. asking students whether they are expert or novice on a particular subject) in order to assure that students' prior knowledge did not differ and only novice learners participated to study. Hence, it is not clear whether students' prior knowledge contributed to their learning. Bearing this in mind, it would be plausible to argue that research should control the confounding effect of prior knowledge on outcome variables (Rey, 2012).

Working memory capacity (WMC) is another individual difference which has an effect on the relationship between using affective design elements in multimedia and

learning. Working memory is regarded to be a cognitive ability with regard to one's ability to use his or her working memory systems (Wiley, Sanchez, & Jaeger, 2014). One of the assumptions of CTML is limited capacity assumption which argues that people have limited working memory capacities for processing visual and audial information (Mayer, 2009, 2014b). Considering this assumption, according to "emotions as extraneous cognitive load" view, use of additional interesting design elements may necessitate extra task processing demands on the limited working memory resources. Use of interesting design elements may compete with processing the essential parts of the instruction which may result in decreased levels of learning (Um et al., 2012). Research found that learners who have lower levels of working memory capacity are more vulnerable to this negative effect compared to learners who have higher levels of working memory capacity. In a study, Sanchez and Wiley (2006) tested the effect of individual differences in working memory capacity on multimedia learning. Participants read three types of text: one that was not illustrated, one that was illustrated with context dependent-relevant images, and one with that was illustrated with context independent irrelevant images (e.g. seductive details). They were given 20 minutes to read the text. The results of the study showed that individuals with low working memory capacity were found to be more vulnerable to the negative effects of seductive details compared to the ones who have high working memory capacity. Park et al. (2011) argued that interesting design elements may sometimes be beneficial and sometimes be detrimental to learning depending on learners' available resources to process these interesting design elements. For example, Park, Seufert, and Brünken (2009) found that learners who have higher levels of working memory capacity obtained better learning performance scores in a lesson that included a background music (as cited in Park et al., 2011).

Knörzer et al. (2016a) explored to what degree cognitive resources such as prior knowledge and working memory capacity affects emotions' influence on learning (Research Question 2). It was predicted that students who have higher levels of cognitive resources could show higher levels of learning outcomes. Another focus of the study was to explore to what degree personality traits such as neuroticism and

openness affects emotions' influence on learning (Research Question 3). Knörzer et al. (2016a) assumed that more open people would be more curious to new things which would affect their learning positively. Additionally, the researchers assumed that neuroticism would not have effect on learning but have effect on emotions, since neuroticism refers to one's emotional stability. 50 university students were exposed to either positive or negative emotions by means of music and autobiographic recall before the actual learning task started. Students used a multimedia material about ATP synthase. Results showed that higher amounts of cognitive resources (prior knowledge and working memory capacity) resulted in higher amounts of learning outcomes. In addition, considering personality traits, it was found that more open learners showed higher levels of learning outcomes, whereas neuroticism did not have an effect on learning but did have an effect on emotions as predicted.

2.13 Measuring Emotion

In order to detect learning emotion, paper-pencil based self-report measures have been used in most of the studies regarding the use of affective design issues in multimedia learning (Plass et al., 2014; Um et al., 2012) However, it has been suggested by the literature that more direct and better measures could be used to gain a better understanding about the issue (Dong, 2007; Mayer & Estrella, 2014).

According to Norman (2004), emotions are working with the help of neuro transmitters affecting the related regions of the brain and body chemically. There are many new approaches in identifying human emotions working on the basis of these changes occurring in the body (El-Nasr, Morie, & Drachen, 2010). Cardiovascular Measures, EMG, fMRI, EEG, EDA could be given as examples to these new approaches. Among these approaches, some of them are detecting emotions based on the arousal dimension, some of them are detecting emotions based on the valence dimension and some of them are detecting emotion based on both arousal and the valence dimensions. The devices that detect emotions based on both valence and the arousal dimensions of the emotion are relatively more expensive compared to the devices that detect emotion based on the single dimension (either arousal or valance).

Besides, although, two-dimensional emotion detection devices allow for detecting more complex emotions, use of such devices require complex and expensive equipment (El-Nasr et al., 2010). Since this study was conducted in its natural environment for three weeks, it would be very labor intensive for a single researcher to utilize two-dimensional emotion detection devices. Instead, one of unidimensional cardiovascular measures, Emwave Emotion Recognition Technology was used for the current study. The device uses Heart Rate Variability (HRV) data to detect emotions.

Cardiovascular measures use the relationship between circulatory system and autonomic nervous system in detecting emotions. More specifically, Heart Rate (HR) and Heart Rate Variability (HRV) data are employed for cardiovascular measurement. HR is measuring the arousal dimension of the emotion, whereas HRV is measuring the valance dimension of the emotion (El-Nasr et al., 2010). HRV is defined as "a measure of the beat-to-beat changes in heart rate" (Rozman et al., 2008, p. 196). Based on the HRV values and the related plotted heart rhythm patterns, the researchers are able to analyze "mental-emotional dynamics of a human body" (Rozman et al., 2008).

Devices that are employing HRV data for emotion recognition have many benefits over the devices that are employing HR data. First, HR based measures detect the arousal (degree of activation) dimension of the emotion. In other words, such measures are not capable of differentiating positive or negative emotions. Second, HR based measures consider average HR values through a session neglecting the relationship between beat to beat intervals. In sum, HRV based measures provide a more detailed picture of mental-emotional dynamics of a human body by using beat to beat changes in heart rate instead of average heart rate values. For this reason, a HRV based measure, Emwave Emotion Recognition Technology was used in the current study. Detailed information about use of the technology and how this technology works will be provided in the forthcoming sections.

2.14 Summary of the Literature Review

In summary, based on the cognitive limitations of working memory capacity, three important goals of instructional design are suggested: eliminate extraneous processing, manage essential processing and foster generative processing (Mayer, 2014b). Most of the previous research on multimedia has focused on techniques for eliminating extraneous processing and managing essential processing. However, little is known about fostering generative processing (i.e., generating motivation to learn) (Mayer, 2014). Instructional designers are challenged to foster generative processing as the question of what motivates learner is not clear (Mayer, 2014a). Besides, multimedia research produced inconclusive results since traditional cognitive theories underestimated the role of affective factors such as emotion and motivation (Astleitner & Wiesner, 2004)

Recently, Cognitive Affective Theory of Learning with Media (CATLM) (Moreno, 2006, 2007) has been suggested. Based on the theory, "motivational factors may mediate learning by increasing or decreasing cognitive engagement", "metacognitive factors mediate learning by regulating cognitive processing and affect", "differences in learners' prior knowledge and traits such as cognitive styles and abilities may affect how much is learned with specific methods and media" (Moreno, 2006, p. 151). Considering CATLM, one approach in an effort to foster learning by increasing cognitive engagement is emotional design. Emotional design is defined as "trying to make the core elements in a lesson more emotionally appealing through giving them human-like features (for example, symmetrical faces with facial expressions) and rendering them in enjoyable colors" (Clark & Mayer, 2016, p. 224).

Emotional design approach is different from "seductive details". Seductive details research deals with "interesting but irrelevant design elements". On the other hand, emotional design concentrates on "interesting but relevant design elements". Research showed that seductive details could be harmful for learning. The additional elements posed by irrelevant seductive details may necessitate additional processing load in limited working memory capacity (Harp & Mayer, 1998). This situation is

consisted with suppression hypothesis or “less is more” approach which posits that emotions may have deleterious effect for learning due to limited working memory capacity (Oaksford et al., 1996; Seibert & Ellis, 1991). On the other hand, emotional design research has shown that if affective design elements are used in accordance with the coherence principle of Cognitive Theory of Multimedia Learning (CTML), that is, if design elements that are both interesting and relevant to learning objective are used in multimedia, learning achievement is fostered. This situation is consisted with facilitation hypothesis or “focused more is more approach” which posits that positive emotions broaden and facilitate cognitive processing (Fredrickson, 1998).

Emotional design in multimedia is relatively a new approach. Studies regarding emotional design are in their “infancy” (Mayer & Estrella, 2014, p. 12). Besides, limited studies on emotional design compared the effect of using emotional design by incorporating more than one emotional design approaches into multimedia (i.e., color, shape and anthropomorphism) with the neutral design that adopted only black and white grayscale design. When various emotional design elements were investigated separately, different results were obtained. For example, in the study of Plass et al. (2014), it was observed that while rounded objects used independently from colors enhanced the levels of students’ experienced positive emotions, use of only colors in multimedia alone did not have any effects on students’ positive emotions. For this reason, it may be concluded that discrimination of different design elements and their distinctive effects on positive emotions and learning is not at the expected level (Heidig et al., 2015).

The literature showed that research about using emotion in multimedia learning did not focus on the “contextual factors” in detail. First, consisted with the individual difference assumption of CATLM, cognitive abilities and traits such as working memory capacity and prior knowledge may have effects on learning achievements (Moreno, 2006). Hence the confounding effects of such individual differences should also be explored. Second, most of the previous studies on emotional design was conducted with college students, although it is well known that younger populations

may react use of emotion differently (Mayer & Estrella, 2014). Third, previous studies used quite short experiment times (less than an hour to only a few minutes) (Thalheimer, 2004) being limited to laboratory conditions. In order to increase ecological validity of the studies, longer experiment times within more authentic environments may be needed. Last, previous studies used paper-pencil tools on the basis of self-report to detect positive emotions. More direct and better measurement tools may be utilized to gain a different perspective of measuring emotion (Dong, 2007; Mayer & Estrella, 2014).

CHAPTER 3

METHODOLOGY

This chapter outlines the research methods used for the study. The chapter begins with purpose, research questions and hypothesis of the study. Then, research design and participants of the study are explained. In addition, procedures of the study along with the design and development of the multimedia instructional materials are discussed. Finally, data collection instruments, data analysis, validity and reliability of the quantitative data and trustworthiness of the qualitative data are presented.

3.1 Purpose of the Study

The purpose of this study is to explore the effect of incorporating emotional design into multimedia learning on the students' positive emotion, mental effort and academic achievement (as measured by learning recall and learning transfer). Being consistent with the assumptions of CATLM that individual differences may also affect how much people learn with specific multimedia and methods, the confounding effects of individual differences such as prior knowledge and working memory capacity are also explored. In addition, in order to gain a better understanding of the effects of various affective design elements, this study aimed to understand students' views about using emotional design in multimedia learning. In line with the purpose, four different multimedia learning materials were created for four conditions. Each material was identical in terms of the content. Only the extent of emotional design differed. The conditions were Neutral Design group (ND) that were instructed by the material with black and white grayscale design objects,

Colorful Design group (CD) that were instructed by the material with attention grabbing, bright, saturated colors, Emotional Design group (ED) that were instructed by the material including expressive anthropomorphism for inanimate objects and exaggerated positive facial expressions for human beings and finally Emotional Design and Sound Effects group (EDSE) that used context dependent interesting sound effects as well as expressive anthropomorphism and exaggerated positive facial expressions.

3.2 Research Questions and Hypothesis

There are four main research questions directing the research which are given as follows:

- How do use of different levels and complexity of affective design elements in multimedia instructional materials (i.e., emotional design) affect students' positive emotion?

- How do use of different levels and complexity of affective design elements in multimedia instructional materials (i.e., emotional design) affect students' mental effort ratings?

- How do use of different levels and complexity of affective design elements in multimedia instructional materials (i.e., emotional design) affect students' learning achievement after controlling for the effect of confounding variables?

- What are the students' views of using emotional design in multimedia learning?

Based on the main research questions, the following null hypothesis are formulated:

Hypothesis 1: Students' positive emotions are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)

Hypothesis 2: Students' mental effort ratings are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)

Hypothesis 3: Students' achievement scores (as measured by recall and transfer of learning) are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of prior knowledge and working memory capacity.

> Hypothesis 3a: Students' recall of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest recall and working memory capacity.
>
> Hypothesis 3b: Students' transfer of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest transfer and working memory capacity.

3.3 Research Design

Based on the research questions, a mixed methods research design was used in the study. A mixed methods study is defined as follows:

> A mixed methods study involves the collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority and involve the data at one or more stages in the process of research (Creswell, Clark, Gutmann, & Hanson, 2003, p. 212).

The purpose of using mixed methods design is to understand the research problems in a more comprehensive manner by combining the advantages of both quantitative and qualitative methods. Use of both methods in a study may be more powerful than using either method alone (Fraenkel, Wallen, & Hyun, 2012). Mixed methods research does not simply mean collecting quantitative and qualitative data but it includes "merging, integrating, linking, or embedding" the two approaches (Creswell, 2012, p. 535).

Among the types of mixed methods design, the embedded design was used. As other mixed methods design, both quantitative and qualitative data are collected in the embedded design. In embedded design, the researcher primarily uses one type of data (quantitative or qualitative) and refer to the secondary data (quantitative or qualitative) in order to support or strengthen the results of the primary type of data. The secondary data can be collected before, during or after the intervention either concurrently or sequentially. The common use of embedded design in the literature is that the researcher uses quantitative data as a primary means of data collection and embed qualitative data within the quantitative experimental investigation (Creswell, 2012). In the embedded design, quantitative and qualitative data are analyzed often in a separate manner. The researcher addresses different research questions for both quantitative and qualitative phase of the study. "The quantitative data will address whether the intervention had an impact on the outcomes, whereas the qualitative data will assess how the participants experienced the intervention" (Creswell, 2012, p. 545). Given this rationale, it was decided by the researcher that this type of mixed methods design best suited to the purposes of the study. Because, this study predominantly used experimental quantitative research methodology in which most of the research questions were addressed. Qualitative data were embedded within the quantitative data to gain a better understanding of participants' experiences of learning with multimedia materials that differed in terms of emotional design. According to Creswell (2012), qualitative data collection during the experiment may influence the outcomes of the study. In order to eliminate that risk, the researchers must take necessary precautions (e.g., collecting qualitative data after the experiment

ends). Furthermore, collecting both quantitative and qualitative data during the intervention may be labor intensive for a single researcher (Creswell, 2012). Based on these suggestions, the researcher collected quantitative data before, during and after the experiment. On the other hand, qualitative data were collected after the experimental investigation ended.

In the quantitative phase of the study, a pretest/posttest quasi-experimental design was used. Previous studies on the use of affective design elements in multimedia learning were criticized for being conducted in the laboratory settings and having quite short learning sessions (an average of 4 minutes) (Thalheimer, 2004). In order to increase ecological validity of the experiments, it was suggested by the literature that longer overall learning times in more authentic environments are needed (Mayer & Estrella, 2014; Rey, 2012). Based on this suggestion, this study was conducted in a typical central middle school in its natural environment for three weeks. The school setting did not allow the researcher to create experimental conditions. Hence, the students were not randomly assigned individually to the conditions. Instead, the intact classrooms were randomly assigned to the treatment conditions as groups. As Creswell (2012) stated, quasi experimental designs best fit situations when the settings do not allow creating artificial conditions.

In order to compare treatment conditions on certain variables addressed by research questions, four different multimedia materials were developed for four treatment conditions. The treatment conditions and corresponding multimedia instructional materials are tabulated as follows:

Table 2 Treatment Conditions and Corresponding Multimedia Instructional Materials

Group	Treatment
Neutral Design (ND)	The base version of the material was used. The design only focused on the main parts of the instruction. Simple black and white grayscale design objects were used. Emotional design elements such color, expressive anthropomorphism and interesting cartoon sound effects were not used.
Colorful Design (CD)	In addition to the base version of the instruction, colorful design was employed. Saturated, bright and attention grabbing colors were added to the base version.
Emotional Design (ED)	In addition to CD group design, expressive anthropomorphism was added to the lifeless objects. Also, exaggerated smiling faces were added to human characters, which were neutral for the ND and CD group. The facial expressions of all characters were changing in accordance with what they were doing.
Emotional Design and Sounds Effects (EDSE)	In addition to ED group design, interesting context dependent sound effects were used, which played when the objects moved. All sounds were context dependent that students were familiar with from famous cartoon films.

The dependent variables of the study are students' positive emotion scores, mental effort ratings and posttest achievement scores (as measured by posttest recall and posttest transfer scores). The independent variable is the treatment conditions (ND, CD, ED and EDSE groups). Pretest achievement (as measured by pretest recall and pretest transfer scores) and working memory capacity are selected as covariates.

Before the experiment started, students' prior knowledge about the subject matter was tested by the pre-achievement test. In addition, the computerized forms of Working Memory Capacity (WMC) tests were implemented. During the experiment, students' emotions while they were using the different types of multimedia instructional materials (ND, CD, ED, and EDSE) were recorded by the Emwave Emotion Recognition Technology (ERT). After the experiment finished, the same achievement test and students' self-ratings of their mental efforts were administrated

as posttests. The design of the quantitative phase of the study and related data collection procedures are tabulated as follows:

Table 3 Design of the Quantitative Phase of the Study

Group	Before the Treatment	During the Treatment	After the Treatment
Neutral Design Group (ND)	•Pre-Achievement Test •WMC Test	Emwave ERT	•Post-Achievement Test •Mental Effort Ratings
Colorful Design Group (CD)	•Pre-Achievement Test •WMC Test	Emwave ERT	•Post-Achievement Test •Mental Effort Ratings
Emotional Design Group (ED)	•Pre-Achievement Test •WMC Test	Emwave ERT	•Post-Achievement Test •Mental Effort Ratings
Emotional Design and Sound Effects Group (EDSE)	•Pre-Achievement Test •WMC Test	Emwave ERT	•Post-Achievement Test •Mental Effort Ratings

Note: WMC: *Working Memory Capacity*, ERT: *Emotion Recognition Technology*

In the qualitative phase of the study, semi-structured interviews with the participants were implemented. The participants of the interviews were determined based on their scores on certain variables. The reasons for conducting interviews with students were that the quantitative experimental data informed the researcher only about the strength of the intervention on the outcome variables whereas qualitative data provided detailed interpretations about how the students experienced the intervention (i.e. their views about using different forms of multimedia instructional materials). Qualitative data were collected through semi structured interviews after the whole quantitative data collection procedures ended. Quantitative data and qualitative data were analyzed separately. After each data form was analyzed, the products of each data form were integrated.

3.4 Participants

The literature on the use of affective design elements in multimedia learning indicated that most of the studies regarding the issue were conducted with university students. However, with regard to emotional design, it was stated that younger population's affective reaction to the certain design elements may be different than the older ones (Lohr, 2007). Mayer and Estrella (2014) argued that further research is needed to explore how younger population react to emotional design. Based on this suggestion, instead of university students, younger populations, specifically middle school students were selected as study participants in the current study.

For the school selection, the following criteria was used: first the school setting should have been located in the city center. Being located in the city center was an important criterion for school selection, because in rural areas, the students' social economic states were quite different than the urban areas. Second, the school should have had enough computers or the technical capacities of the computers should have been sufficient for running the multimedia program. Considering these criteria, this study was conducted in Şemseddin Karahisari Middle School which is a public typical state school located in the city center of Afyonkarahisar.

Totally, 113 7th grade students participated to the *quantitative* phase of the study. The average age of the participants was 12. Students took basic computer training course at their 5th and 6th grades. Hence, the students were thought to have basic skills to use the computer based multimedia instructional materials. The school had totally 14 7th grade classes. Four of all the classes were selected for the study. The classes were selected on the basis of their teachers who were volunteer to participate to the study. Since the students participated to the study for three weeks, random assignment of each student to the conditions was not possible. Instead, four intact classrooms were assigned to the four conditions randomly. Seven students were absent during some parts of the study. For this reason, their data were not included into the statistical analysis. Totally, there were 106 students for the study with 28 students in ND group, 25 students in CD group, 28 students in ED group and 25

students in EDSE group. Number of participants are cross tabulated by group and gender in the following table:

Table 4 Distribution of the Participants by the Groups

Group	Gender		Total
	Male	Female	
ND	17	11	28
CD	13	12	25
ED	13	15	28
EDSE	14	11	25
Total	57	49	106

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects

In the *qualitative* phase of the study, for the selection of participants, purposeful sampling method was used. "Purposeful sampling focuses on selecting information rich cases whose study will illuminate the questions under study" (Patton, 2002, p. 230). Among the types of purposeful sampling, maximal variation sampling was used. "Maximal variation sampling is a purposeful sampling strategy in which the researcher samples cases or individuals that differ on some characteristic or trait (e.g., different age groups)"(Creswell, 2012, p. 207). The purpose of the maximal variation sampling is to develop many perspectives (Creswell, 2012). The students who were to participate to the interview were selected based on the gender and the results of posttest achievement scores. Students' WMC scores were not considered for the selection of the participants, because it would increase the number of participants for interviews which would be labor intensive for the researcher. Anyway, the literature revealed that WMC scores are highly correlated with science achievement scores (Yuan, Steedle, Shavelson, Alonzo, & Oppezzo, 2006).

For the selection of interviewees, the following procedures were implemented: first, for each treatment conditions, students' achievement scores were analyzed and students were grouped as high, average and low achievers based on their mean scores. Second, from each group, one female and one male participant were selected.

As a result, six students from one treatment condition were selected which yielded totally 24 students from four treatment conditions. Additionally, four students who had different characteristics than the others based on the difference of their pre-achievement and post achievement scores were included to the interviewees. As a result, totally 28 students were selected for face to face interviews.

3.5 Procedures of the Study

For the preparation of the multimedia instructional material, the 7th grade science curriculum declared by Ministry of Education (Turkish Ministry of Education, 2016) was considered as a framework. More specifically, "Work, Energy and Energy Conservation", one of the subtopics of the "Force and Energy" unit, was chosen. It is suggested by the curriculum that a three-week instructional period is needed to cover the topic (Turkish Ministry of Education, 2016). Accordingly, the experimental investigation was carried out for three weeks (one session per week). The experimental investigation was conducted in the fall semester of 2015-2016 academic year. Totally, the experiment lasted for five weeks.

In the first week, the researcher conducted a one-week pilot study with volunteer students who belonged to different 7th grade classes of the school. Those students did not participate to the actual experimentation. In the pilot study, the researcher tested whether any technical problem existed either in terms of hardware or software that had potentials to hinder students from using Emwave Emotion Recognition Technology (ERT) and multimedia instructional materials properly.

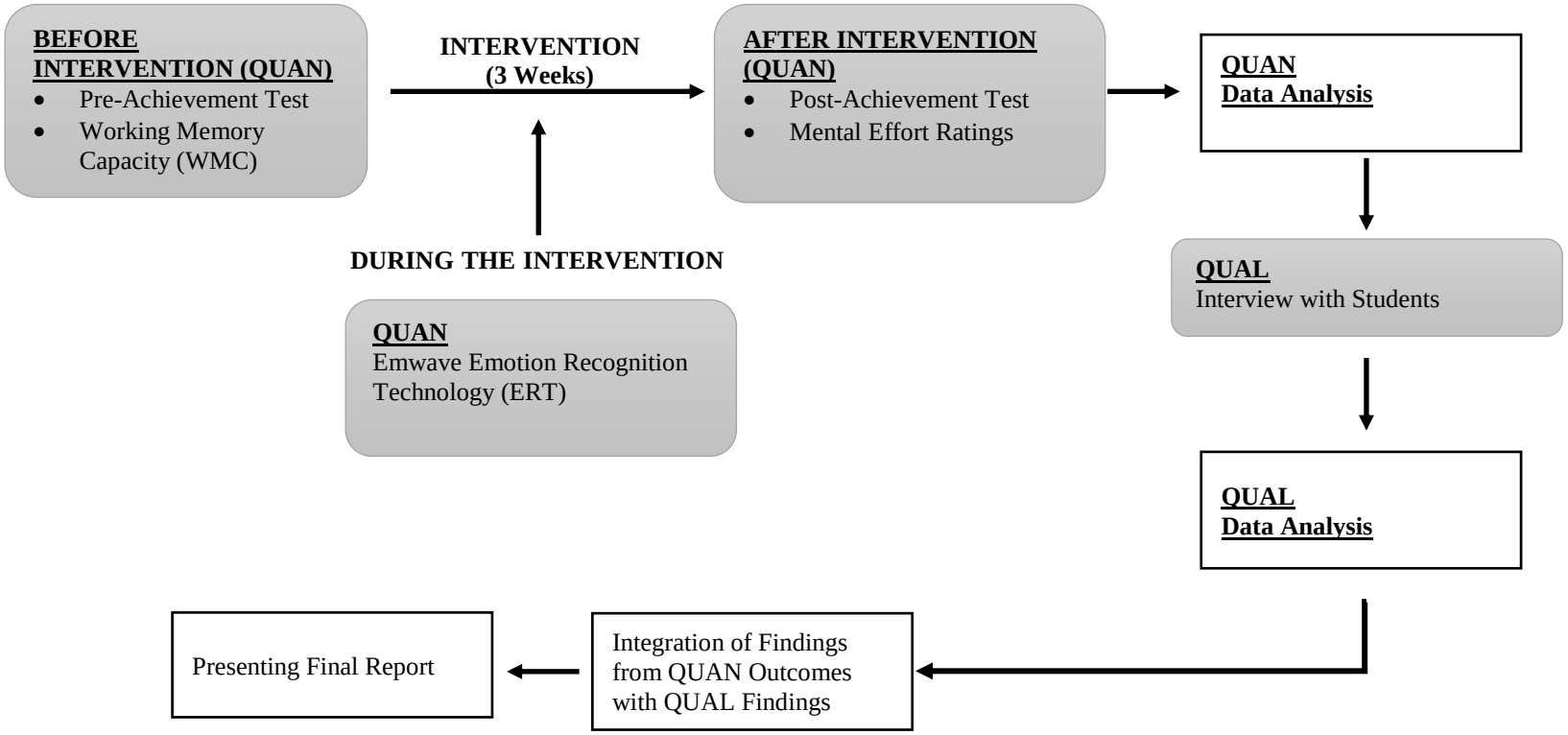
In the second week, the researcher conducted an orientation study for students who were to participate to the actual study to demonstrate the usage of the ear sensor and multimedia instructional materials. The researcher mentioned about the things that students should know and pay attention to during the experiment. Then, students were given chance to try the ear sensor one by one. In the next class, a series of tests were administrated by the researcher to explore the entry level characteristics of the students. First, to examine the levels of students' prior knowledge regarding to the

topic of “Work, Energy and Energy Conservation”, a pre-achievement test was conducted. The test involved both recall and transfer dimensions of the learning. Second, for the detection of the levels of students’ working memory capacity, Mr. Peanut (Mr. Cucumber) Test and the Backward Digit Span Tests were applied to the students.

In the last three weeks, the actual experimentation was conducted. Students learned the topic by multimedia instructional materials which were designed with respect to different emotional design approaches. Throughout the experiment, students’ positive emotions were detected and recorded by Emwave Emotion Recognition Technology (ERT) depending on their Heart Rate Variability (HRV). Before the experiment started, the researcher and the director of the research division of HeartMath Institute communicated through email. The authorized researcher of the institution specified that the system should not be used throughout the session, since the record of the data for the whole session could produce noisy data. This is because the control of the younger students during the experiment would be more difficult compared to the other age groups. Instead, she suggested that the device could be used for a certain amount of time at the first and last periods of the sessions. Based on this suggestion, for the first two weeks, students used ERT tool for the first 15 minutes and for the last 15 minutes of the sessions. For the last week, students used ERT tool for the first five minutes and for the last five minutes of the session. The reason why students used the device for first and last five minutes of the last week’s session was that the duration of the learning time of this material was shorter compared to the first two weeks’ materials. In sum, the researcher collected two datasets for each week and six datasets for the total experiment time (2x3=6).

After the experiment, the same achievement test used before the experiment was administrated as a post achievement test (recall and transfer). In addition, in order to measure how much mental effort during the learning process that students exerted to learn the topic, a mental effort test was implemented. Then, students’ achievement scores were analyzed and the students who were to participate to interviews based

on the maximal variation sampling were determined. The researcher applied to the METU Applied Ethics Research Center to obtain Institutional Review Approval. After that, the face to face interviews with students were conducted. The interview was conducted with the students who were selected based on the purposeful sampling. The students were informed about the reasons behind their participation to the interview. They were asked questions regarding their views on the use of various affective design elements, parts of the instructional materials that they liked most and liked least, how they felt while following the lesson, parts that facilitated and suppressed their learnings, and their engagement to the course. It took approximately 10 to 15 minutes to implement the interview. Students' responses to the interview questions were tape-recorded. In addition, the researcher took brief notes during the interview. The following, a visual diagram illustrating the procedures of the study is presented:



From Creswell and Clark (2011)

Figure 4 Visual Diagram Illustrating the Procedures of the Study (Embedded Mixed Method Design)

*Note.*QUAN = Quantitative Data, QUAL = Qualitative Data

3.6 Design and Development of the Multimedia Instructional Materials

Four types of multimedia learning software for four treatment conditions were developed within the scope of the study. The materials addressed the topic of "Work, Energy and Energy Conservation". The topic is covered by the 7th grade science curriculum determined by Ministry of Education (Turkish Ministry of Education, 2016). The reason why this topic was chosen is twofold: first, based on the informal interviews with science teachers, it was indicated by some of the teachers that some students have difficulties to understand the mechanical concepts related to the topic. Second, it was thought by the researcher that this unit was one of the most appropriate units to incorporate emotional design principles into multimedia learning. For example, anthropomorphism or personification of inanimate objects could easily be applied to the design, since the design would include lots of inanimate objects such as boxes being lifted by a forklift, balls moving in a free fall, accelerating cars, rocks rolling from a slope and so on. Various facial expressions could easily be applied to the inanimate objects changing in accordance with their movements. For example, consider a free fall movement. Just before the ball was dropped from a certain amount of height, the facial expression of the ball was positive with a smiling, happy face. Just after it was dropped, it turned to the negative with an emotion indicating a fear. The selection of the "Work, Energy and Energy Conservation" topic was also convenient for using interesting sound effects for the design of the material. As noted earlier, a wide range of different movements, actions and interactions among objects exist in the topic. For example, when an elastic spring is compressed and then released, an interesting "spring release" sound effect is heard.

After deciding the learning unit, the researcher investigated the learning gains desired by the science curriculum. The learning gains served as a framework for the design and development of the multimedia instructional material. The Ministry of Education declared the learning gains of the topic in the curriculum as follows:

Relationship between Force, Work and Energy

- Understands that the scientific concept of the work is directly proportional to the force applied and displacement and states unit of it.

- Associates energy to the concept of work and classifies it as kinetic and potential energy.
  The energy is classified as kinetic energy, gravitational potential energy and elastic potential energy, but mathematical equations are not referred.

Energy Conservation

- Explains that kinetic energy and potential energy are transformed into each other with examples and concludes that the energy is conserved.

- Explains the effect of frictional force on kinetic energy

  a. In the exemplification of the effect of frictional force on kinetic energy, frictional surfaces, air resistance and water resistance are considered.

  b. Showing by a simple experiment, it is concluded that the loss of kinetic energy is transformed into the heat energy.

Based on the learning gains, the following subtopics were generated:

- The Scientific Concept of Work and Work and Energy Relationship,
- Kinetic Energy
- Gravitational Potential Energy
- Elastic Potential Energy
- Energy Transformations and the Conservation of the Energy
- Energy and Frictional Force

After identifying the subtopics, as a next step, the team for the design and development of the multimedia instructional material was formed. The design and development team involved two instructional designers and software company personnel. On the other hand, in this process, apart from the design and development team, the researcher periodically consulted five science teachers, two subject area experts and an instructional designer for their views and assessments regarding the multimedia material.

The first step of the development of the multimedia instructional material was to prepare a storyboard for each screen. Considering the learning gains identified by the curriculum (Turkish Ministry of Education, 2016), the researcher first investigated various textbooks, instructional videos, well-known commercial multimedia instructional materials, power point presentations and so on. After that, the storyboards of each screen were started to be designed. The storyboards included the sketch design of totally 60 screens. In Appendix B, sample storyboards and scenarios (from screen 12 to screen 20) were given. The first 20 screens were about "The Scientific Concept of Work and Work and Energy Relationship", the next 20 screens were about "The Types of the Energies" including "Kinetic Energy", "Gravitational Potential Energy" and "Elastic Potential Energy". The remaining 20 screens were about "Energy Transformations and the Conservation of the Energy" and "Energy and Frictional Force". The storyboard and the related scenarios designed for each screen were scrutinized recursively by an instructional designer with respect to the principles of the instructional message design. After that, the storyboards were revised in line with the feedback given by the instructional designer.

As a next step, the researcher met with four science teachers working at the middle school in which the main study was conducted. The researcher presented each screen to the teachers and asked their opinions whether any problems existed in the scenarios. The teachers suggested some corrections and improvements based on their experiences regarding the key concepts and parts of the topic that need to be taken

into consideration. One of the teachers also referred to the need of using emotional design indirectly by saying that students are fed up with book based formal information. He suggested to use something different to stimulate joy of learning. Based on the teachers' opinions, necessary revisions were implemented. As a next step, the storyboards were presented to two subject area experts from state universities. In line with the expert opinions, the storyboards were put into the final form and sent to the software development company.

For the development of the multimedia instructional software, an iterative process of *development-evaluation- feedback and development* was followed. First, based on the storyboards and the scenarios, the software company developed the first version of the multimedia materials. Then, the researcher met three 8th grade students. The researcher presented each screen of the developed multimedia materials to the students and asked their opinions regarding to the instructional elements used in the screens. The reason why the researcher applied to the 8th grade students' views was that those students learnt the topic while they were at 7th grade and were thought to have prior knowledge about "Work, Energy and Energy Conservation" topic. The students' opinions about the screens of the multimedia were noted by the researcher. After that, the researcher applied a science teacher's opinions about the materials. The researcher also noted the teacher's opinions about the materials. Then, both the students' and the science teacher's views were evaluated together by the two instructional designers. The instructional designers discussed on the necessary revisions that should be done in the materials. Finally, the materials were sent back to the software company to be revised based on the feedbacks given by the instructional designers. The software company put the multimedia instructional materials into the final forms in line with the feedback.

Since there were four treatment conditions in the study, four versions of the instructional multimedia material were created. The materials were essentially the same in terms of the contents, animations and audio narrations for all groups, but they only differed in terms of the extent and complexity of emotional design. For all

groups, Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2009) together with Cognitive Load Theory (CLT) (Paas & Sweller, 2014) were used as theoretical frameworks. For example, narrated audio was used along with visuals instead of on-screen text in order not to split learners' attention between on screen text and visuals. By this way, it was ensured to apply modality principle. Coherence principle was applied by using design materials in a manner that they were directly related to the learning objectives. For emotional design, no other extraneous design adjuncts were added. Instead, context dependent emotional design elements were used by manipulating intrinsic design elements such as color, anthropomorphism and interesting sounds. Signaling principle was applied by using both vocal and visual emphasizes to signal the important parts of the instruction. Other CTML principles that were applied to screens were tabulated and can be seen in Appendix C (only screens from 12 to 20 are provided).

First of all, Neutral Design (ND) material was created. This material served as the base version for all materials. For this reason, all other design elements were built on this base version. ND material included only black and white grayscale simple illustrations and animations along with the audio narration. Both male and female voice were used for the audio narration to address different participants' needs. The sample screenshots from ND material is given as follows:

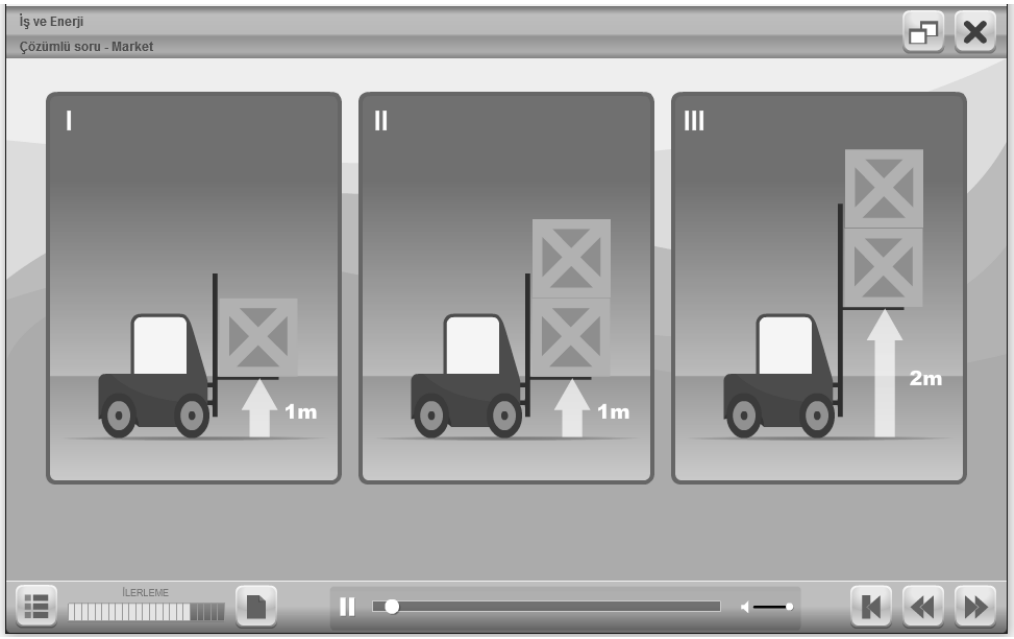


Figure 5 A Sample Screenshot from the ND Group Material

For ND group, neutral (neither positive nor negative) facial expressions were used for both lifeless objects and humans. These neutral facial expressions did change in accordance with the actions and movements of the lifeless objects and humans. The following, a sample screenshot depicting a character of a human being from the ND multimedia material could be seen. In the original version of the material, the characters' facial expression was neutral and was not changing while he was lifting the weights.

Figure 6 A Sample Screenshot of a Human Being from the ND Material

The second version of the material adopted the Colorful Design (CD) approach. This material is exactly the same with the first material except that saturated, bright, and attention catching colors were used. Both warm and cool colors were used in the design. According to Lohr (2007) warm colors tend to advance whereas cool colors tend to recede. In order to make an element more noticeable, one should consider using warm colors. In addition, as noted before, Norman (2004) argued that people are genetically programmed to seek for "food, warmth and protection". Based on these suggestions, warm colors were used for the main objects in the screen which were needed to be focused on. By this way, it was aimed to select more important parts of the instruction by directing attention to those parts and to ignore less important ones. The sample screenshot from CD material is given as follows:

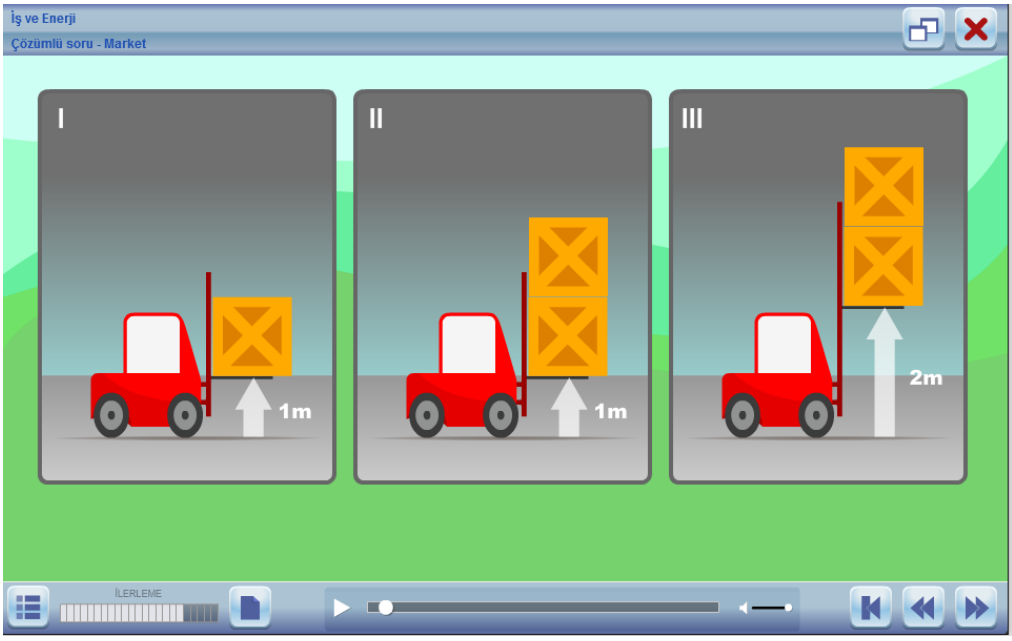


Figure 7 A Sample Screenshot from the CD Group Material

For the CD group, the facial expressions used for the human characters and lifeless objects were literally the same as the ND group. Neutral facial expressions were used for the human beings, whereas no facial expressions were used for the lifeless objects. A sample screenshot depicting a character of human being used for the ND group is given as follows:

Figure 8 A Sample Screenshot of a Human Being from the CD Material

The third material adopted Emotional Design (ED) approach. Again, this material is the same with the previous ones but this time, expressive anthropomorphism was added to lifeless objects. For example, when an object's energy increased, the neutral facial expression of the related object was turned to be positive with a smiling face. When the energy was decreased, the facial expression of the object was turned to be negative with a sad face. When a ball was dropped from a certain height suddenly, the facial expression of the ball turned to the negative indicated a "fear". The sample screenshot from ED material is given as follows:

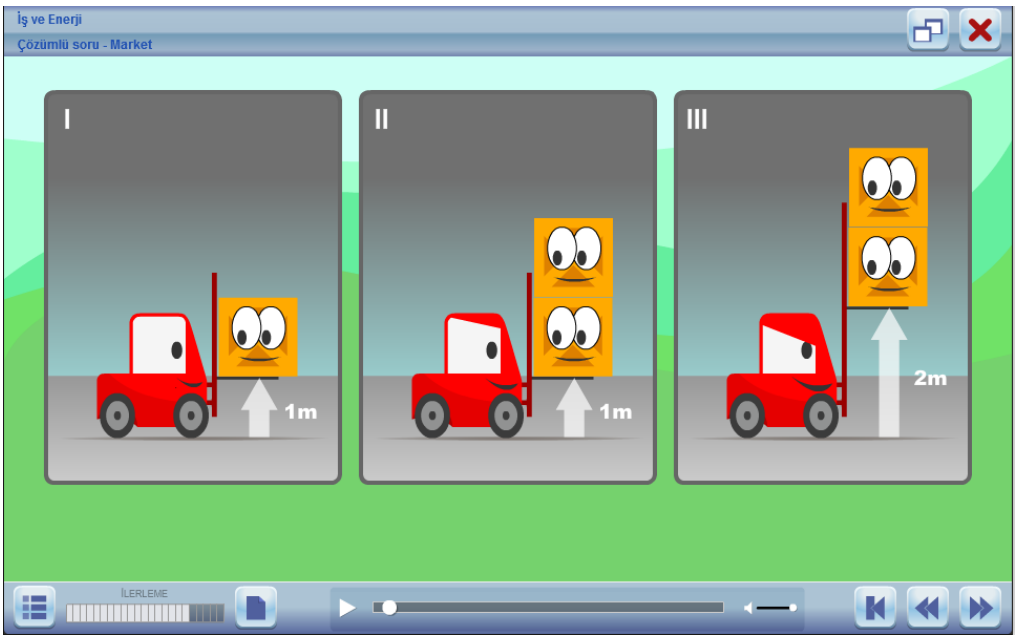


Figure 9 A Sample Screenshot from the ED Group Material

For the characters of human beings used for ED group, all human characters were depicted as having exaggerated facial expressions. In order to increase positive emotions and decrease negative emotions of the students, in most of the times, the human characters were depicted as having positive facial expressions with smiling faces. However, facial expression used for the human beings were expressive rather than stable. In other words, characters' facial expressions were changing based on what they were doing. The following a sample screenshot depicting a character of human being used for the ED group is given:

Figure 10 A Sample Screenshot of a Human Being from the ED Material

The last material adopted Emotional Design and Sound Effects approach (EDSE). This design was exactly the same with the previous one (ED). However, in addition to anthropomorphism and expressive facial expressions for human characters, interesting context dependent sound effects were added to the design which were specific to the related object's movements. For example, when an animation depicted the object being lifted up by a force, the "whistle up" cartoon sound effect was heard. In the same manner, when an object was dropped, a "whistle down" cartoon sound was heard. Similarly, when an animation depicted the force of friction on the rough surface, a friction sound effect was heard. Since the screenshot of the EDSE group is literally same with ED group in terms of visuals, the sample screenshot for this screen is not provided.

3.7 Data Collection Instruments

A mixed methods research design was used in the study. Hence, both quantitative and qualitative data collection instruments were used in the study. The dependent variables of the study are students' positive emotion scores, mental effort ratings and posttest achievement scores (as measured by posttest recall and posttest transfer scores). The independent variable is the treatment conditions (ND, CD, ED and EDSE groups). Pretest achievement (as measured by pretest recall and pretest transfer scores) and working memory capacity are selected as covariates.

Emwave Desktop Emotion Recognition Technology (ERT) was used to measure students' positive emotions. The subjective rating of mental effort test was used to measure students' mental effort investments. Students' prior knowledge was measured with Work, Energy and Energy Conservation Achievement Test. The same test was used as a post achievement test. Mr. Peanut Test and Backward Digit Span Test were used to measure students' working memory capacities. Finally, a semi structured interview protocol was used to collect qualitative data. Detailed information about instruments, validity and the reliability issues were discussed in the following sections.

3.7.1 Quantitative Data Collection Instruments

3.7.1.1 Emwave Desktop Emotion Recognition Technology (ERT)

Most of the research on using emotional design in multimedia (Plass et al., 2014; Um et al., 2012) used paper based self-report scales (e.g., Positive Affect Scale or PAS) to measure students' learning emotion. However, it has been suggested by the literature that more direct and better measures should be used in order to gain a more accurate perspective regarding students' emotional reaction to the various design elements (Dong, 2007; Mayer & Estrella, 2014). For this reason, instead of self-report paper based measures, the current study used Emwave Desktop Emotion Recognition Technology (ERT) to detect students' emotions.

Emwave desktop is an Emotion Recognition Technology and stress detector developed by the HeartMath Institute (Chen & Wang, 2011). The system is made up of an ear pulse sensor, a USB module plugged into the computer and a software program that plots the heart rhythm patterns. Through infrared lights, the sensor measures the speed of blood flow reaching to the ear lobe per unit of time. The sensor sends the values to the USB module. Based on the blood flow, heart rate (HR) and Heart Rate Variability (HRV) are calculated. By using the software provided by the system, one can monitor HR and related HRV values plotted over real time. In addition, the software program generates a set of values related to the HRV that could be used for emotion analysis (Emwave Pro Library, 2016).

Figure 11 Emwave Emotion Recognition Technology (ERT)

Figure 12 ERT And Students While They Are Using Multimedia Instructional Materials.

It is widely accepted that Automatic Nervous System (ANS) affects heart rate (Acharya et al., 2006). ANS has two components that are functioning oppositely: the sympathetic nervous system and the parasympathetic nervous system. As Hasan, Bègue, and Bushman (2013) indicated, by analogy, the sympathetic nervous system works like an accelerator whereas parasympathetic nervous system works like a brake. Sympathetic nervous system accelerates hearth rates (HR) by stimulating cardiac muscles. Conversely, parasympathetic nervous system causes a decrease in the heart rate (HR) and activated when the organism is at rest and is responsible for the maintenance and control of the internal organs (Hasan et al., 2013). The incoherence or imbalance between sympathetic nervous system and parasympathetic nervous system is observed, when people are in a negative emotional state (Childre & Cryer, 2004, as cited in Hasan et al., 2013). In contrast, when people are in a positive emotional state, the increased synchronization or harmony is observed between two components of the ANS (Bradley et al., 2010). This situation is termed as "coherence" (Rozman et al., 2008).

Lower heart rate is related to higher levels of parasympathetic nervous system activity which is beneficial for relaxation. Higher levels of hearth rate are needed in order to energize the body and in order to show a performance at high-speed. However, for optimal performance and for optimal behavioral change, a harmony between relaxation and energy (i.e., coherence) is needed (Rozman et al., 2008).

It has been shown by the research that there is an important relationship between HRV, emotional states and cognitive functioning (Bradley et al., 2010; Emwave Pro Library, 2016). HRV is defined as "the variation over time of the period between consecutive heartbeats" (Acharya et al., 2006, p. 1031). "Heart Rate Variability (HRV) is a measure of the beat-to-beat changes in heart rate" (Rozman et al., 2008, p. 195). Instead of the average Hearth Rate (HR), the Emwave system uses HRV, because the average HR does not give a detailed picture of our heart's changing rhythms. When the average HR is measured, the moment to moment variations in HR is ignored (Rozman et al., 2008).

Heart rhythm coherence is effected by many factors such as breathing patterns, physical exercises and our thoughts (Emwave Pro Library, 2016). Research showed that one of the most important factors influencing HRV is our emotions (Hasan et al., 2013). According to HRV analysis, when people experience stress and negative emotions such as anxiety, irritation, frustration or depression, higher level of fluctuations in the heart rate is seen. In such situations, irregular and disordered hearth rhythm pattern is observed, reflecting a limited synchronization between parasympathetic and sympathetic branches of the autonomic nervous system which in turn suppresses cognitive functioning and increases stress and instability. In contrast, sustained positive emotions such as care, appreciation, love or joy leads to the harmonious and ordered heart rhythm pattern indicating a successful synchronization between parasympathetic and sympathetic branches of the autonomic nervous system. Such states are regarded to be a psychological ground for the relationship between positive emotions and increased cognitive functioning involving higher levels of perception, memory, attention, creativity and problem solving (Bradley et al., 2010; Fredrickson & Branigan, 2005; Isen, 1999; Rozman et al., 2008). The relationship between certain emotions and heart rhythm pattern could be seen in the following figure. As can been seen from the figure, when a participant feels frustration, an irregular, disordered and incoherent heart rhythm pattern is observed. In contrast, when he or she feels appreciation, a sine wave-like coherent heart rhythm is observed.

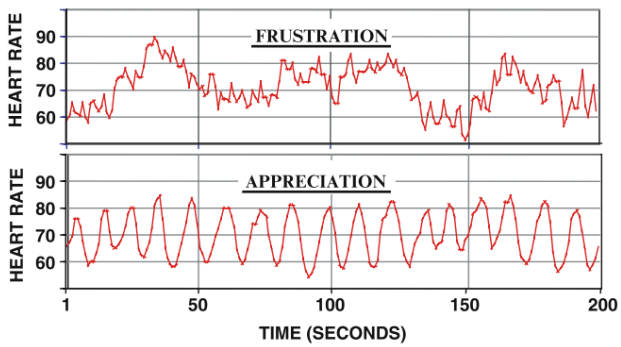


Figure 13 Heart Rhythm Pattern in Response to Negative and Positive Emotion. From Rozman et al. (2008)

Reflecting one's emotional state and performance, HRV is related to the heart rhythm pattern which is independent of HR. Although in most of the situations, changes in HR co-vary with emotional states, the change in emotional states have mainly been attributed to the heart rhythm coherence. "Patterns are independent of heart rate; that is, one can have a coherent or incoherent pattern at higher or lower heart rates" (McCraty & Childre, 2010, p. 12).

The relationship between HR and emotion was also referred by Pekrun et al. (2007) in their emotion classification theory. Based on the degree of activation or arousal, emotions may be activating (i.e., increased HR) or deactivating (i.e., decreased HR). However, as Rozman et al. (2008) pointed out, "it's rhythm, not rate that reflects mental-emotional dynamics and performance ability" (p. 197). The following, some emotions indicated by HRV could be seen:

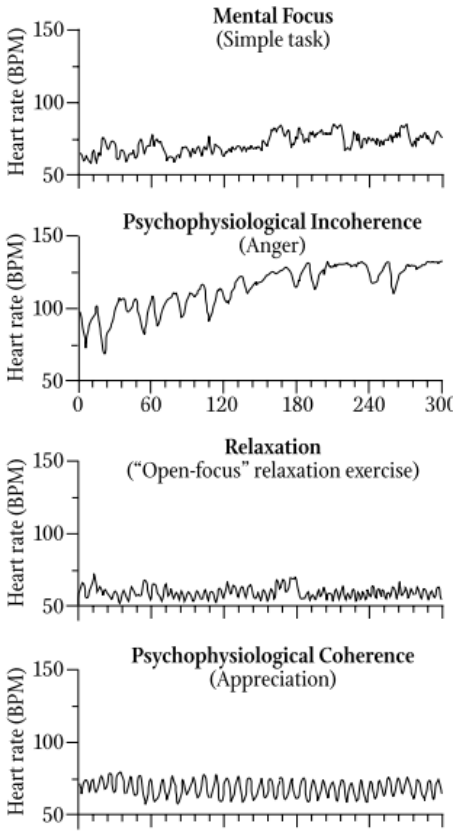


Figure 14 The Relationship between Heart Rhythm Patterns and Different Emotions. From McCraty and Childre (2010).

The Emwave Desktop system uses Heart Rate Variability (HRV) to determine whether a participant is in a coherence state. The coherence state is defined as the psychophysiological state "reflected by a smooth, sine wave-like (coherent) pattern in the heart rhythms" (Rozman et al., 2008, p. 197). As stated before, a high coherence between consecutive heart beats (HRV) is an indicator of the harmony or synchronization between sympathetic and parasympathetic branches of the Automatic Nervous System (ANS). In such situations, people tend to experience positive emotions. A low coherence, on the other hand, is indicative of the imbalance between two branches of the ANS. People tend to feel stress in such circumstances.

The Emwave pro has a software program that plots the HRV over the time and a built-in mathematical algorithm used for the calculation of the coherence scores. The interface screen of the software program is shown in the following figure:

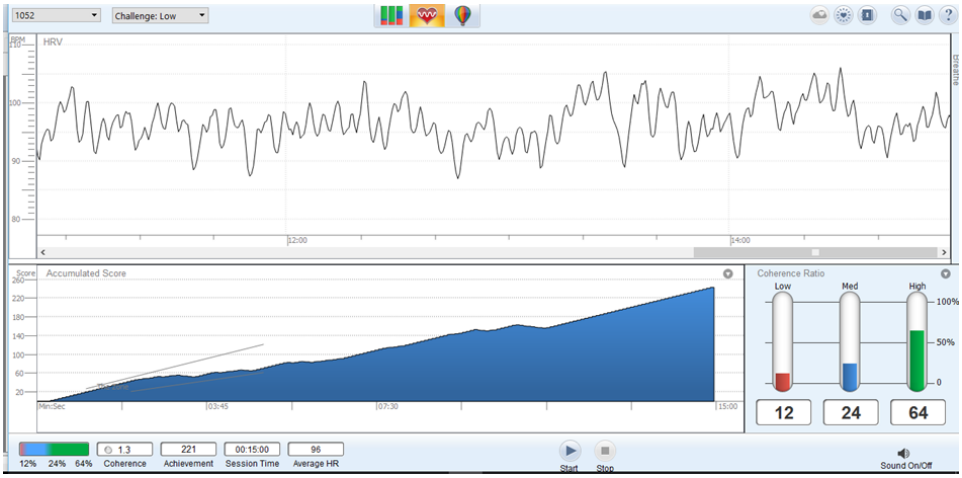


Figure 15 Heart Rhythm Pattern of a Student Who Tends to Show Positive Emotions

The figure shows a student's (student85) heart rhythm pattern and a set of values related to this pattern, while she or he is studying with the multimedia instructional material. At the top of the screen, heart rhythm pattern of the student could be seen. The bottom left portion of the screen shows the accumulated coherence score of the participant. The bottom right portion of the screen displays the coherence ratios. The coherence ratios show the participant's psychological coherence score based on the HRV analysis. Along with the session, the coherence ratios scores are updated every

five seconds in association with the heart rhythm coherence. There are three bars in the coherence ratios graph. The red bar indicates the low coherence (12), the blue bar indicates the medium coherence (24) and the green bar indicates the high coherence (64). Each bar shows the amount of time spent in low, medium and high coherence zones by ratios, proportionate to the total time spent in the complete session (Emwave Pro Library, 2016). The red bar indicates the low coherence between sympathetic and parasympathetic activity. This zone also indicates the amount of "negative emotions" experienced throughout the session. The blue bar indicates the medium coherence between sympathetic and parasympathetic activity. This zone also reflects the amount of "peaceful emotions". Finally, the green bar indicates the high coherence between sympathetic and parasympathetic activity. This zone indicates the amount of "positive emotions" experienced in the entire session (Chen & Wang, 2011). The sum of low, medium and high coherence ratios always equals to 100 % (Emwave Pro Library, 2016). Consider the coherence values of the student85. Low coherence value of the student is 12, whereas medium coherence and high coherence values are 24 and 64 respectively. The positive emotion is calculated by adding medium coherence value and high coherence value and found as 88 (24+64). From these values, based on the coherence values, it could be argued that the student mostly experienced positive emotions (88) along with the session. In addition, Heart Rhythms Patterns of the student was consistent with the calculated coherence value. As can be seen from the graph, since the student mostly experienced positive emotions while using the multimedia instructional material, a smooth, consistent, sine-wave like pattern could be observed. Notice that the sum of all coherence scores is equal to 100 (12+24+64).

In the following figure, data related to another student's (student63) heart rate pattern is shown.

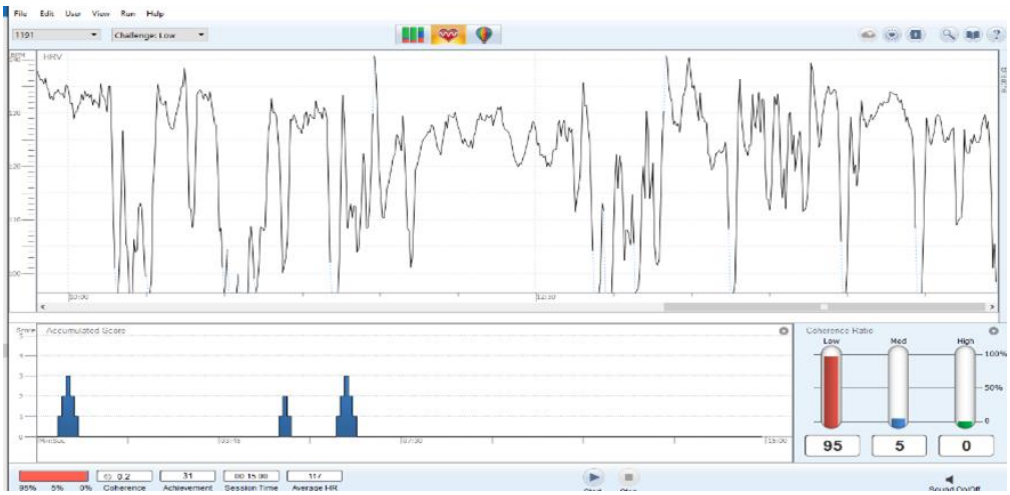


Figure 16 Heart Rhythm Pattern of a Student Who Tends to Show Negative Emotions

Considering the heart rhythms patterns of the student, it could be seen that the students heart rhythms pattern is irregular and disordered following a fluctuating trend with sudden high and low peaks. This trend is also consisted with the student's coherence value. As can be seen from the bottom right portion of the screen, the low coherence value of the student is 95, whereas medium and high coherence scores are 5 and 0 respectively. Based on the disordered and inconsistent heart rhythms patterns and the amount of low coherence value, it could be argued that the student was mostly experiencing negative emotions during the procedure.

3.7.1.2 Mental Effort Test

In the current study, the subjective rating of mental effort test was used (Appendix E). Participants reported their invested mental effort ratings to learn the related topics of the week. The test was originally developed by Paas and Van Merriënboer (1993). The adaptation study of the test to Turkish context was conducted by Kılıç and Karadeniz (2004). Based on these analysis, Cronbach's Alpha internal consistency of the test was found to be .78.

The test was totally used three times. After each week, the students were asked to report their mental effort investments to learn the related topics of the week. For example, in the first week, the following question was asked to the students: "how

much mental effort did you invest to learn the topic of the scientific concept of work and work and energy relationship?" The students rated their perceived invested mental efforts on a nine-point scale ranging from 1 (very, very low mental effort) to 9 (very, very high mental effort). Lower scores indicate lower levels of perceived mental effort investments, while higher scores indicate higher levels of perceived mental effort investments. Since the experimentation needed a three-week period, the mean score of mental effort investments were calculated by using participants' scores obtained from each week.

3.7.1.3 Mr. Peanut (Mr. Cucumber) Test

Mr. Peanut or Mr. Cucumber Test is a Working Memory Capacity (WMC) test developed to measure visual-spatial dimension of the working memory. The test was originally developed by Case (1985) to detect short-term visual memory of the younger populations. In this test, a clown figure (Mr. Peanut) who decorates himself with colored stickers is shown to the participants. The stickers are located on the different parts of the clown's body. The figure is shown to the participants for a length of time. Then, the character disappears for a while and comes back with no stickers. The task of the participants is to recall the location of the stickers by showing the position of the stickers on the clown's body.

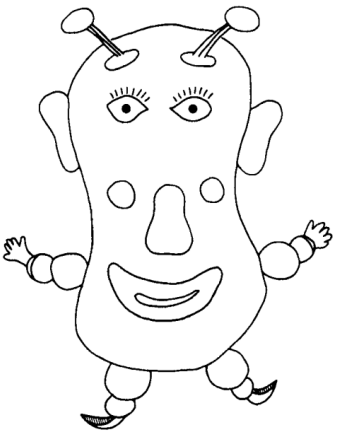


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Figure 17 Clown Figure Presented in the Mr. Peanut Test

In this study, a computerized version of the test was used (Inquisit Scripts, 2016). The instructions about how to use the test was translated into Turkish by the researcher. The test starts with an empty clown figure and a welcoming message underneath it which could be given as follows:

> This is Mister Peanut. He's a friendly guy. He enjoys decorating himself with stickers.
>
> - Sometimes he puts them on one leg.
> - Sometimes he puts them on one antenna.
> - Sometimes he puts them on one cheek.
>
> Your job is to remember and show me where he put the stickers.

After the welcoming page, the participants face with two practice sessions. In the first part of the practice session, there are two clown figures. On the left portion of the screen, there is a clown figure who decorated himself with the colored stickers. On the right side, there is a clown figure without the stickers. The clown on the right is supposed to be filled with stickers by looking at the clown on the left. Meanwhile, the following text is shown to the participants: “here Mr. Peanut has decorated himself. Can you show me on the empty Mr Peanut, where he put the stickers? Use the computer mouse”

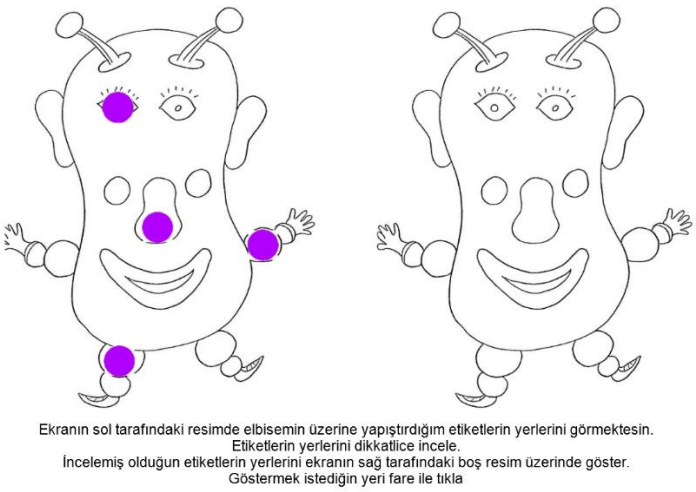

Figure 18 Practice Section of the Mr. Peanut Test

In the next screen, participants continue with the second part of the practice session. But, this time, the two clown figures are not together. First, the participants see the clown figure with the stickers on it. After that, the figure with stickers disappear and then appear with no stickers. Before this procedure, the participants see the following statements on the screen:

> Let's try to do the same using your memory. You will see Mr. Peanut again. He has decorated himself with stickers. Then Mr. Peanut will go away to take off the stickers. Try to remember where he put the stickers. When Mr. Peanut returns, show me where the stickers were.

After the practice session, the participants are directed to the actual task. Before the actual task, the following statements are shown to the participants:

> Let's move on to the real task. It's just like what you did before. You will see Mr. Peanut. He has decorated himself with stickers. Then Mr. Peanut will go away to take off the stickers. Try to remember where he put the stickers. When Mr. Peanut returns, show me where the stickers were.

In the real task, the numbers and the locations of the stickers are getting more complicated in accordance with the correct answers given by the participants. The test has seven levels and the levels are tested in a progressive manner. In each level, participants see three trials.

In the first level, the participants face with one sticker. The sticker could be located on the three different parts of the clown’s body. In order to move up to the next level, the participants should successfully recall at least one of all three presentations. The following, a sample screenshot is given from level 1:

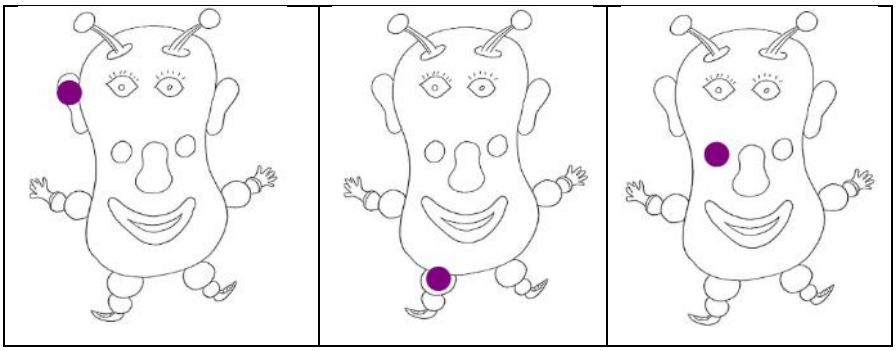

Figure 19 Level 1 of the Mr. Peanut Test

In the second level, as in the first level, the clown figure is shown three times. But this time, the clown decorates himself with two stickers. Again, if the participants are move to the next level (level 3), they should be successful in recalling at least one of the all three presentations. The following, a sample screenshot is given from level 2:

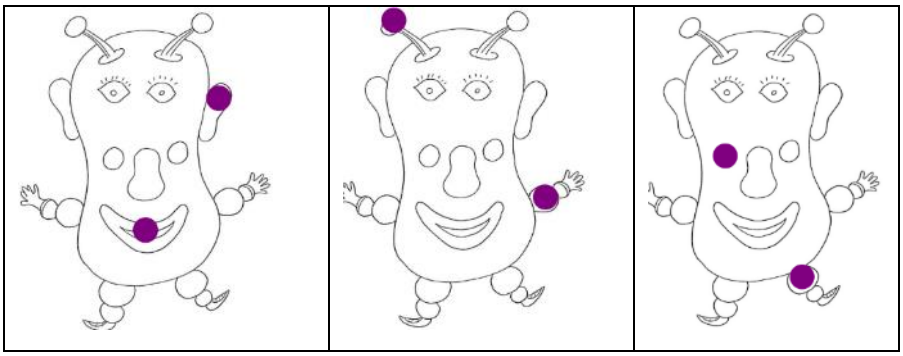

Figure 20 Level 2 of the Mr. Peanut Test

If a participant is not able to recall at least one of all three trails in one level, then the test is ended up.

The scoring procedure of the test was determined by (Morra, 1994). A subject can get one point for each progressive level, when he or she correctly recalls at least two trials. If the subject recalls only one trial, then one-third of a point is given to the subject. The total scores of the subject is rounded up to the nearest unit (Morra, 1994). For example, consider the following scenarios:

Table 5 Examples of Student Responses to the Mr. Peanut Test, Morra (1994).

Student A		Student B		Student C	
Level	Response	Level	Response	Level	Response
1.	+ + +	1.	+ + –	1.	+ + +
2.	+ – +	2.	+ – +	2.	– + +
3.	+ + –	3.	– + –	3.	+ – –
4.	– + –	4.	– – +	4.	– + +
5.	– – –	5.	– – –	5.	– + –
				6.	– – –

As can be seen from Table 5, Student A and Student B couldn't recall at least one trail of all three trials in level 5. Hence, the test was stopped for both of these students. On the other hand, student C mastered level 5, whereas he or she failed in level 6. For the calculation of the total score for one of the three students, consider student A. This student correctly recalled at least two trials from level 1 to the level 3. However, the student only recalled one trial in level 4. For this reason, Student A got one point for level 1, one point for level 2, one point for level 3, and one-third of a point in level 4. Totally, the student A got 3.3 (1+1+1+1/3) points from the test, which could be rounded to the integer of "3". As a result, WMC was founded 3 units for the student A (Morra, 1994).

The validity analysis of the Mr. Peanut Test was conducted by Jager (2004). Among the types of the validities, concurrent validity was used. In order to validate whether the test is a valid measure of WMC, the scores of the participant responses to Mr. Peanut Test were correlated with the scores of the participant responses to WMC dimension of the Wechsler Intelligence Scale for Children (WISC-IV). Based on the analysis, a high, positive and significant correlation was found between the scores obtained from Mr. Peanut Test and the scores obtained from the WMC dimension of the WISC-IV test (r = .51) (Jager, 2004). Thus, it could be stated that the Mr. Peanut Test is a valid measure to detect WMC. On the other hand, the reliability analysis of the test was conducted by Morra and Camba (2009). Spearman–Brown split-half coefficient reliability was found to be .81 for the test. Based on the analysis, it could be argued that Mr. Peanut Test is a valid and a reliable measure of WMC.

3.7.1.4 Backward Digit Span Test

In order to explore the levels of students' verbal WMC as well as visual-spatial one, the researcher conducted Backward Digit Span Test. By doing so, it was planned to make a more accurate estimate on of the WMC. To this end, Backward Digit Span Test of the Psychology Experiment Building Language (PEBL) test battery was used. The PEBL is an open source software which includes various experimental tests offered for free license (Mueller & Piper, 2014). As was for the Mr. Peanut Test, the instructions about how to use test was translated into Turkish by the researcher. In the Backward Digit Span Test, participants are shown a series of digits respectively. The task of the participants is to recall the digits in reverse order. For instance, if the digits of "3" and "6" are presented to the participants respectively, the participants are required to type the numbers in reverse order as "63". In the first level, two digits are shown to the participants. As in the Mr. Peanut test, the participants see three trials in each level. In order to move up to the next level, the participants are required to recall at least one of the all three presentations. The number of the digits in a specific level represents the value of a subject's WMC. In other words, the highest numbers of digits correctly typed in reverse order by the subject equals to the score of subject's WMC (Morra, 1994). For example, if a subject finally could reach to the level of 4, then the WMC of the participant could be calculated as 4.

The reason why the researcher conducted Backward Digit Span test instead of Forward Digit Span test was that Backward Digit Span test measures processing dimension of the WMC as well as recall, whereas Forward Digit Span test concentrates mostly on the recall domain of the memory. Central executive component of WMC may be involved in Backward Digit Span test, since the participants are required to recall the items in reverse order (Kessels, van den Berg, Ruis, & Brands, 2008).

The validity and reliability issues of the Backward Digit Span Test were discussed by Morra (1994), Morra and Camba (2009) and Waters and Caplan (2003). In an article discussing the mental capacity (M capacity) of the younger subjects, Morra

(1994) explored whether different tests of M capacity significantly correlated with each other (Study 1). The results of the study indicated that the results of the Backward Digit Span Test significantly correlated with Mr. Peanut Test (Mr. Cucumber Test) (r = .23), Counting Span Test (r = .29), Figural Intersections Test (r = .25) and Backward Word Span (r = .28). All these results could be interpreted as the concurrent validity of the Backward Digit Span Test with other M capacity tests. The reliability of the Backward Digit Span Test was calculated by Morra and Camba (2009) based on the Spearman–Brown split-half coefficients and found to be .78. Moreover, citing the work of Wechsler (1981), Waters and Caplan (2003) reported test–retest reliability of the Backward Digit Span Test as .83.

3.7.1.5 Work, Energy and Energy Conservation Achievement Test

The achievement test consisted of the two parts: recall and transfer of learning (Appendix D). The test was used both before and after the experimentation. The purpose of the pre-achievement test was to measure students' prior knowledge about the topic. The purpose of the post achievement test was to measure the levels of the achievements of the students who used different multimedia instructional materials. Before, preparing the achievement test, the researcher explored the various print or digital materials such as national and international exams, course and workbooks published by the Ministry of Education and other private print companies and the state exams conducted by the different countries. Then, the researcher prepared an item pool in line with the learning gains declared by the Ministry of Education (Turkish Ministry of Education, 2016). After developing the initial forms of the items, the researcher applied to three science teachers' views as expert opinions. The science teachers discussed the questions in terms their difficulties, suitableness to the students' expertise and other issues that needed to be taken into consideration. After that, the researcher consulted with a subject area expert working in a state university at the Department of Elementary Science Teacher Education. The researcher also consulted with a Turkish language teaching expert in order to check whether the items are clear and understandable by the students. Based on the expert opinions, the researcher revised the items which needed revisions and put the items into the final

forms. The following, distributions of test items with respect to their topics were given.

Table 6 Test Items and Topics

Subjects	Recall Test Item Number	Transfer Test Item Number
• The Scientific Concept of Work and Work and Energy Relationship,	1, 2, 3, 4, 17	1, 3, 14
• Kinetic Energy	5, 6, 12	2, 7
• Gravitational Potential Energy	7, 14, 19	5, 11
• Elastic Potential Energy	8, 10	13
• Energy Transformations and the Conservation of the Energy	9, 11, 16, 18, 20	6, 8, 12
• Energy and Frictional Force	13, 15	9, 10

3.7.1.5.1 Recall Test

The recall test consisted of 20 multiple choice questions (Appendix D). The items in the recall test were developed on the basis of the remember dimension of the Bloom's taxonomy. "When the objective of instruction is to promote retention of the presented material in much the same form in which it was taught, the relevant process category is remember" (Mayer, 2002, p. 228). The following items could be given as examples used in the recall test: "the energy due to an object's height is called _____. Which of the following concepts is true for the missing part of the statement?" "The energy due to an object's motion is called_____. Which of the following concepts is true for the missing part of the statement?" "Which of the followings does gravitational energy depend on?" The participants were awarded for one point for each correct answer and zero points for incorrect answers. The total score for each participant was tallied. Hence, the scores of the participants could vary from zero to 20.

The recall test was piloted with 126 students. For the pilot study, 8th grade students were selected as participants, since the researcher thought that the students had to take the course and sufficient prior knowledge in order to answer the items appropriately. Based on the results of the pilot study, reliability, item difficulty and item discrimination were calculated. The Cronbach's Alpha internal reliability coefficient was found .72. According to Fraenkel et al. (2012), scales with an alpha internal reliability coefficient value of .70 or higher is acceptable. Hence, the reliability value identified for the pilot study was regarded to be convenient for the actual study. The researcher also conducted item analysis to explore whether the items were usable in terms of the difficulty and the discrimination. If the item difficulty is around .50 then the item perfectly discriminates those who know the information of the test and those who do not (Salkind, 2011). Furthermore, an item with a discrimination index of .30 or greater is regarded to be usable (Chase, 1999). Given this suggestion, the average difficulty of the test was found to be .49. Among all the items, only one of the item (item5) was found to be problematic. The item difficulty was .20 and the item discrimination .14 for this item respectively. This item was reviewed by the researcher and the experts and based on the feedback given by the experts, the necessary revisions were made in the item. In sum, the results of reliability and the item analysis showed that the recall test included items that could be useable for the actual study.

3.7.1.5.2 Transfer Test

The transfer test included 14 open-ended items (Appendix D). According to Mayer (2002), based on the revised Bloom's Taxonomy, the Remember dimension represents the retention or recall of the learning, while other dimensions such as Understand, Apply, Analyze, Evaluate, and Create correspond to the transfer of learning. If an instructional designer is to measure the degree of how much meaningful learning occurred, then he or she should consider Understand, Apply, Analyze, Evaluate, and Create dimensions instead of solely focusing on the Remember dimension. Arguably, the most referred dimension for transfer in school based settings is Understand (Mayer, 2002).

A sample item used for the transfer test is as follows: “You can see a sparrow, an eagle and a pigeon sitting in the branches of a tree at the same height. Compare these animals’ gravitational potential energies and explain your conclusion”. Another sample transfer item was: “Suppose that a lion, a mouse and a cat are moving in a frictionless environment at the same speed. Compare these animals’ kinetic energy and explain your conclusion”. Participants were awarded for 1 point for each correct answer on the transfer test.

3.7.2 Qualitative Data Collection Instruments

3.7.2.1 Interview Protocol

Although the researcher predominantly used quantitative data in this study, he also referred to the qualitative data in order to support or strengthen the results of the quantitative data. The researcher addressed different research questions in both quantitative and qualitative phases of the study. The purpose of the quantitative phase of the study was to understand whether the experiment had any effect on the outcome variable. On the other hand, the researcher explored how participants experienced the experimental intervention with the help of the qualitative data (Creswell, 2012). In other words, the students’ experiences regarding the use of emotional design were investigated in the qualitative phase of the study.

The researcher used a semi structured interview protocol to collect qualitative data (Appendix F). Face to face in-depth interviews were conducted with the interviewees. The primary research question that guided the design and development of the interview protocol was the following: “What are the students’ views of using emotional design in multimedia learning?” During the design and development phase of the protocol, the researcher consulted with the opinions of three experts who are working at the different departments of the faculty of education in state universities. All experts had experience in designing and conducting qualitative research. First of all, the researcher and one of the experts came together to develop the interview protocol. The questions in the interview protocol were developed in a manner that were compatible with the research questions of the quantitative phase of the study.

That is, the questions prepared for the interview protocol addressed the research questions of the quantitative phase of the study. The first version of the interview protocol included 12 open ended questions. After the first version of the protocol was developed, the researcher applied to the other two experts' opinions about the protocol. Based on the expert opinions, the protocol was put into the final form. The final form of the protocol included seven questions. The researcher also conducted a pilot study with two students who were not selected for the actual interviews. The purpose of the pilot study was to ensure the clarity of interview questions. The pilot study revealed that the questions were clear and understandable by the students.

3.8 Data Analysis

3.8.1 Quantitative Data Analysis

Both parametric and non-parametric data analysis were implemented for the analysis of the quantitative data. IBM SPSS Statistics 24 was used for the analysis of the quantitative data. Both descriptive and inferential statistics were used to test the hypothesis of the study. The alpha significance level for each quantitative analysis was set as .05.

To test hypothesis 1, students' emotional reaction to the multimedia learning materials during the experiments were recorded by Emwave Recognition Technology (ERT). After each session, students' emotion database (emwave.emdb) were collected by the researcher from each computer. Values related to the students' positive emotions were also noted down on a list in order to minimize data loss in case a technical problem emerges. The researcher collected the data through ERT tool two times a week. Since the duration of the experiment time corresponds to three weeks, the researcher obtained six datasets (2 x 3 = 6). The average positive emotion was obtained by summing all datasets and dividing by six. For the analysis of the data, the researcher first decided to employ a one way analysis of the variance (ANOVA) to explore whether students' emotional reaction to multimedia materials differed significantly. However, normality analysis showed that the data were not

normally distributed. For this reason, a non-parametric alternative of ANOVA, Independent Samples Kruskal-Wallis test was used.

The following statistical analysis were conducted to test hypothesis 2. First, students reported their perceived mental effort investments to learn the related topic after each week's session ended. Then, the average mental effort exerted by the students were calculated by summing each week's score and diving the score by number of weeks (3 weeks). To test the hypothesis, it was planned to employ ANOVA test. However, violation of the normality assumption did not allow researcher to use the test. Hence, Independent Samples Kruskal-Wallis Test was used instead of ANOVA to test hypothesis 2.

Hypothesis 3 was tested by using One Way Analysis of the Covariance (ANCOVA). Whether students' recall and transfer scores significantly differed across treatment conditions, ANCOVA test was conducted twice both for recall and transfer. Students' prior knowledge (recall and transfer) and their working memory capacity were taken as covariates. The dependent variables were recall and transfer of learning. The independent variable was the treatment condition. The control variables were prior knowledge (recall and transfer) and working memory capacity. WMC score was derived by adding student scores obtained from Mr. Peanut visual-spatial short term memory task and Backward Digit Span Test.

There were totally 20 multiple choice questions in the recall test. Participants were awarded for one point for each correct answer and zero points for incorrect answers. The total score for each participant was tallied. Hence, the scores of the participants could vary from zero to 20.

There were totally 14 open-ended items in the transfer test. Participants were awarded for 1 point for each correct answer on the transfer test. While calculating the scores that students obtained from the transfer test, two scorers independently scored student responses to open ended items. One of the scorer was the researcher

himself. Other scorer was a science teacher working in a different school in which the experiment conducted. After the scoring procedure finished, the two scorers came together to compare the results by discussing on the items which were scored differently. The discussion was ended after the scorers reached consensus on the scoring of the specific item. The following, how data analysis was conducted was given in a table with respect to hypothesis:

Table 7 Data Analysis with Respect to Hypothesis

Hypothesis	Measurement	Parametric or non-parametric	Name of statistics
Hypothesis 1	Emwave Emotion Detection Technology (ERT)	Non-parametric	K independent groups Kruskal-Wallis Test
Hypothesis 2	Mental Effort Ratings	Non-parametric	K independent groups Kruskal-Wallis Test
Hypothesis 3a	Recall of Learning Test	Parametric	One Way Analysis of Covariance (ANCOVA)
Hypothesis 3b	Transfer of Learning Test	Parametric	One Way Analysis of Covariance (ANCOVA)

3.8.2 Qualitative Data Analysis

For the analysis of qualitative data, an iterative and progressively comparative perspective of analysis were implemented (Fraenkel et al., 2012). A content analysis was used to analyze the qualitative data in order to reveal "patterns, themes and categories" in interview data. "Content analysis is used to refer to any qualitative data reduction and sense making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" (Patton, 2002, p. 453).

The researcher followed the following steps while analyzing the data: First of all, the audio recorded data obtained from interviews were transcribed into the text files.

Each text file was given a code number in order to preserve the anonymity of the participants. Then, the researcher read all the text files several times carefully going back and forth. Together with transcribing, reading the whole data several times made researcher get a general sense of the data. As a next step, taking research questions into account, the researcher started to code the data. "Coding is the process of segmenting and labeling text to form descriptions and broad themes in the data" (Creswell, 2012, p. 243). The researcher then listed the all codes derived from the analyses. Based on the similarities and discrepancies, the researcher grouped some of similar codes as single codes and omitted the redundant codes from the list. After several readings, last form of the list of the codes were developed. Finally, codes that pertained to similar constructs were grouped as sub-categories and categories. A theory driven approach was used while coding data.

Reliability of data was ensured with inter-coder reliability value. In order to determine inter-coder reliability, %20 (6 interviewees) of the transcribed data were coded independently from the researcher by an expert in the field who had experience in analyzing qualitative data. Then the researcher and the expert came together in order to discuss codes. Inter-coder reliability was calculated based on the following formula suggested by Miles and Huberman (1994):

$$\text{inter} - \text{coder reliability} = \frac{number\ of\ agreements}{number\ of\ agreements + number\ of\ disagreements}$$

Based on the formula, the inter-coder reliability of the coded document was found as % 84.7. As a rule of thumb, Miles and Huberman (1994) suggested that, an inter-coder reliability value of .80 or above is acceptable. Hence, it was concluded that sufficient inter-coder reliability was achieved for the current study.

3.9 Validity and Reliability of Quantitative Data

3.9.1 Validity

Validity is "appropriateness, meaningfulness, correctness, and usefulness of the inferences a researcher makes" (Fraenkel et al., 2012, p. 147). Researchers address the term validity in three different ways: internal validity, external validity and measurement (instrument) validity. What is referred by internal validity is that changes occurring in the dependent variable are due to the independent variable not due to other unintended variables. In other words, internal validity means the validity of inferences regarding the relationship between cause and effect or independent and dependent variables. External validity means the extent of generalizability of the results of a study to other settings, persons, measures and so on. Instrumentation validity refers to the power of instruments to measure what is intended to measure (Creswell, 2012; Fraenkel et al., 2012). In the current study, the researcher collected the following evidences regarding the validity:

Instrumentation validity

Content related evidence of validity

Researchers obtain content related evidence of validity, when they are to control whether the content and format of an instrument are appropriate with what is intended to measure with that instrument. To validate the appropriateness of the content of an instrument, the researcher must be sure that the content of the instrument should represent an adequate sample of items. The format of the instrument should also be valid (e.g., clarity or appropriateness of the items) (Creswell, 2012; Fraenkel et al., 2012). One way to ensure content related validity is to apply to expert opinions. In the current study, the researcher ensured content related evidence of validity by applying to different expert opinions during the design and development phase of the multimedia instructional materials and achievement test. According to feedback from experts, the related materials were revised to ensure content validity.

Criterion-related evidence of validity

Criterion-related evidence of validity refers to comparing an instrument to other instruments that are developed to measure a similar construct. The researcher explores whether the actual instrumentation correlated with the other instrument that is developed to measure the similar construct. The scores obtained from one measurement are correlated with the scores obtained from other instruments (Creswell, 2012; Fraenkel et al., 2012). In the current study, based on the literature review, the researcher reported the concurrent validity of Mr. Peanut Test and Backward Digit Span Test. Mr. Peanut Test was shown to be correlated with WMC dimension the Wechsler Intelligence Scale for Children (WISC-IV), and Backward Digit Span Test was shown to be correlated with other WMC measures such as Mr. Peanut, Counting Span Test, Figural Intersections Test and Backward Word Span.

Threats to Internal Validity

Possible threats to internal validity were discussed by Fraenkel et al. (2012). Possible threats are: (a) subject characteristics, (b) loss of subjects (mortality), (c) location, (d) instrumentation, (e) testing, (f) history, (g) maturation, (h) attitude of subjects, and (i) implementation.

Subject characteristics is a matter of concern especially in studies, where the group are compared on certain variables, because participants in the groups may differ in terms of age, gender, socioeconomic status and so on. If the researcher does not control the variables that may have an interfering effect on the outcome variable, the results may be distrusted. Subject characteristics is also named as “selection bias” (Fraenkel et al., 2012). In the current study, since the research was conducted in its natural environment for three weeks, the researcher could not randomly assign each individual to the treatment conditions. Instead, intact groups were assigned to the conditions randomly. Therefore, in order to minimize selection bias, the researcher controlled the effect of certain variables (Prior Knowledge and Working Memory Capacity) on the outcome variable (learning achievement) by taking these variables as covariates. Since the variables that could be controlled would be unlimited

(Fraenkel et al., 2012), based on the literature review, the researcher selected two of the most influential ones that he thought to have an influential effect on the outcome variable. Covariates are useful when randomization was not possible (Pallant, 2010). Use of more than one covariate may reduce greater amounts of error variances than use of one covariate alone. For this reason, use of two or more covariates was suggested in order to increase the likelihood of detecting significant mean differences across groups (Pallant, 2010; Stevens, 2009). Given this rationale, two covariates, Prior Knowledge and WMC, were used by the researcher.

Another threat to internal validity is *mortality*. The loss of subjects is common in intervention studies which are implemented over some periods of time. Some of the subjects may be absent during the intervention due to some reasons (illness, relocation of the family and so on.) (Fraenkel et al., 2012). In studies, where the groups are compared with each other, the loss of subjects are not likely affect the results of the study, if the loss of subjects are nearly same for the groups. In the current study, seven students could not participate to some parts of the study. This corresponded to one or two students for each group. On that account, mortality was not seen as a major threat to internal validity.

Location threat occurs when the researcher implements the intervention or collect data in a place having a potential of affecting the results of the study (Fraenkel et al., 2012). Since the study was conducted in its natural environment along with the curriculum, location does not seem to be a serious concern of internal validity.

Instrumentation threat is related to use of instruments in a way that results in validity problems. “This is often the case when the instrument permits different interpretations of results (as in essay tests) or is especially long or difficult to score, thereby resulting in fatigue of the scorer” (Fraenkel et al., 2012, p. 170). In the current study, the transfer part of the achievement test included open ended items which had a risk of resulting in different evaluations. In order to minimize the threat, first the researcher evaluated the students’ responses twice. By this way, the

researcher had chance to control student responses many times. Second the researcher had another scorer evaluate the results of students' responses to the transfer items. Then, the researcher and the scorer met to discuss on their evaluations. Items that were differently scored were compared. The researcher and the scorer discussed on differently evaluated item until they reached %100 agreement. Data collector characteristics may also constitute a threat to internal validity. In this study, the same data collector was present throughout the study. Therefore, instrumentation does not seem to constitute a threat to internal validity.

Testing is another threat to validity. In some studies, use of pretest may result in a practice effect. Such effect may have a detrimental effect on the outcome variable, since students had an experience regarding the test (Fraenkel et al., 2012). Apart from the most of the previous studies using short experiment times (e.g., an average of 5 minutes), this study was conducted for three weeks. That is, there is a three-week difference between the pretest and posttest. Hence, the testing threat probably was not issue for the study.

History effect is an unforeseen or unpredicted events that may have a deleterious effect on the outcome variable (Fraenkel et al., 2012). Since the current study was implemented in the computer laboratory, sometimes students experienced technical problems with computers. In such case, students were given technical support as soon as possible.

Maturation effect refers to change that is not attributed to the treatment but may be attributed to the flow of time. For example, throughout a semester, the students may change simply because of ageing or experience but not because of the intervention (Fraenkel et al., 2012). The study was conducted for three weeks. Before the actual implementation, the researcher also spent one extra week for an orientation study and data collection. Apart from the pilot study, totally, it took four weeks to implement the study. Since the intervention time was not too long, the maturation effect was not regarded to be a significant threat to the validity.

Considering *attitude of subjects*, students' opinions about and participation to the study may affect internal validity of the study (Fraenkel et al., 2012). In order, not to affect the attitude of the students negatively, the researcher also did not tell that the intervention was an experimental study but it was a part of their instruction.

Implementation effect is treating experimental group differently that makes them advantageous in terms of results. Implementation threat was not considered to be an important threat for the current study, because, although students had different science teachers, the teachers did not interfere with the experimental intervention. The students followed the course content through computer based multimedia instructional materials.

3.9.2 Reliability

Reliability is "consistency of scores or answers from one administration of an instrument to another, and from one set of items to another" (Fraenkel et al., 2012, p. 147). Most known reliability techniques used for research studies are test-retest, equivalent-forms, internal-consistency and scorer observer agreements methods (Fraenkel et al., 2012). For the current study, the following instruments were used: Achievement Test, Mr. Peanut Test and Backward Digit Span Test. For the achievement test Cronbach's alpha internal consistency, for WMC measures, Spearman–Brown split-half coefficient reliability and test - retest reliability were reported. Both Mr. Peanut Test and Backward Digit Span Test are prominent measures of WMC used in a variety of studies in the literature (Morra, 1994; Morra & Camba, 2009). For detailed information, "Quantitative Data Collection Instruments" part of the study could be referred.

3.10 Trustworthiness of Qualitative Data

In qualitative research, the researcher acts as a data collection instrument. Therefore, in qualitative research, the credibility of a research is restricted to the ability and effort of the researcher (Golafshani, 2003; Patton, 2002).

In qualitative research, different terms are used for reliability and validity, since the terms of reliability and validity are mostly products of quantitative research. For example, in qualitative research "credibility" is used for "internal validity", "dependability" is used for "reliability" and "transferability" is used for "external validity" (Ruona, 2005). Generally, the term "trustworthiness" is used to encompass the terms of credibility, dependability and transferability (Golafshani, 2003).

Lincoln and Guba (1985) suggested some strategies to ensure credibility of qualitative data which could be listed as prolonged engagement, persistent observation, peer debriefing, member checking, negative case analysis, triangulation. In this study, the researcher used prolonged engagement, purposeful sampling, peer examinations, expert reviews to satisfy credibility.

Prolonged engagement is the presence of researcher in the research site for a sufficient amount of time. In this study, qualitative data were collected by means of in depth interviews. An intimate and warm relationship that is built on trust should be formed between the interviewer and the interviewees to obtain valid answers to interview questions (Yıldırım & Şimşek, 2011). In the present study, the researcher and the students knew each other for four weeks. Besides, during the interview, the researcher used various warm up questions to make interviewees comfortable.

"Purposeful sampling focuses on selecting information rich cases whose study will illuminate the questions under study" (Patton, 2002, p. 230). Among the types of purposeful sampling, maximal variation sampling was used. "Maximal variation sampling is a purposeful sampling strategy in which the researcher samples cases or individuals that differ on some characteristic or trait (e.g., different age groups)" (Creswell, 2012, p. 207). By using maximal variation sampling, it was aimed to obtain a more accurate representation of the reality. In order to control content validity and congruence of qualitative questions with the phenomena being researched, three experts were reviewed interview protocol iteratively during the design and development phase of the protocol. Another approach used by the

researcher was peer check. As suggested by Ruona (2005), the researcher asked one of his colleagues to interpret findings during the various stages of the qualitative analysis.

Dependability (reliability) of qualitative analysis was achieved by inter-coder reliability analysis in this study. “Crucial to internal reliability is interrater or inter observer reliability, the extent to which the sets of meanings held by multiple observers are sufficiently congruent so that they describe phenomena in the same way and arrive at the same conclusions about them” (LeCompte & Goetz, 1982, p. 41). To compute inter-coder reliability, a certain amount of transcribed raw data was coded by an independent coder. Inter-coder reliability was calculated with the formula suggested by Miles and Huberman (1994).

The third issue is external validity or transferability. Taking positivistic point of view, external validity refers to generalizability of the findings. However, as indicated by Ruona (2005), the purpose of the qualitative research is not to generalize findings but to understand them. Hence, it is argued that external validity or transferability of the findings should be conceptualized for qualitative research. Nevertheless, some strategies such as thick description and purposeful sampling were offered in order to ensure transferability of the findings (Lincoln & Guba, 1985). Tactic of thick description refers to researcher’s detailed description of the qualitative data. The researcher conveys the raw data in a rearranged manner with concepts and themes without any personal interpretations (Yıldırım & Şimşek, 2011). In the present study, in order to increase the transferability of the data, categories and subcategories derived from the data were tabulated. The site where the research was implemented, characteristics of the participants were described. Furthermore, direct quotations of interviewees’ responses were included in the analysis report.

CHAPTER 4

RESULTS

This chapter presents the results of the study in accordance with the research questions and hypothesis. The chapter will be discussed under two sections. The first section of the chapter includes the results of the quantitative part of the study. The second section of the chapter includes the results of the qualitative part of the study. Before proceeding with the results of the quantitative part of the study, the data were analyzed by the researcher, whether the assumptions of the parametric tests were satisfied (Appendix G).

4.1 Results of the Quantitative Part of the Study

4.1.1 Results Related to Students' Positive Emotion Scores

The first research hypothesis of the study was to test whether students' positive emotions are significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE). Since the data did not meet the assumptions of the parametric tests (Appendix G), a Kruskal-Wallis test, a non-paramentric form of one way analysis of the variance (ANOVA), was used to test the hypothesis. Results of the Kruskal-Wallis test are tabulated as follows:

Table 8 Results of the Kruskal-Wallis Test Regarding Students' Positive Emotion Scores

Group	*N*	Mean Rank	*df*	$\chi 2$	*p*
ND	28	48.59	3	9.86	**.020**
CD	25	41.02			
ED	28	58.02			
EDSE	25	66.42			

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Table 8 displays the results of the test. The results indicated that the test was significant, H (3) = 9.86, p = .020, which could be interpreted as students' positive emotions were significantly affected by using emotional design principles in multimedia. The calculated mean ranks were 48.59 for ND group, 41.02 for CD group, 58.02 for ED group and 66.42 for EDSE group respectively.

Although the overall effect is significant, the exact nature of the difference among groups is not known specifically based on the Table 8. One way to explore the group differences is to look at the box plots generated for the groups (Field, 2013).

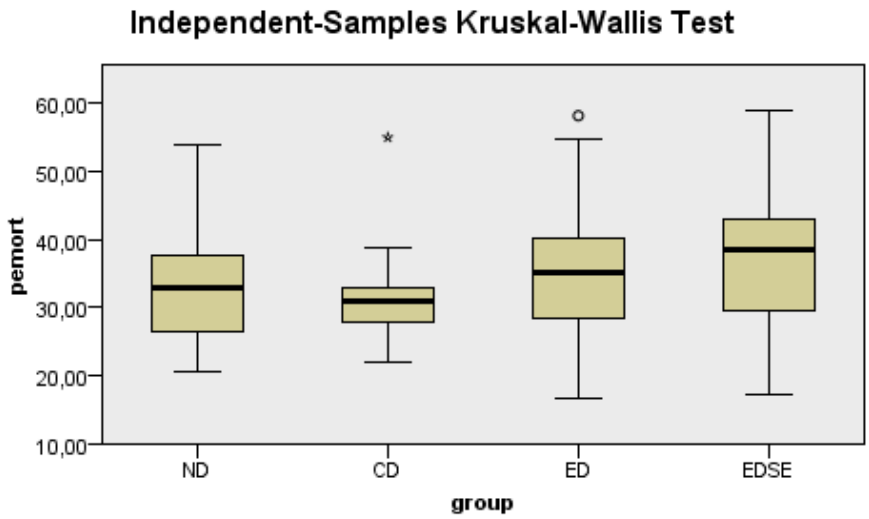

Figure 21 Boxplot Showing the Change of Positive Emotions across Groups

Figure 21 shows the change of students' positive emotions across groups. As can be seen from the box plot graph, medians related to students' positive emotion scores tend to increase across groups, as the levels and complexity of emotional design increases (i.e., from ND to EDSE). However, graphical interpretations alone could be limited. To reveal the exact nature of the differences across groups, follow up tests are needed (Field, 2013).

Follow-up tests were conducted in order to investigate which group significantly differed from each other on positive emotions score. The groups were compared based on the pairwise comparison procedure with adjusted alpha values (Bonferroni correction). With the help of pairwise comparisons, all possible comparison between groups can be performed. However, conducting a series of comparisons might inflate familywise error rates. For this reason, Bonferroni correction is suggested to solve this issue. Alpha value is divided by the number of comparisons to make a more sensitive comparison (Field, 2013). The effect size (*r*) was calculated for each comparison by using $z / \sqrt{N}$ formula (Field, 2013). According to Cohen (1988, 1992), the effect sizes of .10, .30 and .50 indicate small, medium and large effect respectively (as cited in Field, 2013). The pairwise comparisons between groups with effect sizes are given as follows:

Table 9 Results of the Pairwise Comparisons between Groups Regarding Students' Positive Emotion Scores

Sample 1-Sample 2	Test Statistic	*SE*	*z*	*p*	Adj.*p*.	*r*
CD-ND	7.57	8.46	.90	.37	1.00	.12
CD-ED	-17.00	8.46	-2.01	.04	.27	.28
ND-ED	-9.43	8.22	-1.15	.25	1.00	.15
CD-EDSE	-25.40	8.70	-2.92	.00	**.02**	.41
ND-EDSE	-17.83	8.46	-2.11	.04	.21	.29
ED-EDSE	-8.40	8.46	-.99	.32	1.00	.14

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Table 9 displays the results of the pairwise comparisons with adjusted *p*-values. The results showed that positive emotion scores did not differ significantly among students who were taught with multimedia with Colorful Design (CD) compared to multimedia with Neutral Design (ND) ($p = 1.00$), multimedia with Emotional Design (ED) compared to multimedia with Colorful Design (CD) ($p = .27$), multimedia with Emotional Design (ED) compared to multimedia with Neutral Design (ND) ($p = 1.00$), multimedia with Emotional Design and Sound Effects (EDSE) compared to multimedia with Neutral Design (ND) ($p = .21$), and multimedia with Emotional Design and Sound Effects (EDSE) compared to multimedia with Emotional Design (ED) ($p = .1.00$).

The only significant difference with respect to positive emotion scores was found between those students who were taught by multimedia with Emotional Design and Sound Effects (EDSE) compared to those students who were taught by multimedia with Colorful Design (CD) ($p = .020$). The mean rank for EDSE group is 66.42, whereas the mean rank for ED group is 41.02. This result could be interpreted as using EDSE in multimedia produced significant amounts of positive emotions in students compared to using CD.

According to Field (2013), while reporting the results of a study, one should also consider reporting the effect sizes, which indicate the practical significance of the study as well as *p* values which indicate the statistical significance. Considering effect sizes, the largest effect size was observed in CD-EDSE comparison indicating a large effect, based on the Cohen's criteria ($r = .41$). One interesting point was that although ND-EDSE comparison was not significant, the size of the effect was medium ($r = .29$) showing that use of EDSE in multimedia may have a practically moderate effect that contributes to the induction of positive emotions in students compared to the use of ND. In the same manner, although CD-ED comparison was not statistically significant, the effect size for this comparison was nearly medium ($r =.28$) indicating that from the viewpoint of practical significance, use of ED in multimedia may have moderate effect on inducing positive emotion in students

compared to the use of CD. Other effect sizes were small in terms of magnitudes with the values of .12 for CD-ND, .14 for ED-EDSE and, .15 for ND-ED respectively. Note that the smallest effect (r = 12) was observed between CD-ND groups which may be interpreted as using CD in multimedia may have the least effect on inducing positive emotions in students compared to the use of ND.

In conclusion, based on the results given above, it could be argued that hypothesis 1 was rejected. In other words, students' positive emotions were significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE).

4.1.2 Results Related to Students' Mental Effort Ratings

The second hypothesis of the study was to test whether students' mental effort ratings are significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE). Since the data for students' mental effort ratings did not meet the assumptions of the parametric tests (Appendix G), Kruskal-Wallis test, a non-paramentric form of one way analysis of the variance (ANOVA), was used to test the hypothesis. The results of the test are tabulated as follows:

Table 10 Results of the Kruskal-Wallis Test Regarding Students' Mental Effort Ratings

Group	*N*	Mean Rank	*df*	χ^2	*p*
ND	28	45.11	3	9.823	**.020**
CD	25	67.84			
ED	28	56.73			
EDSE	25	44.94			

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Table 10 shows the results of the Kruskal-Wallis test. As results indicated, the test was significant, H (3) = 9.823, p = .020. The results can be interpreted as students'

mental efforts ratings were significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE). Mean ranks calculated for the groups were 45.11 for the ND group, 67.84 for the CD group, 56.73 for the ED group and 44.94 for the EDSE group respectively. To explore the initial picture regarding the difference among groups, a boxplot graph was provided:

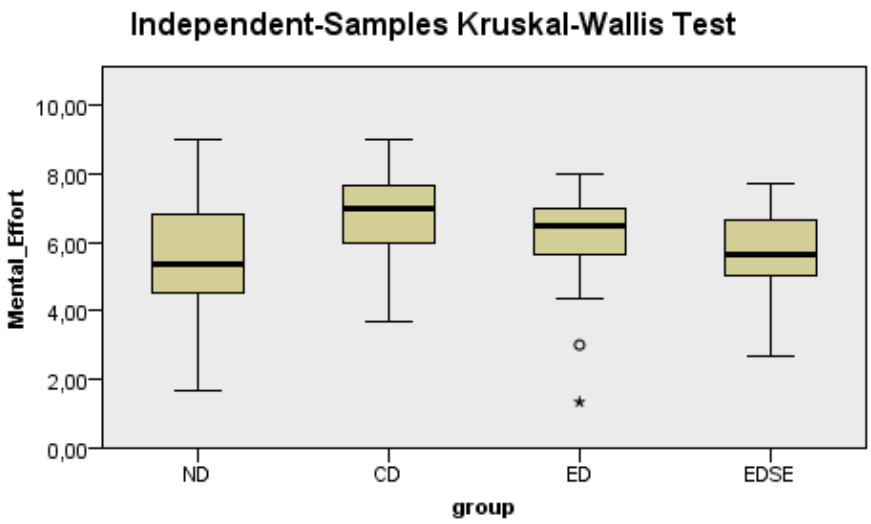

Figure 22 Boxplot Showing the Change of Mental Effort Ratings across Groups

As can be seen from the graph, students' mental effort ratings tend to increase from ND to CD group. However, from CD to ED and EDSE, students' mental effort ratings seem to decrease linearly, as the levels and complexity of emotional design increases. To explore the exact nature of the differences between groups in detail, pairwise comparisons with adjusted alpha values (Bonferroni correction) were carried out. The results are given as follows:

Table 11 Results of the Pairwise Comparisons between Groups Regarding Students' Mental Effort

Sample1-Sample2	Test Statistic	SE	*z*	*p*	Adj.*p*.	*r*
ND-CD	-22.73	8.44	-2.69	.01	**.04**	.37
EDSE-CD	22.90	8.68	2.64	.01	**.05**	.37
ND-ED	-11.63	8.20	-1.42	.16	.94	.19
ED-EDSE	11.79	8.44	1.40	.16	.97	.19
EDSE-ND	.17	8.44	.02	.98	1.00	.00
ED-CD	11.11	8.44	1.32	.19	1.00	.18

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Pairwise comparisons with adjusted *p*-values showed that students' mental effort ratings did not differ significantly among those students who were taught by multimedia with Emotional Design and Sound Effects (EDSE) compared to multimedia with Neutral Design (ND) ($p = 1.00$), multimedia with Emotional Design (ED) compared to multimedia with Neutral Design (ND) ($p = .94$), multimedia with Emotional Design and Sound Effects (EDSE) compared to multimedia with Emotional Design (ED) ($p = .97$), and multimedia with Emotional Design (ED) compared to multimedia with Colorful Design (CD) ($p = 1.00$).

The two significant differences were observed between ND-CD and EDSE-CD comparisons. Students who were taught with Colorful Design (CD) exerted higher levels of mental efforts than the students who were taught by Neutral Design (ND) ($p = .04$) with the mean rank values of 67.84 and 45.11 respectively. Considering the EDSE-CD comparison, students who were taught by Colorful Design (CD) exerted higher levels of mental effort compared to the students who were taught by Emotional Design and Sound Effects (EDSE) ($p = .050$) with the mean rank values of 67.84 and 44.94 respectively.

Considering the effect sizes, the largest effect size was observed for the EDSE-CD comparison ($r = .37$) indicating a medium to large effect. The second large effect was observed for the ND-CD comparison ($r = .37$). Small to medium effect sizes

were observed for the ND-ED, EDSE-ED and ED-CD comparisons respectively (r = .19, r = .19, r = .18). The effect size for ND-EDSE comparison was quite low (r = .00), showing nearly no effect.

After all, according to the results given above, it could be concluded that hypothesis 2 was rejected. Putting differently, students' mental effort ratings were significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE).

4.1.3 Results Related to Students' Learning Achievement Scores

The third hypothesis of the study was to test whether students' achievement scores (as measured by recall and transfer of learning) are significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of prior knowledge and working memory capacity.

The results of the analysis were presented under two sections: results related to students' recall of learning and results related to students' transfer of learning. For each section, a separate ANCOVA was conducted. For the first ANCOVA, posttest recall was dependent variable, type of emotional design or treatment conditions (ND, CD, ED, and EDSE) was independent variable and pretest recall and WMC were covariates. For the second ANCOVA, posttest transfer was dependent variable, type of emotional design or treatment conditions was independent variable (ND, CD, ED, and EDSE) and pretest transfer and WMC were covariates. Before proceeding with ANCOVA, the researcher discussed why prior knowledge (pretest remember and pretest recall) and WMC were selected as covariates.

Choosing Control Variables (Covariates)

Confounding variables (covariates) are regarded as variables that have influence on the dependent variable but do not have influence on the independent variable. Covariates are likely to co-vary with the dependent variable that are needed to be

controlled by the researcher. Generally, covariates are pretest scores, but other variables which have the relationship with the dependent variable could also be covariates (Creswell, 2012). ANCOVA can be used with one or more covariates. If more than one covariate is selected, it can be made a better adjustment for initial differences in within group differences and can be removed more error variances (Stevens, 2009). However, these covariates should be selected carefully. Choosing covariates depends on a variety of factors. First, the theoretical suggestions made by previous research could be taken into consideration. Second, covariates should significantly be correlated with the dependent variable (Pallant, 2010; Stevens, 2009). Considering first suggestion, the literature regarding Cognitive Load Theory (CLT) and Cognitive theory of multimedia learning (CTML) revealed that prior knowledge and working memory capacity could be confounding variables for student learning (Plass, Kalyuga, & Leutner, 2010; Rey, 2012; Sanchez & Wiley, 2006). Considering second suggestion, to explore whether the covariates are significantly related to the dependent variable, first interrelations among dependent variables and independent variables were scrutinized. The results were given as follows:

Table 12 Inter-Correlations for Posttest Recall, Posttest Transfer and Covariates Variables (N = 106)

Outcome Variables	1	2	3	4	5	6
Posttest recall	.34**	.48*	.42**	.10	.07	.15
Posttest transfer	.39*	.56*	.40**	.09	.01	.06
Covariates						
1. Pretest recall	-					
2. Pretest transfer	.48**	-				
3. WMC	.30**	.25*	-			

Note. ** p < .01, * p < .05, WMC = Working Memory Capacity

Considering the relationship between the first dependent variable (posttest recall) and covariates (pretest recall and WMC), it could be easily deduced from the results that there was a positive, moderate and significant correlation between posttest recall and WMC (r =.42, p <.01) (Cohen, 1988), which means that as WMC scores increase, posttest recall scores also tend to increase. In the same way, there was also

a positive, moderate and significant correlation between posttest recall and pretest recall scores (r = .34, p <.01) indicating that as students' pretest recall scores increase, their posttest recall scores also tend to increase. Posttest recall, pretest recall and WMC seem to co-vary. Thus, pretest recall and WMC are regarded as appropriate covariates for the subsequent analysis.

Considering the relationship between the second dependent variable (posttest transfer) and covariates (pretest transfer and WMC), the results indicated that there was a positive, moderate and significant correlation between posttest transfer and WMC scores (r = .40, p < .01) (Cohen, 1988), which means that as WMC scores increase, posttest transfer scores also tend to increase. Besides, there was also a positive, strong and significant correlation between posttest transfer scores and pretest transfer scores (r = .56, p < .01) indicating that as students' pretest transfer scores increase, their posttest transfer scores also tend to increase. When all these evidences are taken into account, it could be argued that prior knowledge (pretest recall and pretest transfer) and WMC are appropriate covariates for further analysis.

4.1.3.1 Results Related to Students' Recall of Learning Scores

To test whether students' recall of learning is significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), a one way between groups analysis of covariance (ANCOVA) was performed with posttest recall score as dependent variable, type of emotional design or treatment conditions (ND, CD, ED and EDSE) as independent variable and pretest recall score and working memory capacity as covariates. Preliminary analysis showed that there were no violations of the assumptions of normality, homogeneity of the variance, independence of observations, independence of the covariate and treatment effect, no high correlations among covariates, linear relationship between covariates and dependent variables and parallelism of the regression slopes. The results of the analysis were given as follows:

Table 13 Results of the ANCOVA Test for Students' Posttest Recall Scores

Source	*SS*	*df*	*MS*	*F*	η^2
Covariate (Pretest recall)	67.78	1	67.78	**7.13***	.07
Covariate (WMC)	126.20	1	126.20	**13.27***	.12
Treatment (ND, CD, ED, EDSE)	102.88	3	34.29	**3.61***	.10
Error	951.32	100	9.51		
Total	20629.00	106			

Note. WMC = Working Memory Capacity, ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference. * $p < .05$.

The results of the ANCOVA test for posttest recall scores are shown in Table 13. Considering covariates, it was found that both pretest recall, F (1, 100) = 7.13, p = .009) and WMC, F (1, 100) = 13.27, p = .000, were significant. The strength of the relationship between WMC and posttest recall (η^2 =.12) was greater than the strength of the relationship between pretest recall and posttest recall (η^2 =.07).

Considering the main effect, it was found that after adjusting for pretest recall and WMC scores, there was a significant mean difference in students' posttest recall scores across the treatment groups, F (3, 100) = 3.61, p = .016. Use of emotional design in multimedia significantly affected students' posttest recall scores. The strength of the relationship between use of different levels and complexity of emotional design in multimedia learning and students' post recall scores was medium as indicated by a partial squared eta of .10 (Green & Salkind, 2005). In other words, use of different levels of emotional design accounted for 10% percent of variance in students' post recall test scores.

As a next step, post-hoc comparisons with Bonferroni correction were performed for multiple comparisons to reveal which groups differed significantly in terms of their posttest recall scores. The results of the pairwise comparisons are given as follows:

Table 14 Means, Adjusted Means and Adjusted Means Difference Regarding Posttest Recall Scores

Group	*M*	*Adjusted M*	1.	2.	3.	4.
1. ND	11.61	11.85				
2. CD	14.44	14.31	**2.46***			
3. ED	13.93	13.86	2.01	-.45		
4. EDSE	14.12	14.06	2.21	-.25	.20	

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference. * $p < .05$.

Table 14 represents the values of post hoc comparisons based on the adjusted means. As can be seen from the table, CD group has the highest adjusted mean score (M = 14.31) of all treatment conditions. The adjusted mean scores of EDSE, ED and ND are 14.06, 13.86 and 11.85 respectively. Among all pairwise comparisons, only the difference between CD and ND groups was found to be significant. The differences between groups for other pairwise comparisons were not significant. CD group (M = 14.31) significantly outperformed ND group (M = 11.85) in terms of their posttest recall scores. Based on these results, it could be argued that hypothesis 3a was rejected. That is to say, students' recall of learning was significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE).

4.1.3.2 Results Related to Students' Transfer of Learning Scores

The last hypothesis of the study is to test whether students' transfer of learning is significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest transfer and working memory capacity. A one way ANCOVA was used to test the hypothesis. The dependent variable was posttest transfer scores. The independent variable was type of emotional design (treatment conditions) (ND, CD, ED and EDSE). Pretest transfer and working memory scores were treated as covariates. Results of the test were given as follows:

Table 15 Results of the ANCOVA for Students' Posttest Transfer Scores

	SS	*df*	*MS*	*F*	η^2
Covariate 1 (Pretest Transfer)	589.92	1	589.92	**37.82***	.27
Covariate 2 (WMC)	168.94	1	168.94	**10.83***	.10
Treatment (ND, CD, ED, EDSE)	44.19	3	14.73	.94	.03
Error	1559.66	100	15.60		
Total	31556.65	106			

Note. WMC = Working Memory Capacity, ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference. * $p < .05$.

Table 15 shows the results of the ANCOVA regarding students' posttest transfer scores. The results indicated that both pretest transfer, F (1,100) = 37.82, p = .000 and WMC, F (1,100) = 10.83, p = .001, were significant covariates. The strength of the relationship between pretest transfer and posttest transfer (η^2 =.27) were greater than the strength of the relationship between WMC and posttest transfer (η^2 =.10). Considering the main effect, results indicated that the treatment effect was not significant, F (3,100) = 0.94, p = .422. Since there was not a significant mean effect regarding post transfer scores across groups, pairwise comparisons were not performed.

Given the results above, it could be argued that hypothesis 3b was confirmed. In other words, students' transfer of learning was not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest transfer and working memory capacity.

4.1.4 Summary of the Quantitative Results

The quantitative part of the study included of testing three hypotheses. *Hypothesis 1* stated that *students' positive emotions are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)*. Based on the results of the analysis, *Hypothesis 1* was rejected. In other words, students' positive emotions were significantly affected by use of different levels and complexity of emotional design in multimedia. Statistically, the only significant difference was observed between CD and EDSE groups. Putting differently, use of EDSE in multimedia induced more positive emotions in students compared to use of CD in multimedia.

Hypothesis 2 stated that *students' mental effort ratings are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)*. Based on the results of the analysis, *Hypothesis 2* was rejected. That is, students' mental effort ratings were significantly affected by use of different levels and complexity of emotional design in multimedia. Statistically, the two significant differences were observed between ND-CD and EDSE-CD comparisons. Students who used multimedia with CD approach exerted higher amounts of mental effort compared to the students who used ND approach. Interestingly, it was found that students who used multimedia with CD approach was found to exert higher amounts of mental effort compared to students who used multimedia with EDSE approach.

Hypothesis 3a stated that *students' recall of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest recall and working memory capacity*. The results of the analysis showed that the Hypothesis 3a was rejected. Students' recall of learning was significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE). The post hoc analysis with pairwise comparisons indicated that only students who used CD approach in multimedia had significantly higher levels of recall of learning scores than the students who used ND approach, whereas other differences were not

statistically significant. *Hypothesis 3b* stated *that students' transfer of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest recall and working memory capacity.* Based on the results of the analysis, the hypothesis was accepted. That is, students' transfer of learning was not significantly affected by use of different levels and complexity of emotional design in multimedia. The summary of the results was also provided as a table in the following page.

Table 16 Summary of Quantitative Results

Hypothesis number	Null hypothesis	Results	Direction of the difference
Hypothesis 1	Students' positive emotions are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)	Rejected	EDSE > CD
Hypothesis 2	Students' mental effort ratings are not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE)	Rejected	CD > ND CD > EDSE
Hypothesis 3a	Students' recall of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest recall and working memory capacity.	Rejected	CD > ND
Hypothesis 3b	Students' transfer of learning is not significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of pretest transfer and working memory capacity.	Accepted	-

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects.

4.2 Results of the Qualitative Part of the Study

The purpose of the qualitative part of the study was to investigate students' opinions with respect to use of emotional design in multimedia. The main research question directing to analysis of qualitative data was "what are the students' views of using emotional design in multimedia learning?" To this end, one to one in depth interviews were carried out with students at the end of the study. The data were analyzed through content analysis to derive "patterns, themes and categories" from interview data (Patton, 2002). Steps followed for qualitative data analysis were discussed in detail in "Qualitative Data Analysis" section of the study.

Based on the results of content analysis, two main categories appeared. The first main category was named as "*Emotional Aspect of Multimedia Learning*", whereas the second main category was named as "*Cognitive Aspect of Multimedia Learning*". Codes, coding frequencies of the related codes (counts and cases), sub-categories, and categories were presented in the following tables:

Table 17 Category of “Emotional Aspect of Multimedia Learning”, Related Sub-Categories and Coding Frequencies

	Categories/Sub-categories		**Code**	**Cases (*N*)**	**Counts (*f*)**
Emotional Aspect of Multimedia Learning	Color		Appealing/Pleasing	15	21
			Attention Grabbing	10	15
			Boring	5	6
			Facilitating	2	4
			Neutral	1	1
			Distracting	1	1
	Facial Expressions	Facial Expressions of Human Characters	Positive Energy	5	5
			Interesting	3	3
			Facilitating	2	2
			Attention Grabbing	2	2
		Expressive Anthropomorphism of Lifeless Objects	Distracting	6	11
			Entertaining	6	6
			Attention Grabbing	5	6
			Facilitating	5	6
			Being Redundant / Absurd	5	6
			Interesting	5	5
			Appealing/Pleasing	4	5
	Sound Effects		Appealing/Pleasing	8	9
			Distracting	6	8
			Sense of Reality	6	7
			Attention Grabbing	4	5
			Neutral	3	4
			Disturbing	2	5

Table 18 Category of "Cognitive Aspect of Multimedia Learning" and Coding Frequencies

	Codes	**Cases (*N*)**	**Counts (*f*)**
Cognitive Aspect of Multimedia Learning	Interactive Exercises and Questions	18	28
	Cognitive Interest	11	20
	Multimedia Principle	12	17
	Real Life Examples	8	11
	Animations	6	7
	Signaling	3	4

Emotional Aspect of Multimedia Learning

One of the two main categories derived from qualitative data was "Emotional Aspect of Multimedia Learning" In this category, students' opinions regarding the use of various emotional design approaches such as color, facial expressions and sound effects were discussed. Accordingly, under the category of "Emotional Aspect of Multimedia Learning", three sub categories were created which could be listed as "Color", "Facial Expressions" and "Sound Effects". The sub category of "Facial Expression" was divided into two new sub categories: "Facial Expression of Human Characters" and "Expressive Anthropomorphism of Lifeless Objects".

Color

Codes derived from students' opinions regarding the use of bright, saturated and attention grabbing colors in multimedia instructional materials were categorized as "Color". In this category, the most frequent code (f = 21) was found as the perception of being "***Appealing/Pleasing***" of the colors. Students were asked their opinions on the use of bright, saturated and attention grabbing colors. Students (N = 15) reported that they perceived colors used in multimedia as being pleasant, and they thought that use of such colors made multimedia materials seem more vivid. Some of these students stated that in particular, warm colors such as red, orange and yellow look much more "sweat" than other colors. They thought that use of such colors were regarded to be more appealing and more pleasing than use of other colors. For example, student18 reported her or his feelings about using such colors in multimedia instructional materials as follows:

> Öğrenci18: Kırmızı… Yani açıyor. Açık kırmızıyı çok seviyorum. Yani, insanın gözünü falan açıyor. Yani, o yüzden. İnsanların daha çok yapası geliyor. Daha çok anlıyorlar, kavrıyorlar, o yüzden kırmızı. Çünkü insan koyu renklerden nefret eder. Kırmızı yemek olarak da iştah açar.
>
> Student18: Red… I mean, it cheers up. I like the light red very much. I mean, it makes one's eyes open and the like. So, that's why. People would be willing to do so. They understand more, comprehend more, that's why red. Because, people hate dark colors. Red appetites as a meal also.

The same student indicated that the bright colors are liked more by the children by saying:

> Öğrenci18: Kahverengi biraz koyu oluyor. Çocuklar açık rengi falan seviyor o yüzden.
>
> Student18: Brown comes a little bit dark. Children love the bright colors and the like.

The second most frequent code (*f* = 15) was the perception of being "***Attention Grabbing"*** of the colors. Students (*N* = 10) reported that use of bright, saturated and vivid colors in multimedia instructional materials had an effect of grabbing their attention. For this effect, students used some statements such as "catching eye", "being salient", "hanging out in the eye", "watching out", "focusing" and "being on the focus". In this regard, one student stated her or his feelings as follows:

> Öğrenci9: Renkler göze çarptığı için, dikkat çekici renkler olduğu için sıkılmıyorsun. En azından sadece oraya odaklanabiliyorsun. Hani başka şeylere… Atıyorum… Mesela, renkler biraz daha sıkıcı ve monoton olsaydı, insanın canı sıkılırdı bana göre. İster istemez başka yerlere bakardım. Ama renkler dikkat çekici olduğu için insanın ister istemez dinleyesi, bakası geliyor.
>
> Student9: Since the colors are catching the eye, since they are attention grabbing colors, you are not bored. At least, you are focusing only there. You know… To another things…For example, if the colors would be more boring and monotonous, people would be bored if you ask me. I would look at elsewhere willy-nilly. But since the colors are attention grabbing, people inevitably feel like they should listen and look at the lesson.

The third frequent code (*f* = 6) of the color sub category was the perception of being "***Boring"*** of the gray-scale color scheme. Students (*N* = 5) thought that using black and white grayscale color scheme in multimedia learning was "***Boring".*** For this issue, students stated that use of grayscale color scheme in multimedia did not look pretty. These students indicated that more colorful approach would be more beautiful and meaningful, compared to the grayscale scheme, since grayscale scheme made them feel bored. One student expressed his or her feelings about this issue as fallows:

> Öğrenci6: …Renkli [düzen] kullanılsaydı… İçimi sıkmazdı o zaman. Karanlık oda gibi. Bilmiyorum yanlış mı düşünüyorum ama öyle…
>
> Student6: … If colorful [scheme] was used… It wouldn't bore me then. It was like a dark room. I don't know if I am wrong but I think in that way.

Students (*N* = 2) thought that use of bright, saturated and attention grabbing colors acted as a "***Facilitating***" role for their learning (*f* = 4). Students specified that bright, saturated and attention grabbing colors were useful in that they helped "remembering" and "comprehending" of the various parts of the lesson. Colors had an effect of "sticking in the mind" and "retrieving the information in the exams". For example, one of the students stated his or her view about this issue as follows:

> Öğrenci14: Yani, görsel… Amaç insan… Görseller insanın beynini açar. Sınavda aklına getirir [bilgiyi]. Yani… Renksiz olduğu zaman benim aklıma gelmiyor şahsen. O yüzden, defterimde de renkli kalemler kullanıyorum.
>
> Student14: Well, visuals… The purpose is human. Visuals open human's mind. Retrieves [information] during the exam I mean… If it is colorless, it [information] doesn't come to my mind personally. Therefore, I use colorful pencils for writing in my notebook as well.

One student had a position of being "***Neutral***" regarding the use of colors in multimedia (*f* = 1), and specified that the bright, saturated and attention grabbing colors did not have any meanings either positive or negative for her or him. When

the student was asked to indicate her or his opinion on using grayscale colorless scheme in multimedia, she or he indicated:

> Öğrenci17: [Gri tonlamalı renkler ile çalışmak] beni hiçbir şekilde etkilemedi. Renkli olsa da aynı şeyler olacaktı renksiz olsa da aynı şeyler olacaktı.
>
> Student17: [Studying with grayscale color scheme] did not affect me under any circumstances. It would be the same thing, whether it was colorful or colorless.

Last of all one student stated that bright, saturated and attention grabbing colors would have a negative effect for having a "***Distractive***" effect on attention (*f* = 1). Therefore, it was stated by this student that grayscale color scheme was more preferable compared to the colorful one. The student indicated that:

> Öğrenci25: Renksiz olduğu için anlatılanlara daha çok konsantre olurdum. Yani renksizi tercih ederdim.
>
> Student25: I would concentrate more on what was being taught, if it was colorless. I mean, I would prefer the colorless one.

Facial Expressions

In this study, various characters were used for the development of multimedia instructional materials. Both humans and lifeless objects were used as characters. For the lifeless objects, expressive anthropomorphism was used to attribute humanoid features to that characters. For the humans, on the other hand, only expressive facial expressions were used. As a result, the category of "Facial Expressions" was divided into two new sub categories: "Facial Expression of the Human Characters" and "Expressive Anthropomorphism of the Lifeless Objects"

Facial Expression of Human Characters

When students were asked to report, their perceptions regarding use of expressive facial expressions for human characters in multimedia, five students stated that using expressive positive smiling facial expressions for human characters had an effect of inducing "***Positive Energy"*** *(f = 5).* Students specified that human characters with

positive smiling facial expressions had affected themselves positively. Students thought that smiling faces used for the human characters made them also smile and be happy. For example, one of the students commented that:

> Öğrenci13: [Karakter] Güldüğü zaman benim de ona karşı gülme, mutlu olma hissim olabilir, ama gülmediği zaman pek renksiz gibi oluyor. Mesela, surat ifadeleri kötü olsaydı bu beni kötü etkilerdi… Daha çok izledim ve daha çok anladım… Gülmediği zaman oraya yönelmem.
>
> Student13: If she or he [the character] smiles, it is possible that I may smile and have a feeling of being happy towards her/him as well, but if she/he doesn't smile, it is like quite colorless. For example, if the facial expression were bad, it would affect me worse. …I watched more, understood more…I don't lean on that way, if the character is not smiling.

Some of the students (*N* = 3) thought that happy facial expressions used for the human characters were "***Interesting***" (*f* = 3). Students thought that happy facial expressions used for the human characters looked very interesting and thanks to these happy facial expressions, they stated that they got more interested towards to the lesson which made them watch and listen to the lesson more. One student stated his/her feelings about this issue as follows:

> Öğrenci19: … Daha güler yüzlü yaklaşmış, daha sıcak görünüyor. Daha sıcak davranıyor. Daha sıcak davranması daha çok ilgimi çekerdi. Daha iyi dinlerdim. Daha anlamaya çalışırdım.
>
> Student19: …. He or she approached more cheerful, look warmer. Behaved warmer. Behaving warmer would attract my interest more. I would listen better. I would try to understand better.

Some students (*N* = 2) stated that facial expressions used for human characters were useful for having a "***Facilitating"*** effect for learning (*f* = 2). Expressive facial expressions were found to have a facilitating effect for learning for some students. Those students argued that facial expression which were changing in accordance with what the characters were doing made them understand the lesson easier. In other words, students thought that they established connections between the expressive

facial expressions and what the characters were doing. For example, one of the students voiced her or his feelings as follows:

> Öğrenci9: …Mesela, cansız varlık kutuyu kaldırıp ileriye doğru götürürken iş yapmamış oluyor, bilimsel anlamda, fen anlamında; o zaman yüzü mutsuz oluyor, oradan hatırlayabiliyoruz. Çağrışım yapıyor… Yine aynı onlar da [canlı varlıklar] cansız varlıklar gibi, bir şey olunca gülüyor, olmayınca mutsuz oluyor. Ama genelde güldükleri için güzel olmuş.

> Student9: …For example, the lifeless object doesn't do work scientifically, when it is taking boxes forward, in that time, their facial expression became sad, we can remember from that. It makes associations. Like lifeless creatures, they [humans] are smiling, when anything happens and become sad when nothing happens. But, they were nice, since they were smiling generally.

Last of all, two students thought that expressive facial expressions used for humans had an effect of being "***Attention Grabbing***" (*f* = 2). One student stated his or her thoughts regarding attention grabbing effect of expressive facial expressions as follows:

> Öğrenci23: Mesela, bu aşçının gülmesi falan iyi olmuş. …Çünkü nasıl desem, o zaman [gülmediği zaman] dikkatimi çekmezdi. Şimdi çekiyor.

> Student23: For example, smile of this cook and the like was nice… Because, how can I say, at that time [when he was not smiling] it wouldn't capture my attention. Now it does.

Expressive Anthropomorphism of the Lifeless Objects

The subcategory of "Expressive Anthropomorphism of Lifeless Objects" included students' views about incorporating humanoid features into lifeless objects. The most frequent code (*f* = 11) in this sub category was being "***Distracting***" of using such an approach. Six students thought that expressive anthropomorphism used for the lifeless objects negatively affected themselves, since they were perceived to be distracting. These students stated that their attention was shifted towards to the expressive anthropomorphism, when it was supposed to be focused on what was being taught. In other words, students argued that their attention was supposed to be

directed towards to the essential elements of the lesson, not to the expressive anthropomorphism used for the lifeless objects. In this regard, one student voiced:

> Öğrenci14: İlk gördüğümde pek ilgimi çekmedi ama sonra, onların suratlarını izlemeye başladım. … İkinci, üçüncü seferde dikkatimi çekti ama birincide dikkatimi çekmedi. Orada suratların olduğunu bile fark etmedim diyebilirim. Dinledikçe, daha çok detaylara dikkat ettim. Dikkatimi dağıtmaya başladılar.
>
> Student14: The first time I saw them, they didn't capture my interest at all, but then, I started to watch their faces. … They captured my attention at the second, third times, but at first, they didn't capture my attention. I could say that I didn't even realize that there were faces. As I listened, I paid attention to the details. They started to distract my attention.

Another student commented his thoughts as follows:

> Öğrenci6: Ama şimdi nasıl konsantre olacağım. Gözlere bak gözlerime bakıyor sanki. Tik oldum. Gözlere bakmaktan tik oldum. O yüzden diğeri daha iyi yani.
>
> Student6: But how can I concentrate now? Look at the eyes, it seems as if they are looking at me. It got my nerves on. It got my nerves on for looking at the eyes. Therefore, the other one is better.

Six students perceived expressive anthropomorphism used for the lifeless objects as being "***Entertaining***" (*f* = 6). Students thought that funny faces used for the lifeless objects made the lesson funnier and entertaining which would be otherwise boring and monotonous. These students also added that expressive anthropomorphism was useful in that it helped them learn the subject by fun. In this regard, one of the students expressed her or his thoughts as follow:

> Öğrenci9: İlk konu sanırım iş yapabilmeydi yanlış hatırlamıyorsam. İş yaparken orada mutlu bir yüz oluyor, yapamayınca mutsuz bir yüz oluyor. Yani eğlenerek öğrenme gibi bir şey oluyor.

> Student9: If my memory serves me right, the first topic was doing work scientifically. When doing work, there was a happy face, when doing not work, there was a sad face. That is, it is like learning by fun.

Five students found anthropomorphism as "***Attention Grabbing***" (*f* = 6). These students thought that anthropomorphism helped them focus more on what was being taught. To those students, thanks to anthropomorphism, they could easily give their focus to the lesson, since anthropomorphism may prevent them from giving their attention to other things. About attention grabbing effect of anthropomorphism, one student said:

> Öğrenci4: Mesela atıyorum bir öğrenci böyle yüz [cansız varlıkların kişiselleştirilmesi] olmadan izliyorsa dikkatini başka şeylere verirdi. Ama böyle yüz olduğunda kutuların yüzünde daha şey oluyor… Daha derse odaklanabiliyor. Yani, daha çok dikkatini çekiyor.

> Student4: For example, assuming that if a student were watching the lesson without the faces like these [anthropomorphism], she or he would give her or his attention to other things. But, when there are faces on the boxes, it becomes more…it could be focused on the lesson more. That is, it captures the attention more.

Five students stated that anthropomorphism was beneficial and effective since they had a role of "***Facilitating"*** their learning (*f* = 6). To these students, anthropomorphism of the lifeless objects by using expressive facial expression as was used for the human characters helped them learn the topic being taught. Student indicated that thanks to the facial expressions that were changing in accordance with what the objects were doing, they could establish the connection between the object's facial expressions and what was being taught. For example, one of the students stated his or her views about the facilitating effect of anthropomorphism as follows:

> Öğrenci7: Topu atarken mesela üzgün ifade vardı topun yüzünde. Enerjilerinden anladım. Olumlu etkiliyor yüz ifadeleri. Top çıkarken gülen surat, inerken üzülen surat oluyordu. Enerji yönünden etkilendim. Yüz ifadesinden aklıma geliyor.

> Student7: When the ball was released, for example, there was a sad facial expression on the ball's face. I understood from their energies. The facial expressions affect positively. When the ball was heightening, there was a smiling face, when it was lowering down, it became a sad face. I was impressed by means of the energy. It calls to my mind from the facial expression.

Five students thought that use of anthropomorphism for the lifeless objects were perceived as ***"Being Redundant / Absurd"*** (*f* = 6). These students thought that anthropomorphism did not have any relationships with what is being taught, and defined such approaches as being "redundant" and "repelling". For example, students expressed their views on the use of anthropomorphism as follows:

> Öğrenci24: …Bunlar saçma biraz ya. Arabanın üstünde göz olur mu ya?
>
> Student24… These are a bit absurd. Is it normal to be the eye on the car?
>
> Öğrenci14: Evet. …İnsanlar çok tuhaf ve o kamyondan nefret ettim. Yük taşıyıcı kamyon… Tipi çok tuhafıma gidiyor ve şu kutular da çok itici. Suratları değişiyor çünkü… Güzeldi, ama bazıları gerçekten çok abartılı olmuş. Güzel görünüyor bazıları, bazıları da çok abartılı olmuş.
>
> Student14: Yes…Humans are quite weird and I hated from that truck. The transporter truck. Type of it comes me very weird and these boxes are quite repelling. Because their faces are changing…it was nice, but some of them were really exaggerated. Some of them look good, some of them were really exaggerated.

Five of the students found the anthropomorphism approach as "***Interesting***" (*f* = 5). These students thought that it would be more interesting for children to use such approaches in multimedia learning materials than the ordinary ones. For instance, some of the students commented that:

> Öğrenci5: Mesela bunu canlı yapmışlar. Buna göz yapmışlar. Bu çocukların ilgisini daha çok çeker böyle.
>
> Student5: For example, they made this alive. They made eyes for this. It would attract children's interest more by this way.
>
> Öğrenci19: Cansız varlıkların yüzü olması daha iyi... Çünkü az evvelde söylediğim gibi daha çok ilgi çeker.

> Student19: It is better to have the face for the lifeless objects. Because as I said a while ago, it would capture more interest.

Four of the students perceived anthropomorphism as being "***Appealing/Pleasing"*** (*f* = 5). These students mentioned about the appealing, pleasing, cheerful effect of anthropomorphism. In the following, some student statements with this regard are presented:

> Öğrenci15: Mesela, top yere düşürüyordu kuma batıyordu. Orada önce gülerken sonra üzgün surat oluyordu. Onlar iyiydi. Onlar güzeldi. Yani, insana zevk veriyor, insanın hoşuna gidiyor.
>
> Student15: For example, the ball was dropping down and then sank into the sand. Therein, at first, they were smiling, then they became the sad face. They were nice. They were beautiful. That is, it gives pleasure to people, it appeals people.
>
> Öğrenci7: …İş makinasının, kutunun gülmesi bizim anladığımızı gösteriyor, seviniyoruz. Hoşuma gitti yani iyi. Kitaplarda falan yok…
>
> Student7: …Smiling of the forklift, smiling of the box shows us that we understand, we become happy. It was pleasing for me, nice. There were no such approaches in the books.

Sound Effects

Sound effect category included student opinions with respect contextual sound effects, which were heard while objects were moving. For example, when a ball was dropped from a certain amount of height, an interesting cartoon ball "whistle down" sound was heard. In this category, most of the students (*N* = 8) perceived sound effects as being **"*Appealing/Pleasing*"** (*f* = 9)**.** Students thought that sound effects were exiting, funny and pleasing and these responses were coded as appealing/pleasing. In the following, sample student responses about the issue are given:

> Öğrenci1:Ses efektleri hoş gösteriyor. … Hoş gösteriyor. Yani iyi gösteriyor. Komik olmuş.

> Student1: Sound effects look appealing … Look appealing. I mean look nice. It was funny.

> Öğrenci3: [Sessiz versiyon] birazcık insanı sıkar gibi oluyor bir zaman sonra izleyip durunca. Birazcık ses olsaymış daha güzel olurmuş.

> Student3: [Soundless version] bores the people though after a certain time as was being watched. It would be better if it included a little bit sound effect.

Some of the students (*N* = 6) thought that sound effects had a negative effect of being "***Distracting***" (*f* = 8). To these students, sound effects interfered with the audio narration. As a result, they indicated that they experienced difficulties on focusing on the audio narration and missed some elements of the instruction because of the sound effects. One of the students commented on this issue as follows:

> Öğrenci14: Sesleri takip edince insan sürekli dinleyemiyor [dersi]. Dikkat dağıtıyor diye düşünüyorum. Yani, zaten görüntüyü biliyoruz. Eğlenceli ama… Anlamam gibi bir şey hissediyorum. Ben anlamam… Öbürlerini bilemem.

> Student14: When following the sound effects, people are not able to listen [instruction]. I believe that they are distracting the attention. I mean, we already know the visuals. They are entertaining but…I feel that I don't understand. I don't understand. I don't know what the others think.

Some of the students (*N* = 6) indicated that using sound effects in multimedia were beneficial in that they augment the **Sense of Reality** (*f* = 7). More specifically, students thought that sound effects make the animations to be perceived more realistic by providing a similar means to the real life. One of the students commented that:

> Öğrenci2: Sesler benzetilmeye çalışılmış. Doğrularıyla benzemeye çalışmış. Orijinalliğe doğru gitmiş, iyiydi. Sesler olmuş yani orijinaline benzetmeye çalışılmış, iyiydi. Mesela, topa vuruyoruz, "çat" diye ses çıkıyor, orada da aynı ses çıkıyor. Yuvarlanma sesi, şıkırdama sesi mesela. Düşünce patlama sesi örneğin.

> Student2: Sounds have been tried to be simulated. They have been tried to be simulated with the original forms. It approximated to the originals, it was nice. For example, when we kick the ball, a sound effect like crash is heard, and the same sound is heard there. Rolling sound, clinking sound for example. Boom sound is heard, when dropping for instance.

Four students indicated that sound effects were beneficial, since they had "***Attention Grabbing***" effects (*f* = 5). These students thought that their attention was captured to the course with the help of the sound effects, when they were distracted or they were bored from watching the lesson. For example, one of the students commented that:

> Öğrenci9: Hem de aynı renkler gibi… Ses olunca, biraz sıkılmaya başlayınca, aniden bir ses çıkınca, direk gözler oraya gidiyor.

> Student9: It is like colors… When there is a sound effect, when you are bored a little bit, when a sound effect is heard suddenly, your eyes are going directly there.

Three students took a "***Neutral***" position against using sound effects (*f* = 4). In this approach, students specified that use of sound effects did not constitute either a negative or a positive meaning for them. They believed that in any usage, either multimedia with sound effects or without sound effects, nothing would change for themselves.

> Öğrenci8:Hımmm bilmem… Sesler fazla fark etmez benim için. Yüz ifadeleri ve renkler yeterince yardımcı oluyor bana. Zaten görüyoruz. Olsa da olur olmasa da olur fark etmez bana.

> Student8: Hmmm don't know… Sound effects do not matter for me a lot. Facial expressions and colors are helping me sufficiently. Anyway, we are seeing. It is same for me with sound effects or without sound effects, it doesn't matter for me.

Last of all, two students found sound effects as "***Disturbing***" (*f* = 5). In this regard, one of a student stated his or her thoughts as follows:

Öğrenci15: Yani çok… Hem çok ses geliyor hem de şey… Nasıl desem? Rahatsız ediyor… Yani gereksiz… Gereksiz buldum o sesleri.

Student15: I mean it is very…both it sounds a lot and … How can I say? It is disturbing…I mean, it is redundant…. I found the sound effects as redundant.

Cognitive Aspect of Multimedia Learning

The category of Cognitive Aspect of Multimedia Learning included student opinions addressing the cognitive design elements used in multimedia instructional materials. Students were asked to report their views on the parts of the instructional materials that they liked most and liked least, parts that facilitated and suppressed their learnings. They were also asked to report their engagement to the course. Student opinions regarding the cognitive dimension of learning were categorized under the cognitive aspect of multimedia learning. The codes derived from the interview data are given as follows based on their frequencies:

- Interactive Exercises and Questions
- Cognitive Interest
- Multimedia Learning
- Real Life Examples
- Animations
- Signaling

The most frequent code under the category of Cognitive Aspect of Multimedia Learning was "***Interactive Exercises and Questions"*** (f = 28). Student views regarding the use of interactive exercises, questions and worked examples in multimedia were coded as "***Interactive Exercises and Questions".*** Students (N = 18) reflected that use of interactive examples, exercises and worked examples in multimedia instructional materials helped them focus more efficiently on the subject, reinforced what was being taught on the instruction phase and facilitated their learnings by this means. For example, one student commented:

> Öğrenci20: Ya mesela bir örnek veriyor ondan sonra altında soru gibi bir şey oluyor. Mesela onlarla pekiştiriyorsun, onlar güzel oluyordu aslında. Anlatıyor anlatıyor mesela ondan sonra hangisi iş yapmıştır gibi sorular oluyor. Onlar pekiştiriyor, onlar güzel oluyor.
>
> Student20: For example, it gives an example and after that there is something of a question under it. For example, you reinforce with them, they actually became nice. Teaching and teaching, for example, and after that there were questions like "which of them were doing scientifically work?" They reinforced, they were good.

The most second repetitive code under the main category of Cognitive Aspect of Multimedia Learning was "***Cognitive Interest***" (*f* = 20). Cognitive interest refers to student interest with respect to cognitive elements of multimedia material, whereas emotional interest refers to student interest with respect to emotional elements of multimedia. The source of cognitive interest is students' own learning, whereas the source of emotional interest is the emotional design elements of multimedia. Based on this distinction, students cognitively become interested towards a material, only if they learn it. Cognitive interest is independent of emotional interest (Harp & Mayer, 1997). Considering the code of "***Cognitive Interest"***, students (*N* = 11) reflected that they were not interested in emotional design elements used in multimedia at all. Instead, they stated that their attention was captured more by the topic itself rather than emotional design and added that they became happy as they learnt new things. For instance, one student voiced:

> Öğrenci10: Ama onlar [duygusal tasarım unsurları] benim ilgilimi çekmiyor da direk ders olarak çekiyor benim ilgimi. Renkler ilgi çekici ama ders daha çok dikkat çekiyor. Mesela, sadece şunlara bakıyorum. 5 kilo mu 2 kilo mu onlara bakıyorum. Önemli olan yerlere… Önemsiz gibi duruyor diğerleri bana.
>
> Student10: But they [emotional design elements] don't capture my attention, the lesson itself captures my attention directly. Colors are interesting but the lesson itself captures attention more. For example, I am just looking at these. Is it 5 kilos or 2 kilos? To the important parts…Other parts seem uninteresting to me.

Another student commented:

> Öğrenci3: Zaten amaç öğretmek olduğu için ben pek rengine dikkat etmiyorum. Niye olmuş bu? Daha değişik olsaymış falan diye değil de öğrenmek için izliyorum.
>
> Student3: Anyway, since the purpose is learning, I don't remark colors at all. Why this was like that? I am not watching it to say I wish it would be different, but, I watch to learn.

Another code under the category was "***Multimedia Principle***" (*f* = 17). Multimedia principle of CTML posits that use of pictures along with words is much more effective than using words alone (Mayer, 2009). Consisted with this principle, interview data reflecting student opinions on the use of words and pictures together to facilitate multimedia learning was coded as "Multimedia Principle". Students (*N* = 12) thought that use of words along with either static or dynamic visuals were more beneficial compared to instructional materials that adopted words only. They indicated that they enjoyed with the use of such an approach in multimedia instructional materials which facilitated their learning. For example, one student stated his/her view on the issue as follows:

> Öğrenci3: Mesela, sadece [sesli anlatım] deseydi bir arabanın gitmesi yani hızlanması kinetik enerjidir deseydi sadece sözle pek olmazdı. Ama burada [öğretim yazılımında] böyle hızlandığını [arabanın] falan da göstermiş, resimlerle kuvvetlendirmiş. Daha iyi olmuş.
>
> Student3: For example, if [the audio narration] said that the drive of a car, the acceleration of the car was the kinetic energy just by word, it would not be sufficiently ok. But here [in instructional software], acceleration of the car or the like was depicted, supported with pictures. It became better.

"***Real Life Examples***" (*f* = 11) was another cognitive element that was used. In the current study, various real life examples were used with which students were familiar from real life. Considering the code of "Real Life Examples", students (*N* = 8) expressed their satisfaction with respect to the appropriateness of the characters and the related contexts to the real life. They also indicated that use of real life examples

was helpful, as they easily concretized abstract concepts. One student stated his/her views about this issue as follows:

> Öğrenci22: Ve hani gerçek kolay cisimlerden, evde bile bulabileceğimiz cisimlerle deney yapılmış ya onlar da iyiydi. Bir de o kuma atılan bilye örneği çekim potansiyel enerjisini baya iyi anlattı.
>
> Student22: And for example, it was conducted experiments from real and simple objects, even we can find at home. They were good as well. In addition, the example of the marble dropped down to the sand taught the gravitational potential energy very well.

One of the other design issues that were thought to have a cognitive influence on students was coded as "***Animations***" (*f* = 7). Students (*N* = 6) thought that supporting what was being taught with animations facilitated their learning. For instance, one student voiced:

> Öğrenci15: O insanların hareket edişi, işte topun düşüşü falan daha çok öğrenmemizi sağladı. Hareketlerle.
>
> Student15: The movement of the humans, the drop of the ball and the like helped us learn more. With the movements.

The same student stated his/her view on animations as follows:

> Öğrenci15: Mesela şey… Arabalar falan gidiyordu… İşte sürat o… Hareket ediyordu. O gerçek gibi olmuş, mesela, arabalar hareket ediyor gibiydi. Yani, gerçek gibi olmuş. Onlar kolaylaştırıyor. Sonra elma falan ağaçtan düşüyor, onlar güzel.
>
> Student15: For example well… The cars and the like were going... That was velocity... It was moving. It was like real, for example, the cars were like they were moving. I mean, it became as if it was the real. They are facilitating. Then, the apple was dropping from the tree, they are nice.

Last of all, the least frequent code was "***Signaling***" (*f* = 4). Students (*N* = 3) specified that they also liked "Signaling" techniques used for capturing their attention to the most important parts of the instruction. They indicated that their learning was facilitated thanks to "Signaling" techniques. For example, one student voiced:

Öğrenci22: Mesela, potansiyel enerji konusunda, esneklik potansiyelde, mesela, sıkıştırıyordu orayı. Orada, mesela, ok, kuvveti okla gösteriyordun. O da biraz daha renkli olsaydı aynı şekilde.

Student22: For example, with respect to potential energy topic, with respect to elastic potential energy, for example, it was putting pressure on there. Therein, it was showing the force with the arrow. I wish, it would be a bit colorful in the same vein.

CHAPTER 5

DISCUSSION, CONCLUSION AND IMPLICATIONS

This chapter includes discussion, conclusion and implications sections of the study. The chapter begins with the discussion of the findings in light of other similar studies dealing with using affective design features in multimedia and continues with the conclusion section. Finally, implications for practice and future research directions are proposed.

5.1 Discussion of the Results

The purpose of this study was to investigate the effect of incorporating various emotional design approaches into multimedia learning on students' positive emotion, mental effort and learning achievement (as measured by learning recall and learning transfer). Student views regarding the use of different cognitive and emotional design elements in multimedia were also scrutinized within the scope of the study. The results of the study were discussed along with the literature in the following sections.

5.1.1 Positive Emotions

First of all, the current study investigated whether students' positive emotions were significantly affected by use of different levels and complexity of emotional design in multimedia. Based on the coherence values obtained from HRV analysis through emwave emotion detection device, the results showed that students' positive emotion scores differed significantly with respect to type of emotional design. That is,

materials which adopted different emotional design approaches (ND, CD, ED and EDSE) contributed significantly to the induction of positive emotions among students.

Through face to face interviews, students were asked to report their views on using various design elements in multimedia such as attention grabbing colors, expressive facial expressions (anthropomorphism of the lifeless objects and facial expressions of the human characters) and sound effects. The results of the interview indicated that students generally reported positive views on the use of such design elements in multimedia. The students described such design elements as “attention grabbing”, “interesting”, “appealing /pleasing”, “positively energizing” and “being entertaining”. Considering quantitative and qualitative results together, it could be argued from all of these findings that use of affective design elements in multimedia induce positive emotions among individuals. This pattern of results is consisted with the literature in which use of affective design issues have been showed to produce positive emotions among individuals (Chen & Wang, 2011; Heidig et al., 2015; Tractinsky, Katz, & Ikar, 2000; Wolfson & Case, 2000).

Quantitative results of the study indicated that generally as the extent of emotional design increased, students’ positive emotions also tended to increase. However, the only significant difference among groups was found between CD group that adopted Colorful Design and EDSE group that adopted Emotional Design and Sound Effects. The amount of positive emotions induced for EDSE group was greater than the amount of positive emotions induced for CD group. Given this finding, it seems that multimedia material in which the combination of interesting sound effects, facial expressions (anthropomorphism of lifeless objects and facial expression of human characters) and attention grabbing colors were used was found to be much more effective in producing positive emotions among individuals than the multimedia material that used attention grabbing colors only. Besides, although the difference was not significant, considering the effect sizes, it was observed that use of EDSE in multimedia was found to have a moderate effect that contributed to the induction of

positive emotions in students compared to the use of ND. In the same manner, although CD-ED comparison was not statistically significant, the effect size for this comparison was nearly medium, and indicating from the viewpoint of practical significance that use of ED in multimedia may have moderate effect on students' positive emotions compared to the use of CD. The size of the effect was smallest between CD-ND groups, meaning that as use of CD in multimedia has the least effect on students in terms of positive emotion induction compared to the use of ND. Taking into consideration of all statistical and practical differences into account, the results are consisted with the current literature on emotional design. That is, as expected, more positive emotions were induced among students as the amount of emotional design elements increased (Dong, 2007; Plass et al., 2014; Um et al., 2012).

In the literature, most of the studies on emotional design, compared multimedia material that used a set of emotional design elements together with the material that used only simple black and white gray scale color scheme (Neutral Design). In other words, in most of the studies, two extreme versions of multimedia materials in terms of emotional design (one with nothing and one with everything) were compared with each other (e.g., Dong, 2007; Mayer & Estrella, 2014; Um et al., 2012). What makes the current study distinctive from most of the other studies regarding emotional design is that this study investigated the effect of emotional design in a gradually increased manner (ND, CD, ED and EDSE) rather than considering all emotional design elements together. As stated before, studies regarding the use of emotional design are just beginning and the discrimination of different design issues and their distinctive effects on positive emotions and learning is not at the expected level (Heidig et al., 2015). What is more, different results regarding positive emotions were observed in the literature when emotional design elements in multimedia were used together and separately from each other. For example, Park, Knörzer, et al. (2015) investigated the effect of using expressive anthropomorphism in multimedia compared to the use of colorful design, and concluded that anthropomorphism did not have a significant effect on positive emotions compared to the colorful design.

Likewise, in their study about the effect of using colors and rounded objects, Plass et al. (2014) found that use of colors in combination with rounded objects induced positive emotions. However, in another experiment conducted by the same research group, it was found that use of such design elements separately from each other produced different results. More specifically, it was found that while rounded objects used independently from colors were found to have effects on positive emotions, use of colors alone in multimedia did not have any effects on students' positive emotions compared to use of neutral design. In the same way, adopting one-dimensional use of emotional design, Heidig et al. (2015) found that use of different types of color combinations did not affect students' emotions compared to use of neutral design. Bearing in mind all these results, it seems evident that use of a set of emotional design approaches together is much more effective in producing positive emotions among individuals than use of one emotional design approach. The more different types of emotional design elements are used, it is likely that the more positive emotions are produced in students. Considering the current study, the results are also consisted with this pattern showing that EDSE group which used the combination of attention grabbing colors, expressive facial expressions (anthropomorphism and facial expression of human characters) and interesting sound effects had the highest amount of positive emotions compared to all other groups. In addition, the current study showed that, generally, the amount of positive emotions tended to increase, as the intensity of the emotional design increased.

The findings of the study regarding positive emotions are also consisted with Norman's (2004) three levels of design theory. Visceral level of design corresponds to the subconscious reaction to the physical appearance of the objects. Visceral level of design is linked with the attractiveness of the design. At this level, the main concern is on how things "feel, look and sound". Considering the results of the study regarding positive emotions, one can argue that as the numbers of attractive or entertaining emotional design elements are increased, students' experienced positive emotions also tend to increase.

5.1.2 Mental Effort

Another objective of this study was to test whether students' mental effort ratings were significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE). According to the analysis of the quantitative data, it was shown by the results that multimedia materials which adopted different levels of emotional design affected the amount of mental effort exerted by the students. When the boxplots generated for each group were investigated, it was seen that the amount of mental efforts first increased and then decreased depending on the amounts of emotional design used in multimedia. More specifically, it was found that students who used Colorful Design (CD) expended significantly higher amount of mental effort compared to the students who used Neutral Design (ND), whereas students in Emotional Design and Sound Effects (EDSE) group expended significantly lower amount of mental effort compared to the students who used Colorful Design (CD).

When students were asked to report their views on the use of various design elements in multimedia, it was found that only one student thought that colors had a distracting effect. On the other hand, the majority of the students thought that anthropomorphism and interesting sound effects had a distracting effect on their attention. This finding is in line with the literature. For example, Lehman, Schraw, McCrudden, and Hartley (2007) found that when seductive details were added, less attention was devoted by the participants to the necessary and important elements of an instructional message compared to the seductive details. Furthermore, Lehman et al. (2007) reported that participants spent less time for reading the base text when seductive text was added. Under these circumstances, it could be argued that the amount of mental effort could have been negatively affected due to the use of anthropomorphism and interesting sound effects that had distracting effects, as stated by the students.

It was found by the literature that use of emotional design elements in multimedia also decreased the level of perceived task difficulty (Um et al., 2012), suggesting that

use of emotional design elements in multimedia might have resulted in students perceiving the tasks as “easy tasks to do”. In line with this finding, for the current study, students in EDSE group might have exerted less effort to learn the subject, since they perceived the task as easy due to the use of emotional design elements. This result was also validated by other research indirectly. For example, Haaranen, Ihantola, Sorva, and Vihavainen (2015) found that students who were taught by emotional design considerably spent less time on learning task compared to those students who were taught by the neutral group. In the same way, it was found that affective design elements of a material reduced the amount of time devoted to a task (Sitzmann & Johnson, 2014). All these findings together may explain why students in EDSE group exerted less mental efforts to learn the topic compared to the students in CD group. Students’ attention could have been distracted by a set of emotional design principles (i.e., use of antropomorphism of the inanimate objects, expressive facial expressions of human beings and sound effects together) that could have led students spend less time for the important elements of the instructional messages. Eventually, students may have exerted less effort to learn the topic due to the presence of emotional desing elements.

Learners’ mental effort to be devoted to a task may be influenced by the structure of a learning environment. That is, “learning environments that foster mindful cognitive engagement set up the expectation that trainees need to exert substantial effort to learn the course content” (Sitzmann & Johnson, 2014, p. 3). Learners manage their mental effort exerted according to the perceived task difficulty of the learning materials (Pintrich, 2000). The perception of “being difficult to learn” of the instructional messages that are delivered by the learning environments might actually lead students to exert a substantial amount of effort to make sense of those instructional messages (Sitzmann & Johnson, 2014).

As Clark (1982) indicated, under some circumstances, entertaining materials may lead students to make defective evaluations regarding their capability of exerting the necessary amount of effort to achieve a learning goal. Some students may think that

their efforts to learn a subject will be more efficient, when they are being taught with “more structured methods”. For these students, lower load methods may interfere with the amount of effort they will exert to learn a particular subject. In the same vein, Salomon (1984) specified that

> “Children's inferential learning may depend on what they perceive the material to be and on how efficacious they think they are with such materials. When children perceive materials to be "lifelike," thus apparently "easy stuff," and themselves to be highly efficacious, they may unwarrantingly invest less mental effort in elaborating the material (“mindlessness”, “shallow” processing”) and learn it less well, even though the material may warrant more mental effort investment” (p. 656).

Solomon’s admonishment is congruent with the results of the current study in many ways. Firstly, as stated before, quantitative data analysis indicated that the amounts of expended mental effort were significantly greater for those students who used CD compared to those students who used ND. On the other hand, students in the EDSE group expended significantly lower amount of mental effort compared to those students who used CD. In other words, while use of attention grabbing colors increased the amounts of expended mental effort compared to the neutral design, use of emotional design and sound effects decreased the amounts of expended mental effort compared to the colorful design. It is probable that use of affective design elements such as anthropomorphism of lifeless objects, facial expressions of human characters and sound effects have been perceived by the students as “entertaining and easy to achieve”. The similar pattern of results was evident in students’ responses to interview questions. Students thought that design principles used for ED and EDSE groups were “positive energizing”, “appealing/pleasing”, “entertaining” and “interesting”. In addition, some students thought those design elements used for ED and EDSE were “redundant/absurd” and “disturbing”. In this sense, students’ thoughts about those design elements can explain why they expended less mental efforts.

Students' opinions regarding the cognitive aspects of multimedia learning may also be evaluated within the context of their mental effort investments. The majority of the students stated that they enjoyed with *Interactive Exercises and Questions* provided by multimedia materials. In addition, they reported that they were cognitively interested with the multimedia materials rather than being emotionally interested in the parts of the materials. They stated that they focused on the important parts of the materials ignoring the emotional ones. What is more, students thought that they liked cognitive design elements such as multimedia principles, real life examples, animations and signaling principles adopted for all types of materials. Students thought that those elements facilitated their learnings. These findings may explain why students exerted much effort to materials which did not use ED and EDSE compared to the materials which adopted ED and EDSE.

In sum, both quantitative and qualitative findings together may explain why students' mental effort was decreased due to the use of facial expressions and sound effects compared to the use of colorful design. Firstly, it may be due that students might have been cognitively interested in multimedia materials rather than being emotionally interested. That is, they may have cognitively focused on the important parts of the materials passing emotional design elements. Alternatively, or secondly, materials that adopted emotional design elements such as facial expressions and sound effects might have been perceived by the students as being "easy and entertaining" that led them expend less amount of effort to learn the subject. A similar pattern of results was found in Solomon's (1984) study who found that "easy" and "entertaining appearance" of materials may result in less mental effort investment. In the current study, the decrease of mental effort investment from CD group to other groups may be due that use of interesting emotional design features in multimedia was perceived by the students as "easy to learn" because of their "entertaining appearance". Considering the entertaining appearance of the ED and EDSE materials, students might have made inaccurate judgments regarding the amount of effort they must exert to achieve (Clark, 1982).

5.1.3 Learning Achievement (Recall and Transfer)

The last hypothesis of the study was to test whether students' achievement scores (as measured by recall and transfer of learning) were significantly effected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of prior knowledge and working memory capacity.

Learning achievement was measured as learning recall and learning transfer. Considering recall of learning scores, it was found that students' post recall of learning was significantly effected by use of different levels and complexity of emotional design (ND, CD, ED and EDSE). Pairwise comparisons indicated that the only significant difference was found between colorful design (CD) that adopted bright, saturated and attention grabbing colors and Neutral Design (ND) that adopted black and white grayscale color scheme. Students who were taught by CD material had higher levels of recall scores than students who were taught by ND material. Considering the transfer of learning scores, the results indicated that it was found that students' posttest transfer of learning scores did not significantly change across treatment conditions (ND, CD, ED and EDSE), meaning that use of different levels of emotional design did not contribute significantly to students' post transfer scores.

Considering face to face interviews, when students were asked on their views regarding the use of different design elements in multimedia, some of the students believed that affective design elements such as colors, expressive facial expressions and sound effects had attention grabbing effects. They thought that thanks to such design elements, their attention was captured by the learning materials and therefore they listened and watched the lesson more. On the other hand, some students interpreted affective design elements such as expressive facial expressions and interesting sound effects in the manner of being "distracting", "being redundant / absurd" and "disturbing". These students indicated that they had difficulties to stay focused on the essential and important parts of the instruction due to the emotional elements of the materials, and therefore they believed that they could prefer materials

that included non-emotional design elements to the materials that included emotional ones.

When students were asked to report their views on the materials, many of the students stated that they were satisfied with the use of cognitive design elements such as interactive exercises and questions, multimedia principle, real life examples, animations and signaling and they specified that use of such elements facilitated their learning. Besides, some of the students reflected that use of emotional design elements in multimedia did not contribute to their learning. They argued that "their primary goal was to learn the subject" by saying that emotional design elements were not interesting at all but rather the lesson itself was interesting. Putting it another way, these students reported that they were happy because of learning the subject, learning "new things" not because of the emotional design elements. From this finding, Kintsch's (1980) distinction between *cognitive interest* and *emotional interest* could be revisited. It seems that many of the students became cognitively interested rather than being emotionally interested towards the learning materials. According to cognitive interest theory, the source of interest is students' own learning. As students achieve learning, they pay more attention to learn and become more interested in learning (as cited in Harp & Mayer, 1997). It seems from these results that cognition affects emotion rather than emotion affects cognition.

Based on the quantitative analysis, this study found that students' recall scores were significantly affected by use of emotional design features in multimedia. However, the only significant difference was found between CD and ND groups. Considering the transfer of learning scores, no significant differences across treatment conditions were found anyway. According to these results what can be concluded is that only use of attention grabbing colors affected students' recall of learning scores. Facial expressions and sound effects seemed to not affect recall and transfer of learning. These results are consisted with the study conducted by Park, Knörzer, et al. (2015) who found that expressive anthropomorphism did not result in higher levels of achievement scores compared to the control condition. In addition, the results are

congruent with the study conducted by Haaranen et al. 2015 who compared anthropomorphic graphics to abstract graphics in their effectiveness of learning achievement and found that anthropomorphic graphics did not lead to higher levels of achievement scores compared to the abstract graphics. On the other hand, the results of the study were inconsistent with some of the previous studies regarding the issue. For instance, considering the overall achievement scores (recall and learning), in some studies, (e.g., Mayer & Estrella, 2014; Um et al., 2012), it was showed that use of the combination of attention grabbing colors and anthropomorphism of the lifeless objects together in a multimedia was much more effective than using none of these design features (neutral design). However, such studies adopted "two groups comparison approach" by using multi-forms of emotional design approaches for the treatment group and none of the emotional design approaches for the control group. In such studies, the significant difference may be due to the weaknesses of neutral design and not the strength of emotional design, because in neutral design that adopted black and white color scheme, it may be difficult for learners to discriminate and understand the important the main and important parts of the instruction. Apart from those studies, the current study investigated the effect of emotional design in a gradually increased manner in which the extent of emotional design increased gradually. By this way, the gradual effect of distinct design elements could be explored. When this is the case, different patterns of the results were found from those other previous studies (e.g., Mayer & Estrella, 2014; Um et al., 2012). Anyway, some of the studies later investigated the effect of discriminating various design issues and their effect on learning and found different patterns of results when those design elements were not considered together but considered one by one (Heidig et al., 2015; Park, Knörzer, et al., 2015; Plass et al., 2014), showing a similar pattern of results with the current study.

Considering all these findings together, from the viewpoint of surface and deep learning, it could be argued that at least one emotional design manipulation (attention grabbing, saturated and bright colors) affected surface learning of students (as indicated by recall of learning). On the other hand, none of the emotional design

manipulations had an effect on deep learning (transfer of learning). This is in line with the literature. For example, Brom et al. (2016) found that anthropomorphic faces and funny graphics only superficially affected students' recall of learning scores. Other studies also found that emotional design manipulations were mostly effective for surface learning (Mayer & Estrella, 2014; Plass et al., 2014, experiment 1). As reported by Brom et al. (2016), only the original study of Um et al. (2012) showed that emotional design affected both deep and surface learning. In sum, the current study found that learning outcomes were not much affected by use of different levels and complexity of emotional design. This results may be attributed to the fact that having predominantly cognitive dimensions in design of all learning materials. As a result, emotional design did not have much effect on learning outcomes.

5.1.4 General Discussion

In their model proposition regarding the use of motivational and emotional factors in multimedia, Astleitner and Wiesner (2004) referred to a variable called "mental resource management". They argued that mental research management has three different aspects: "attention" "engagement" and "monitoring". What is referred by attention is that one's concentration to his or her working memory resources to a certain task at a certain time. Engagement is referred as the number of cognitive activities concerning to a certain task at a certain time. Monitoring is linked with monitoring the success of mental efforts and one's capability to change his or her attention and engagement in a consistent and efficient manner to achieve maximum learning (Astleitner & Wiesner, 2004). According to the model, when students' attention is not directed to a certain task, a situation or a process, it may be possible that information processing related to learning may be interrupted or even it may be stopped completely. Another scenario is that even though students' attention is captured by a certain task, it may be probable that students are not engaged in lesson sufficiently. In other words, even though attention is grabbed by the material, students will not succeed, if they don't exert necessary amount of mental effort to learn. Last of all, in some situations, even if the attention is captured and students are cognitively engaged in the lesson, in order to use limited working memory resources

efficiently, students are supposed to have metacognitive capabilities to monitor and control their attention and engagement. Monitoring should assure that the achievement of cognitive activities is progressively assessed for what should be the result of shifting attention and engagement (Astleitner & Wiesner, 2004).

The results of the present study could be congruent with Astleitner and Wiesner (2004)'s argument in many respects. For example, the majority of the students who were taught by Neutral Design (ND) indicated that the ND material that adopted black and white grayscale color scheme did not capture their attention at all, since it was perceived by them as being "boring". They argued that they could have paid more attention to the material, if it had adopted more colorful approach. That is maybe why mental effort investments of the students who used Neutral Design (ND) approach were found to be significantly lower than the students who used Colorful Design (CD) approach. Maybe, due to having black and white grayscale color scheme, students' attentions were not captured by the material at all and thereby they did not expend necessary amount of mental efforts to learn the topic. This was also confirmed by students' recall of learning scores. Students in the ND group had significantly lower amounts of recall of learning scores compared to the students in the CD group, since students in ND group were not engaged in the material sufficiently, as they thought black and white grayscale color scheme was "boring". On the other hand, although the majority of the students perceived Emotional Design (ED) and Emotional Design and Sound Effects (EDSE) materials as "appealing/pleasing", "attention grabbing", "positively energizing", "interesting", "facilitating" and "entertaining", it was found that those students who used ED and EDSE materials showed lower amount of mental effort compared to the students who used CD approach. For this reason, as indicated by Astleitner and Wiesner (2004), attention alone in not enough. Even though students' attentions were captured by the learning materials, inadequate amount of mental effort investment or engagement levels might have resulted non-significant results in terms of learning achievements. In addition, it may be probable that students who used ED and EDSE approaches might have devoted their attentions to emotional design features such as facial

expressions and interesting sound effects too much, when they were supposed to devote their attention to cognitive design features more. Such emotional design issues might have interrupted or stopped their cognitive processing. Indeed, when students were asked to report their views on the use of such design elements, some of them indicated that they were “distracting” and “disturbing”. This finding could be regarded as an additional evidence why students invested less mental effort for these materials and why these materials did not produce higher amounts of learning achievement scores.

Incorporating colors, expressive anthropomorphism of lifeless objects, expressive facial expressions of human characters and interesting sound effects into multimedia could be attention grabbing for students. However, metacognitive skills might also have an effect on the relationship between emotional design and multimedia learning (Moreno, 2006). To which parts and how much attention should be paid to the instruction by the students? Do students have the capability of selectively encoding information by focusing on the more and skimming over the less important parts of the instruction? Do they expend necessary mental effort to learn? Obviously, all these factors may have a role in learning with multimedia (Astleitner & Wiesner, 2004).

In sum, the results of the present study could be linked with The Yerkes–Dodson Law. The law posits that an inverted U-shape relationship exists between students’ arousal and learning performance. It was argued by the law that the arousal level of students should be neither too high nor too low. The maximum performance is observed when the individuals have a medium arousal level (Yerkes & Dodson, 1908, as cited in Rey 2014). Considering the results of the study, it was observed that students in the Colorful Design group showed both higher levels of recall of learning scores and mental effort investment compared to the Neutral Design group. On the other hand, students in the Emotional Design and Sound Effects showed neither higher levels of learning achievement nor higher levels of mental effort investment compared to Colorful Design group. Accordingly, it could be postulated from these results that higher levels of arousal levels induced by use of various

emotional design elements together might have not affected students' performance in a positive way. The results of the present study offer that the ideal way of presenting multimedia materials in a manner that includes neither too much nor too little emotional design elements.

5.2 Conclusion

The purpose of this study was to explore the effect of using different emotional design features in multimedia on students' positive emotion, mental effort and learning achievement (as measured by learning recall and learning transfer). Student views on the use of various cognitive and emotional design elements in multimedia was also scrutinized within the scope of the study.

Considering hypothesis 1, according to the analysis, it was observed that generally, as the amount of emotional design elements gradually increased, students' positive emotions also tended to increase gradually. However, the only significant difference was found between Emotional Design and Sound Effects (EDSE) approach and colorful design (CD) approach. Positive emotions of students who used EDSE group were higher than positive emotions of students who used CD group. As interview data indicated, the majority of the students reported positive views on the use of emotional design elements in multimedia, although a few students reported negative views. Students believed that such design elements were "attention grabbing", "interesting", "appealing /pleasing", "positively energizing" and "being entertaining". What can be concluded from this result is that emotional design in multimedia positively affected students' positive emotions while they are studying with multimedia materials (Plass et al., 2014; Um et al., 2012).

Considering hypothesis 2, the second finding of the study was that type of emotional design (ND, CD, ED and EDSE) affected the amount of mental effort invested by the students differently. The highest mental effort rating was put by the students who were taught by CD. As expected, students who used CD expended more mental effort than the students who used ND. However, contrary to what has been expected,

students in EDSE group expended less mental effort compared to the students in CD group, suggesting that except attention grabbing colors, as the amounts of emotional design elements increased, the amount of invested mental effort decreased. It can be concluded from these results that when attention grabbing colors were added, invested mental effort increased. However, other design manipulations such as facial expressions and sound effects negatively affected students' mental effort investment by decreasing the levels of it. Revisiting qualitative responses of the students, this may be because the following factors: first, students could invest less mental effort to learn a topic, if they perceive materials as "easy to understand" due to interesting and entertaining appearance. Second, as some of students indicated, they may be distracted by facial expressions and sound effects since they believe that such design elements are "redundant", "absurd" and "disturbing" which lead them expend less mental effort to learn the topic. Finally, some students thought that they were cognitively interested in multimedia materials rather than being emotionally interested. As all cognitive design elements were common for all groups, the decrease of the amount of invested mental effort may be because of emotional design elements such as facial expressions and sound effects.

Considering hypothesis 3, the third finding of the study was that use of different emotional design approaches in multimedia was found to affect students' recall but not transfer of learning scores. Considering recall of learning, the only significant difference was observed between CD and ND group, suggesting that students who used bright, saturated and attention grabbing colors showed higher amounts of recall of learning scores, compared to the students who used neutral design approach. On the other hand, use of facial expressions (anthropomorphism of lifeless objects and facial expressions of human characters) and interesting sound effects did not have any effects either on students' recall or transfer of learning scores. Students thought that they were satisfied with cognitive design elements such as interactive exercises and questions, multimedia, animation and signaling principles, real life examples which were common for all groups. It was interesting to note that some students thought that they did not give their attention to emotional design elements (emotional

interest) by giving their focus to what was being essentially taught (cognitive interest).

When the results of the present study considered as a whole, it may be seen that students' positive emotion generally tended to increase, as the extent and amounts of emotional design elements increased. Students positive ratings with respect to emotional design elements derived from the qualitative analysis of the interview also confirmed this trend. Contrary to what has been found by some research studies (Plass et al., 2014; Um et al., 2012), it was found by the present study that students' emotional states induced by the design features of the multimedia materials and their positive ratings regarding the instruction are not directly related to their learning, since liking is not always an indicator of learning (Clark & Lyons, 2010). In other words, higher levels of positive emotions always do not result in higher levels of learning achievement or vice versa. Students may report positive feelings with and satisfaction towards an instruction. Besides, they may exhibit positive emotions during a learning session (Clark, 1982). However, they could invest less mental effort to learn a topic, if they perceive an instruction as "easy to understand" due to interesting and entertaining appearance. Learning is a predominantly mental activity although emotions could have short lasting effects on people's cognitive processing. In the current study, attention arousing effect of positive pictures did not lead students to invest higher cognitive engagement (Calvo and Lang, 2004, as cited in Park, Knörzer, et al., 2015). Nevertheless, it could not be argued that emotional design is useless, since emotional design neither improved students' learning nor hampered it (as seductive details did).

5.3 Implication and Suggestion for Practice

This study investigated the effect of incorporating different emotional design features into multimedia instructional materials on students' positive emotions, mental effort investments and academic achievement (recall and transfer). Students' opinions regarding the use of emotional design elements in multimedia were also

investigated. Based on the results, a set of implications were derived which may be useful for instructional designers and practitioners for their future practices.

First of all, obviously, emotional design features may induce positive emotions in students. However, results indicated that use of different emotional design elements in multimedia did not produce higher levels of cognitive engagement and learning achievement. Only use of attention grabbing colors were effective in terms of students' recall of learning scores. Considering these findings, it could be argued that the instructional designers and practitioners should be careful in their considerations of using emotional design elements in multimedia. They should drop the myth that "liking" always results in "learning" (Clark & Lyons, 2010) and should be aware of potential benefits and pitfalls of using emotional design elements in multimedia. For this reason, instructional designers should first give their priority to promote ***cognitive interest*** rather than ***emotional interest***. They should first use cognitive design elements in multimedia in congruent with the cognitive theories of learning (e.g., CTML and CLT) and then they should incorporate emotional design elements into multimedia carefully by considering the limited capacity of cognitive resources. Simply augmenting emotional interest does not guarantee better learning (Park, 2005). Given this fact, conducting cost-benefit analysis, it is also essential that policy makers should carefully select multimedia materials developed with the intent of augmenting emotional interest.

The present study found that use of expressive facial expressions along with sound effects did not produce better learning outcomes. On the other hand, although use of such design elements was not effective in terms of increasing learning achievements, they were effective in terms of increasing students' positive emotions. In addition, students reported positive ratings as well as negative ratings regarding the use of such design elements. Anyway, unlike seductive details emotional design elements neither hindered nor enhanced learning. Considering all of these, the potential emotional and motivational benefits of such design elements should not be ignored by the practitioners. They may be used for those students who possess low levels of

individual interest towards to the topic and for those who possess low motivation to learn. On the other hand, use of such design elements may “distract or annoy” those students who possess higher levels of motivation and who already found the topic interesting (Song & Keller, 2001). Analyzing different characteristics of the learners may help teachers to utilize emotional design elements more efficiently.

In the present study, students’ opinions regarding both positive and negative experiences of using different emotional design elements in multimedia could be interpreted as students may have different needs about and expectations from different multimedia materials. Accordingly, instructional designers could design learning environments in a manner that is compatible with the distinct learner characteristics. One of the methods of making learning materials more reactive to unique needs of students is personalized instruction. With the help of personalized learning environments, the unique needs of individuals who possess different opinions regarding the use of various emotional design elements in multimedia could be satisfied.

5.4 Recommendations for Further Research

Emotional states that were brought by the students to the learning environment can interact with the emotional states induced internally by the learning environment (Park, Knörzer, et al., 2015; Plass et al., 2014). What is more, learning with emotionally designed multimedia materials may be moderated by non-cognitive individual traits such as “neuroticism, openness, conscientiousness, anxiety, frustration, tolerance, learned helplessness etc.” (Leutner, 2014, p. 175). Future research is needed to clarify how different student characteristics affect their learning with emotionally designed multimedia.

Most of the studies on emotional design compared multimedia materials that used multi-dimensional operationalization of emotional design (i.e. use of color, anthropomorphism and baby face bias together) to neutral design. Further studies are needed that systematically explore differentiated effects of different emotional

design elements. In addition, when exploring the effect of different colors, it would not be plausible to compare the effect of the color to the “no color” condition. It may be probable that any color will be superior to the “no color” condition. To explore the effect of different types of colors on certain variables, the colors may be compared with each other instead of comparing them to the black and white conditions. For example, the effect of warm colors could be compared to the effect of cold colors to reveal their effectiveness.

In the present study, some of the students referred to metacognitive strategies that they used while studying with the multimedia materials. They stated that they focused on the more important and ignored the less important parts of the lesson by managing the amount of attention that they devoted. Considering this finding, it could be probable that learning with multimedia that adopted emotional design may be mediated by metacognitive strategies that one uses. Further studies on emotional design in multimedia learning could be reconsidered by testing the mediating effect of metacognitive factors on learning.

In the present study, some of the students stated that their job was to learn the content, they were interested towards to the topic itself and they were not interested in emotional design elements. On this basis, students’ intrinsic motivation could be considered as well as extrinsic motivational factors for the further studies.

Most of the previous studies on emotional design, including the present study, has focused on natural sciences (e.g. how a virus causes a cold, immunization). On the other hand, cognitive design principles cannot be easily generalized to other domains (e.g. social sciences) (Westelinck, Valcke, De Craene, & Kirschner, 2005). In addition, although incorporating emotional design elements into multimedia learning may be easier and more applicable for the scientific topics, the element interactivity or the difficulty level may be higher in science learning than in social studies learning. Further studies on emotional design could deal with other domains (e.g. social sciences).

Students' emotional reactions to multimedia materials were detected by Emwave Emotion Recognition Technology. In this study, each student could not be assigned to the treatment conditions randomly, the students were assigned to the conditions as groups (classrooms). Future studies could replicate this study in a more controlled laboratory conditions by using Emwave Emotion Recognition Technology and compare the results with the present study. In such studies, it could be also possible to explore students' Hearth Rate Rhythm Patterns instead of average coherence scores. By this way, a more accurate and a detailed picture of emotional states of students could be revealed.

Considering different student views regarding the use of emotional design in multimedia, future studies should investigate the issue in a manner that is more compatible to distict student needs. Effect of emotional design may differ for students with different learning profiles. Different students may be effected differently by use of different emotional design features. Students who have low levels of individual interest toward to the topic and who have low levels of learning motivation may take advantage of emotional design, while other students with higher levels of motivation and individual interest towards to the topic may find emotional design distracting or annoying (Song & Keller, 2001). Students' cognitive resources (e.g., prior knowledge and working memory capacity) and their personality traits (e.g., openness and neuroticism) may affect their emotional states during learning with an emotionally designed multimedia (Knörzer, Brünken, & Park, 2016). In this sense, emotional design features may be classified based on cognitive load and different learning characteristics. Future studies may relate personalized choice based learning environments literature to emotional design (Rey, 2012; Song & Keller, 2001). Another idea would be that the effect of different student characteristics on learning with emotionally designed multimedia could be investigated in a more detailed manner by using regression analysis (Park, Flowerday, et al., 2015). By doing so, partial effects of different variables related to distict student characterstics on learning could be investigated.

5.5 Limitations of the Study

Previous research used external mood inducement procedures (e.g. having students watch comedy films to induce positive emotions) in addition to internal mood inducement ones (e.g. using emotional design features). In the current study, one limitation was that due to the long experiment time and difficulty of the classroom management, external mood inducement was not possible.

Emotional states that were brought by the students to the learning environment can interact with the emotional states induced internally by the learning environment (Leutner, 2014). In addition, learning with emotionally designed multimedia materials may be moderated by non-cognitive individual traits such as "neuroticism, openness, conscientiousness, anxiety, frustration, tolerance, learned helplessness etc." (Leutner, 2014, p. 175). One limitation of the current study was that emotions that were brought by the students to the learning environment and their motivational profiles (intrinsic or extrinsic) were not known.

The current study used Emwave Emotion Recognition Technology to detect students' positive emotions. In order to increase ecological validity, this study was conducted within the curriculum for 3 weeks. Accordingly, randomization of each student to the conditions was not possible. Non-randomized design could have made difficult to control the extraneous factors during the experiment, although the researcher showed the greatest effort to eliminate those factors. One should consider this limitation when interpreting the results of the current study regarding positive emotions.

Another limitation of the study was that multimedia materials only addressed a one topic (Work, Energy and Energy Conservation). The results of the study cannot be easily generalized to other learning topics. Additionally, the results of the study are pertinent to 7th grade students of a particular middle school. As a result, the present findings may be limited those student groups.

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APPENDIX A

APPROVAL FORMS

Form 1: Institutional Review Approval

O.D.T.Ü
FEN BİLİMLERİ ENSTİTÜSÜ
YÖNETİM KURULU KARARI

Tarih: 25.12.2014
Sayı: FBE: 2014/ 3

GÖREVLENDİRME VE İZİN

Bilgisayar ve Öğretim Teknolojileri Eğitimi EABD doktora programı öğrencisi Ahmet Murat Uzun'un 09 Kasım 2015-15 Haziran 2016 tarihleri arasında "*Duygusal tasarım ilkelerine göre hazırlanan çoklu ortam öğretim materyallerinin öğrencilerin duygu durumları ve akademik başarılarına etkisinin incelenmesi*" başlıklı araştırmasına ilişkin hazırlanan anketi, Afyonkarahisar -Merkez-Şemsettin Karahisarı Ortaokulu ve Kocatepe Ortaokulunda uygulama yapmak için görevlendirilme başvurusu incelenmiş; ilgili danışman görüşüne dayanarak adı geçen öğrencinin isteği doğrultusunda görevlendirilmesine oybirliği ile karar verilmiştir.

Prof. Dr. Gülbin Dural *FBE Müdürü*	**Prof. Dr. Gürsevil Turan** *FBE Müd. Yard.*	**Doç. Dr. Sinan Gürel** *FBE Müd. Yard.*
KATILAMADI **Prof. Dr. Ayşen Savaş** *Üye*	**Prof. Dr. İnci Batmaz** *Üye*	**Prof. Dr. Serkan Dağ** *Üye*

Form 2: Provincial Directorate of Ministry of Education Approval

T.C.
AFYONKARAHİSAR VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : 49809702/605/2974521 18/03/2015
Konu: Bilimsel ve Eğitim Amaçlı İzin

VALİLİK MAKAMINA

İlgi : Afyon Kocatepe Üniversitesi' nin 16/03/2015 tarih ve 70813604-044/3303 sayılı yazıları.

Afyon Kocatepe Üniversitesi Eğitim Fakültesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü öğretim elemanı Arş.Grv. Ahmet Murat UZUN' un, Ortadoğu Teknik Üniversitesi Eğitim Fakültesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü öğretim üyesi Prof.Dr. Zahide YILDIRIM'ın danışmanlığında yürüttüğü "Duygusal Tasarım İlkelerine Göre Hazırlanan Çoklu Ortam Öğretim Materyallerinin Öğrencilerin Duygu Durumları ve Akademik Başarılarına Etkisinin İncelenmesi" adlı deneysel ve betimleme çalışması kapsamında ilimiz genelinde Müdürlüğümüze bağlı ortaokullarda anket çalışması yapması ve çalışmaları tamamlandıktan sonra sonuçlarının birer örneğinin İl Milli Eğitim Müdürlüğü'ne teslim edilmesi şartıyla, Müdürlüğümüz Strateji Geliştirme (Ar-Ge) birimi teklifi doğrultusunda, müdürlüğümüzce uygun görülmektedir.

Makamınızca da uygun görülmesi halinde gereğini olurlarınıza arz ederim.

Metin YALÇIN
İl Milli Eğitim Müdürü

OLUR
18/03/2015

Akgün CORAV
Vali a.
Vali Yardımcısı

Ek: 12 sayfa

Karaman İş Merkezi K:5 ARGE Birimi
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e-posta: adsoyad@meb.gov.tr

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Faks: (0 272) 2137605

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Form 3: Applied Research Center Ethics Approval

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816/ 551 — 1088

22.11.2014

Gönderilen : Prof. Dr. Zahide YILDIRIM
Bilgisayar ve Öğretim Teknolojileri Eğitimi

Gönderen : Prof. Dr. Canan Sümer
IAK Başkanı Vekili

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü öğrencisi Ahmet Murat Uzun'un "Duygusal Tasarım İlkelerine Göre Hazırlanan Çoklu Ortam Öğretim Materyallerinin Öğrencilerin Duygu Durumları ve Akademik Başarılarına Etkisinin İncelenmesi" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

22/11/2014

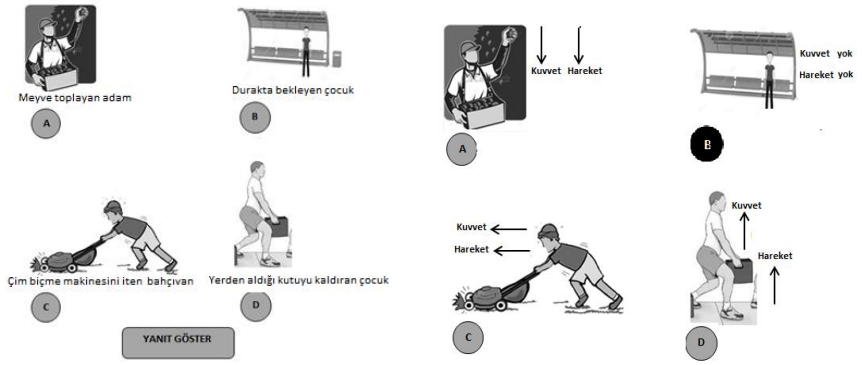
Prof.Dr. Canan Sümer
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı Vekili
ODTÜ 06531 ANKARA

APPENDIX B

SAMPLE STORYBOARDS AND SCENARIOS

Table 19 Sample Storyboards and Scenarios (From Screen 12 to 20)

Ekran Numarası	12
Konu	Çözümlü Örnek - Hangi Durumda Fen Anlamında İş Yapılmaz?



Seslendirme: Haydi, şimdi öğrendiklerimizi pekiştirelim. Ekranda verilen durumların hangisinde bilimsel olarak iş yapılmamıştır? Seçeneklerden birisini işaretleyerek cevabını belirt. Hazır olduğunda, çözümü görmek için yanıt göster düğmesine tıkla.

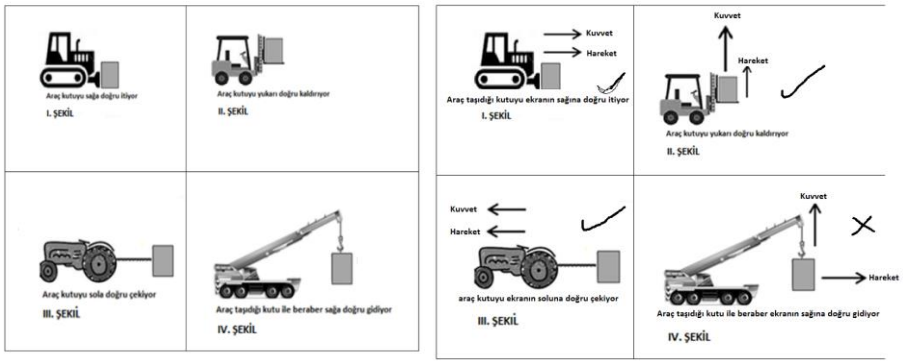
…(a) ilk olarak A seçeneğini inceleyelim. Meyve toplayan adam, meyveyi dalından kopararak sepete koyuyor. Adamın hareketini dikkatlice incele. Adam meyveyi koparmak için (b) **aşağı** doğru bir kuvvet uyguluyor ve yine meyvenin (c) **aşağı** doğru hareket etmesini sağlıyor. Adamın meyveyi toplamak için uyguladığı kuvvetin ve topladığı meyvenin hareket doğrultusunun (d) **aynı** olduğunu görüyorsun değil mi? Kuvvet ve hareketin doğrultusu aynı olduğuna göre, adamın bilimsel anlamda iş yaptığını söyleyebiliriz. (e) C seçeneğinde, çim biçme makinasını iten bir bahçıvan görmektesin. Hareketi dikkatlice incele. Bahçıvan makinayı itmek için (f) **ileriye** doğru bir kuvvet uyguluyor ve makinayı yine (g) **aynı yöne** doğru hareket ettiriyor. Kuvvet ve hareketin yine (h) **aynı** doğrultuda olduğunu görüyorsun. Bu nedenle, bahçıvanın da bilimsel olarak iş yaptığını söyleyebiliriz. (ı) Şimdi de D seçeneğini inceleyelim. Burada, kutuyu yerden yukarı doğru kaldıran bir çocuk görmektesin. Çocuğun kutuyu yerden kaldırmak için (i) **yukarı** yönlü bir kaldırma kuvveti uyguladığını görüyorsun değil mi? Bu kuvvetin, kutuyu (j) **yukarı** doğru hareket ettireceğini de biliyorsun. Öyleyse, kuvvet ve hareketin doğrultusunun (k) **aynı** olduğunu söyleyebiliriz. Bu nedenle**,** bu çocuğun da bilimsel olarak iş yaptığını söyleyebiliriz. (l) Son olarak B seçeneğini inceleyelim. Durakta öylece bekleyen çocuk (m) **kuvvet uygulamadığı gibi** herhangi bir cismin de (n) **kuvvet doğrultusunda yer değiştirmesine** sebep olmamıştır. Bu nedenle, bu kişi bilimsel anlamda iş yapmamıştır. Sorunun doğru cevabı b'dir.

Table 19 (continued)

Senaryo: Birinci bölümde kullanıcı kendine uygun olan yanıtlardan birini seçer. Hazır olduğunda "yanıt göster" butonuna tıklar. Çözümün yapıldığı diğer ekrana geçilir. İkinci bölümde sorunun çözümü detaylı olarak verilir. Ekranda dört adet görselin dördü de bulunmaktadır. Bu görseller, sıra kendilerine geldiğinde büyüyerek ekranın ortasına gelecek ve odaklanılacak ana görsel haline geleceklerdir. Seslendirme ses içeriğini okumaya başlar. Seslendirme (a) bölümüne geldiğinde meyve toplayan adam görseli büyüyerek ekranın ortasına gelir ve odaklanılacak ana görsel halini alır. Arkada kalan diğer tüm görseller soluklaşmıştır. Bu Görsel büyür büyümez adam daldan bir adet meyve kopararak sepete koyar. Adam ikinci meyveyi dalından koparmak için meyveyi tuttuğu anda adamın hareketi duraklatılır. Bu sırada seslendirme de (b) bölümüne gelmiştir. Bu sırada meyve toplayan adamın sağ tarafında yukarıdan aşağı doğru aşağı yönlü bir ok animasyon yardımıyla çizdirilir. Okun hemen altında "kuvvet" yazısı belirir. Seslendirme (c) bölümüne gelindiğinde daha önceki okun yanına aynı yaklaşımla aşağı yönlü olan bir ok animasyon yardımıyla çizdirilir. Okun altında "hareket" ifadesi belirir. Seslendirme (d) bölümüne gelindiğinde aşağı yönlü olan iki oka da aynı anda vurgu yapılır. Daha sonra görsel küçülerek eski yerine geri döner. Seslendirme (e) bölümüne geldiğinde C seçeneğindeki görsel büyüyerek ekranın ortasına gelir ve odaklanılacak ana görsel halini alır. Arkada kalan diğer tüm görseller soluklaşmıştır. Görsel büyür büyümez animasyon oynatılır. Burada bahçıvan sola doğru çim biçme makinasını iter. Seslendirme (f) bölümüne geldiğinde bahçıvanın hareketi duraklatılır. Sola doğru bir ok animasyon yardımıyla çizdirilir. Okun soluna "kuvvet" yazısı yazdırılır. Seslendirme (g) bölümüne gelindiğinde öncekinin altına yine sola doğru bir ok çizdirilir. Okun soluna "hareket" yazısı yazdırılır. Seslendirme (h) bölümüne gelindiğinde kuvvet ve hareketi temsil eden oklara aynı anda vurgu yapılır. Daha sonra görsel küçülerek eski yerine geri döner. Seslendirme (ı) bölümüne geldiğinde D seçeneğindeki görsel büyüyerek ekranın ortasına gelir ve odaklanılacak ana görsel halini alır. Arkada kalan diğer tüm görseller soluklaşmıştır. Görsel büyür büyümez animasyon oynatılır. Çocuk yerden aldığı kutuyu havaya kaldırır. Daha sonra çocuğun hareketi duraklatılır. Buradaki amaç duraklatılan animasyon üzerinden kuvvetin ve yer değiştirmenin detaylı bir şekilde anlatılmasıdır. Seslendirme (i) bölümüne geldiğinde yukarı yönlü bir kaldırma kuvvetini temsil eden ok çizdirilir. Okun üzerinde "kuvvet" yazısı belirir. Seslendirme (j) bölümüne gelindiğinde ekran görüntüsünde görüldüğü gibi kutunun sağında yukarı yönlü bir ok çizdirilir. Okun üzerinde "hareket" kelimesi yazdırılır. (h) Seslendirme bölümüne gelindiğinde oklara aynı anda vurgu yapılır. Daha sonra görsel küçülerek eski yerine geri döner. Seslendirme (l) bölümüne geldiğinde B seçeneğindeki görsel büyüyerek ekranın ortasına gelir ve odaklanılacak ana görsel halini alır. Arkada kalan diğer tüm görseller soluklaşmıştır. Burada animasyona gerek yoktur. Seslendirme (m) bölümüne gelindiğinde durak görselinin sağ tarafında ekran görüntüsündeki gibi "Kuvvet yok" yazısı belirir. Aynı şekilde (n) bölümüne gelindiğinde "Hareket yok" yazısı belirir. Görsel küçülerek eski yerine geçer. B seçeneği ışıklandırılır.

Table 19 (continued)

Ekran Numarası	13
Konu	Çözümlü Örnek - Hangi Durumda Fen Anlamında İş Yapılmaz?



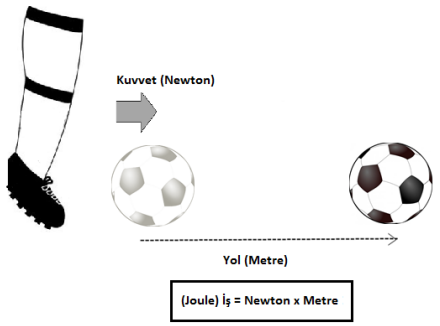
Seslendirme: Şimdi de ekrandaki araçların hareketini inceleyelim. Bu araçlardan hangisi bilimsel olarak iş yapmamıştır? Bulalım.

(a) Öncelikle, I. Şekildeki aracın hareketini inceleyelim. Araç yerde bulunan (b) kutuya ekranın **sağına doğru** (c) bir itme kuvveti uygulayarak kutunun yatay düzlemde (d) bir miktar hareket etmesini sağlıyor. Kutuya uygulanan kuvvetin ve cismin hareket doğrultusunun **aynı** (e) olduğunu görüyorsun. Bu nedenle, I. Şekildeki aracın (f) bilimsel olarak iş yaptığını söyleyebiliriz. (g) Şimdi de II. şekildeki aracın hareketini inceleyelim. Araç kutuyu kaldırmak için **yukarı doğru** bir (h) kuvvet uyguluyor ve kutunun (ı) **yukarı doğru** hareket etmesini sağlıyor. Kuvvet ve hareketin doğrultusu (i) **aynı** olduğuna göre bu aracın da (j) bilimsel olarak iş yaptığını söyleyebiliriz. (k) III. Şekildeki aracın hareketini inceleyelim. (l) Burada araç kutuyu ekranın soluna doğru bir miktar çekiyor. Araç kutuyu çekmek için ekranın **soluna doğru** bir (m) çekme kuvveti uyguluyor ve kutunun **aynı yönde (**n) hareket etmesini sağlıyor değil mi? Kuvvet ve hareketin doğrultusu (o) **aynı** olduğuna göre bu aracın da (ö) bilimsel olarak iş yaptığını söyleyebiliriz. (p)Son olarak IV. Şekildeki aracın hareketini inceleyelim. Araç taşıdığı kutu ile beraber ekranın sağına doğru bir miktar yol alsın (r). Ne görüyorsun? Aracın kutuyu taşımak için uyguladığı kuvvet (s) **düşey,** hareket ise (t) **yatay** doğrultuda gerçekleşiyor değil mi? Öyleyse, uygulanan kuvvetin ve hareketin doğrultusunun (u) **birbirine dik** olduğunu söyleyebiliriz. Böyle bir durumda iş **yapılmadığını** daha önce söylemiştik. Bu nedenle burada (ü) "bilimsel olarak iş yapılmamıştır" diyebiliriz.

Table 19 (continued)

Senaryo: Ekranın başında dört adet hareketsiz duran statik görsel bulunmaktadır. I. Şekilde bir kutuyu iten iş makinasını temsil eden görsel, II. Şekilde yerden aldığı bir kutuyu havaya doğru kaldıran bir iş makinasını anlatan görsel, III. Şekilde kutuyu çeken traktörü anlatan bir görsel ve son olarak IV. Şekilde taşıdığı kutuyla beraber hareket eden iş makinasını anlatan bir görsel bulunmaktadır. Görsellerin etrafında henüz ok işaretleri ve "Kuvvet" ve "Hareket" yazıları bulunmamaktadır. Seslendirme ses içeriğini okumaya başlar. Seslendirme (a) bölümüne gelindiğinde I. Şekilde bulunan araç görseli büyüyerek ekranın ortasına gelir. Arkada kalan diğer tüm görseller soluklaşmıştır. Araç yerdeki kutuyu iterek kutunun sağa doğru hareket etmesini sağlar. Seslendirme (b) bölümüne geldiğinde aracın hareketi duraklatılır. Seslendirme (c) bölümüne geldiğinde sağa doğru bir ok animasyon yardımıyla çizdirilir ve okun ucuna "Kuvvet" kelimesi yazdırılır. Seslendirme (d) bölümüne geldiğinde önceki okun altında sağa doğru bir ok yine animasyon yardımıyla çizdirilir ve okun ucuna "Hareket" kelimesi yazdırılır. Seslendirme (e) bölümüne gelindiğinde yönleri aynı olan kuvvet ve hareketi temsil eden oklara aynı anda yanma sönme efekti yaptırılır ve bu şekilde bu kuvvetlerin yönünün aynı olduğuna vurgu yapılması sağlanır. Seslendirme (f) bölümüne gelindiğinde ekranın sağ tarafında yeşil tick (onay) işareti görünür. Bu işlemler bittikten sonra görsel küçülerek eski yerine geçer. Seslendirme (g) bölümüne geldiğinde II. Şekildeki görsel büyüyerek ekranın ortasına gelir. Bu sayede odaklanılacak ana görsel haline gelir. Arkada kalan diğer tüm görseller soluklaşmıştır. İş makinası yerde bulunan kutuyu kaldırır. Hareket daha bitmeden animasyon gösterimi duraklatılır. Bu sırada seslendirme de (h) bölümüne gelmiştir. Tam bu sırada kutunun üzerinde yukarı doğru bir ok işareti animasyon şeklinde çizdirilir ve okun ucuna "Kuvvet" yazısı belirir. Seslendirme (ı) bölümüne gelindiğinde kutunun yanında yukarı doğru bir ok işareti animasyon şeklinde çizdirilir ve ok işaretinin ucuna "Hareket" yazısı yazdırılır. Seslendirme (i) bölümüne geldiğinde bu okların ikisine birden yanma sönme efekti ile vurgu yapılır. Seslendirme (j) bölümüne gelindiğinde ekranın sağ tarafında yeşil tick (onay) işareti görünür. Bu işlemler bittikten sonra görsel küçülerek eski yerine geçer. Seslendirme (k) bölümüne geldiğinde buradaki araç görseli büyüyerek ekranın ortasına gelir. Arkada kalan diğer tüm görseller soluklaşmıştır. (l) Seslendirme bölümüne gelindiğinde araç kutuyu sola doğru çekme hareketini başlatır. Seslendirme (m) bölümüne gelindiğinde hareket daha bitmeden animasyon gösterimi duraklatılır. Tam bu sırada aracın üzerinde sola doğru bir ok animasyon yardımıyla çizdirilir. Okun ucuna "Kuvvet" kelimesi yazdırılır. Seslendirme (n) bölümüne gelindiğinde önceki okun altında yine sola doğru bir ok animasyon yardımıyla çizdirilir ve okun ucuna "Hareket" kelimesi yazdırılır. Seslendirme (o) bölümüne gelindiğinde iki oka da yanma sönme efekti ile vurgu yapılır. Seslendirme (ö) bölümüne gelindiğinde ekranın sağ tarafında uygun bir yerde yeşil tick (onay) işaretinin görünmesi sağlanır. Bu işlemler bittikten sonra görsel küçülerek eski yerine geçer. Seslendirme (p) bölümüne geldiğinde buradaki araç görseli büyüyerek ekranın ortasına gelir. Arkada kalan diğer tüm görseller soluklaşmıştır. Seslendirme (r) bölümüne geldiğinde araç taşıdığı kutu ile beraber sağa doğru hareket eder. Seslendirme (s) bölümüne gelindiğinde hareket bitmeden animasyon gösterimi duraklatılır. Tam burada aracın kutuyu tuttuğu yerden yukarı doğru bir ok animasyon yardımıyla çizdirilir ve okun ucuna "Kuvvet" yazısı yazdırılır. Seslendirme (t) bölümüne gelindiğinde aracın taşıdığı kutunun sağından sağa doğru bir ok animasyon yardımıyla çizdirilir. Okun ucuna "Hareket" yazısı yazdırılır. Seslendirme (u) bölümüne gelindiğinde iki okun da yazıları (Kuvvet ve Hareket) aynı anda kaybolur, oklar başlangıç noktasından dik açı yaparak birleştirilir ve birleşme noktasında da "dik" işareti belirir.

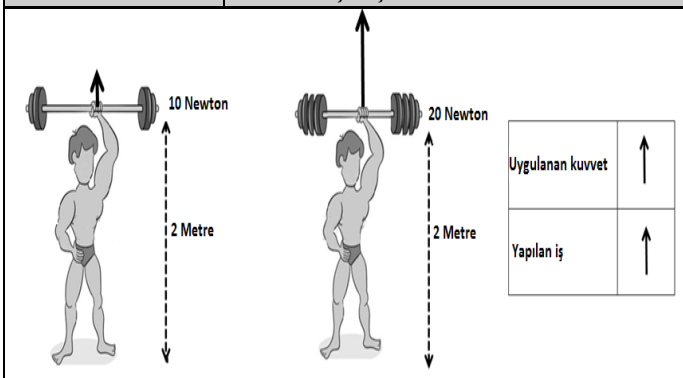
Table 19 (continued)

Ekran Numarası	14
Konu	Kuvvet, Alınan Yol ve İş İlişkisi
	**Seslendirme:** Yaptığımız iş neye bağlı olarak değişir? Yaptığımız iş uyguladığımız **kuvvetin büyüklüğüne** ve cismin bu kuvvet etkisiyle **aldığı yola** bağlıdır. Yani, iş**, uygulanan kuvvet** ve **alınan yol** ile doğru orantılıdır. Kuvvet biriminin **Newton**, yol biriminin ise **metre** olduğunu hatırlıyorsun değil mi? **İş** birimini ise kuvvet ve yer değiştirme birimlerinin çarpımı olan **Newton X Metre,** yani özel adıyla **Joule** olarak adlandırırız. Sonuç olarak bir cisme 1 Newton büyüklüğünde bir kuvvet uygulayarak kuvvet uyguladığımız cismin kuvvet doğrultusunda 1 Metre yol almasını sağlamışsak 1 Joulelük iş yapmış oluruz. Haydi, şimdi de kuvvet, alınan yol ve iş arasındaki ilişkiyi çeşitli örneklerle inceleyelim.

Senaryo: seslendirme içeriği seslendirmeye başladığı anda ekranda öylece duran bir top şekli yer almaktadır. Bu sırada topun rengi normaldir. Seslendirme "yaptığımız işin büyüklüğü cisme uyguladığımız kuvvetin büyüklüğüne" ifadesinde yer alan "kuvvetin" kelimesini seslendirdiği an ekranın sol tarafından gelen bir futbolcu ayağı topa vurur. Futbolcu ayağını temsil eden görsel topa değdiğinde hareket çok kısa bir süre (anlık) duraklatılır. Topun tam üzerinde bir ok işareti belirir. Ok işaretinin üzerine de "kuvvet" yazısı yazdırılır. Daha sonra top harekete geçmektedir. Topun ilk konumu yerini kesikli çizgi olarak muhafaza eder. Top hareket ettikçe topun ilk konumu ile top arasında alınan yol arttığı için bu durum uzayan kesikli çizgiler ile ifade edilmektedir. Yani, top hareket ettikçe topun ilk durumunu temsil eden görsel ile topun hareket halindeki durumunu temsil eden görsel arasındaki kesikli çizginin uzunluğu artmaktadır. Belirli bir süre sonra topun hareketi durdurulur. İlk konumla son konum arasındaki mesafeyi belirten kesikli çizgilerin altına "yol" ifadesi yazdırılır. Seslendirme "yani, iş uygulanan kuvvet ve alınan yol ile doğru orantılıdır" ifadesindeki "kuvvet" kelimesini seslendirdiğinde kuvveti temsil eden büyük ok yanıp sönerek kuvvete vurgu yapılır. Seslendirme "yol" kelimesini seslendirdiğinde yolu ifade eden kesikli çizgiler yanıp söner ve bu sayede alınan yola vurgu yapılması sağlanır. Seslendirme "kuvvet biriminin Newton" cümlesindeki "Newton" kelimesini seslendirdiğinde kuvveti temsil eden ok işaretinin üzerinde bulunan "kuvvet" yazısının yanında parantez içerisinde Newton yazısı belirir. Seslendirme "yol biriminin ise metre olduğunu hatırlayalım" cümlesindeki "metre" kelimesini seslendirdiğinde kesikli çizgilerin altında bulunan "yol" yazısının yanında parantez içerisinde metre yazısı belirir. Seslendirme "bu durumda iş birimini kuvvet ve yer değiştirme birimlerinin çarpımı olan" ifadesinde yer alan "iş" kelimesini seslendirdiğinde "İş= Newton x Metre ifadesi ekran görüntüsünde olduğu gibi "yol (metre)" ifadesinin altına yazdırılır. Seslendirme "yani özel adıyla Joule olarak adlandırırız" ifadesindeki "Joule" sözcüğünü seslendirdiğinde kelimesinin soluna Joule ifadesi yazdırılır.

Table 19 (continued)

Ekran Numarası	15
Konu	Kuvvet-İş İlişkisi



Seslendirme: Uygulanan kuvvet ve yapılan iş arasında nasıl bir ilişki vardır? Ekrandaki örneği dikkatlice incele. Beden Eğitimi dersi için spor salonunda alıştırma yapan Cem, ilk durumda (a) 10 Newtonluk halteri yerden 2 metre yükseğe kaldırıyor. Daha sonra ikinci durumda (b) 20 Newtonluk halteri yine yerden 2 metre yükseğe kaldırıyor. Sence Cem hangi durumda daha fazla iş yapmıştır?

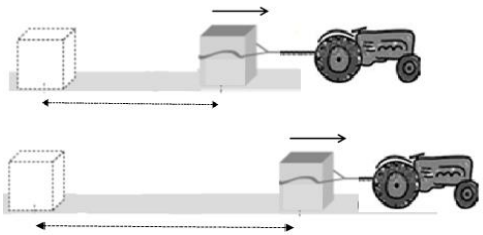
(c) 20 Newtonluk ağırlık (d) 10 Newtonluk ağırlığın iki katıdır. Dolayısıyla 20 Newtonluk ağırlığı kaldırmak için gerekli olan (e) kuvvet de, 10 Newtonluk ağırlığı kaldırmak için gerekli olan (f) kuvvetin iki katıdır. Cem'in **her iki durumda da** halteri (g) **2 metre** kaldırdığını söylemiştik. Buna göre Cem'in **20 Newtonluk** ağırlığı kaldırdığı ikinci durumda daha fazla iş yaptığını söyleyebiliriz. Buradan çıkarılacak sonuç şudur: bir cisme (h) **uygulanan kuvvet** arttıkça (ı) **yapılan iş** de buna bağlı olarak artar.

Senaryo: Ekranın başında, Cem önünde halterle hareketsiz beklemektedir. Yani, Cem yerde duran halteri henüz kaldırmamıştır. Seslendirme (a) bölümüne geldiğinde Cem yerde duran 10 Newtonluk halteri kaldırmaya başlar. Karakter halteri tek eliyle kaldırmalıdır. Karakter halteri 2 Metre kaldıracaktır. Halter kaldırıldıktan hemen sonra halterin son konumundan yere doğru bir ok işareti çizdirilir. Okun sağ tarafına "2 Metre" yazısı yazdırılacaktır. Halterin yanındaki 10 Newton yazısı ise halterin yerden havaya kadar olan tüm hareketinde ona eşlik etmiştir. Seslendirme (b) bölümüne geldiğinde aynı karakter ekranın sağ tarafında bu kez 20 Newtonluk halteri kaldıracaktır. Hareket genel hatlarıyla aynıdır. Tek fark, karakterin 10 Newtonluk ağırlık yerine 20 Newtonluk ağırlığı kaldırmasıdır. Sporcu halteri yine tek eliyle kaldırmalıdır. Sporcu halteri yine 2 Metre kaldıracaktır. Halter kaldırıldıktan hemen sonra halterin son konumundan yere doğru bir ok işareti çizdirilir. Okun sağ tarafına "2 Metre" yazısı yazdırılır. Halterin yanındaki 20 Newton yazısı ise halterin yerden havaya kadarki hareketinde ona eşlik etmiştir. Seslendirme (c) bölümüne geldiği an 20 Newtonluk haltere vurgu yapılır (vurgulama işlemi 20 Newtonluk ağırlığın resim kenarlığının yanma sönme efekti yapması ile gerçekleştirilebilir). Seslendirme (d) bölümüne geldiğinde 10 Newtonluk haltere vurgu yapılır (vurgulama işlemi 10 Newtonluk ağırlığın resim kenarlığının yanma sönme efekti yapması ile gerçekleştirilebilir).

Table 19 (continued)

Seslendirme (e) bölümüne geldiği an 20 Newtonluk halteri tutan haltercinin halteri tuttuğu yerden yukarı doğru bir ok işareti çizdirilir. Seslendirme (f) bölümüne geldiği an 10 Newtonluk halteri tutan haltercinin halteri tuttuğu yerden yukarı doğru bir ok işareti çizdirilir. İlk çizilen ok diğerinden büyüktür. Çünkü 20 Newtonluk ağırlığı kaldırmak için gerekli olan kuvveti temsil eden ok işareti 10 Newtonluk ağırlığı kaldırmak için gerekli olan kuvveti temsil eden ok işaretinden büyük olmalıdır. Seslendirme (g) bölümüne geldiği an halterlerin kaldırıldığı 2 Metrelik yükseklikler aynı anda vurgu yapılır. Seslendirme (h) bölümüne geldiği an görsellerin yanında "Uygulanan kuvvet" yazısı belirir. Yazının hemen yanına yukarı yönlü bir ok işareti belirir. Seslendirme (ı) bölümüne geldiği an önceki satırın altına "Yapılan iş" yazısı belirir. Yazının hemen yanına yukarı yönlü bir ok işareti belirir.

Ekran Numarası	16
Konu	Alınan-Yol İş İlişkisi

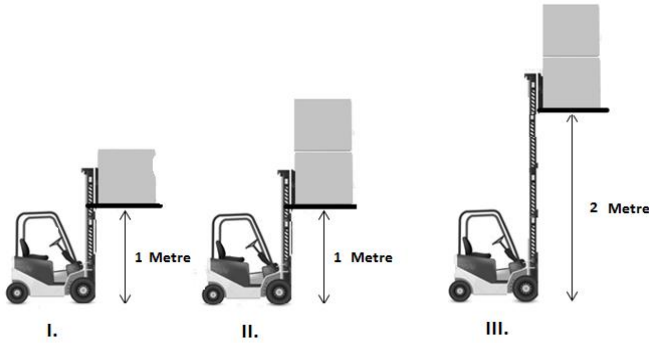


Seslendirme: Şimdi de alınan yol ile iş arasındaki ilişkiyi inceleyelim. Mustafa'nın dedesi ahırdaki inekleri beslemek için traktör kullanarak belirli uzaklıklardan ahıra saman balyası çekiyor. Bunun için traktör (a)İlk Olarak ahırdan 10 metre uzaklıkta bulunan 5 adet saman balyası çekiyor. Traktör (b) daha sonra ahırdan 20 metre uzaklıkta bulunan yine 5 adet saman balyasını ahıra çekiyor. Gördüğün gibi traktör her iki durumda da eşit miktarda saman balyası çekiyor ve saman balyalarını çekmek için her iki durumda da **eşit büyüklükte** kuvvet uyguluyor. Buna göre traktör sence hangi durumda daha fazla iş yapmıştır? Traktörün ikinci durumda saman balyalarına (c) aldırdığı yol, ilk durumda saman balyalarına (d) aldırdığı yolun iki katıdır. Traktörün her iki durumda da eşit miktarda saman balyası taşıdığını ve saman balyalarını çekmek için (e) eşit büyüklükte kuvvet uyguladığını söylemiştik. Buna göre saman balyalarının 20 metre hareket ettirildiği (f) **ikinci durumda** traktörün daha fazla iş yaptığını söyleyebiliriz. Çünkü traktör ikinci durumda saman balyalarına **daha fazla** yol aldırmış yani diğer duruma göre daha fazla iş yapmıştır.

Senaryo: Ekran ortadan ikiye ayrılmıştır. Ekranın sağında ve solunda bulunan traktör görsellerinin her ikisi de arkasına bağlı olan römork ve üzerindeki saman balyaları ile hareketsiz olarak beklemektedirler. Seslendirme (a) bölümüne geldiğinde soldaki traktör arkasına iple bağlı olan römork üzerindeki 5 adet saman balyasını 10 Metre sağa doğru çeker ve durur. Traktör durur durmaz ilk konum ve son konum arasındaki mesafe kesikli çizgili ok işareti ile belirtilir ve ok işaretinin altına da alınan yol yani 10 Metre ifadesi yazdırılır. (traktörün ilk konumu kesikli çizgilerle belirtilir). Seslendirme (b) bölümüne geldiği an sağ taraftaki traktör römork ve üzerindeki saman balyalarını çekme işlemine başlar ve römorku 20 Metre çeker. İlk durumdakine benzer bir şekilde traktör durur durmaz ilk konum ve son konum arasındaki mesafe ok işareti ile belirtilir ve ok işaretinin altına da alınan yol 20 Metre yazdırılır. (traktörün ilk konumu kesikli çizgilerle belirtilir). Seslendirme (c) bölümüne geldiği an, 20 Metrelik yolu ifade eden ok işareti ve "20 Metre yazısı" yanma sönme efekti yapar. Seslendirme (d) bölümüne geldiği an 10 Metrelik yolu ifade eden ok işareti ve "10 Metre yazısı" yanma sönme efekti yapar. Seslendirme (e) bölümüne geldiği an her iki görselde de saman balyalarının tam üzerinde eşit büyüklükte kuvvetleri temsil eden iki adet ok işareti belirir. Seslendirme (f) bölümüne geldiği an ikinci duruma (sağdaki) vurgu yapılır.

Table 19 (continued)

Ekran Numarası	17
Konu	Çözümlü Örnek - Kuvvet, Alınan Yol Ve İş Arasındaki İlişki



Seslendirme: Ekranda gördüğün iş makinası büyük marketlerin birisinde yeni gelen deterjan, yağ, konserve gibi ürünlerin bulunduğu kutuları marketin deposunda bulunan raflara kaldırıyor. İş makinası **(x)** birinci durumda 1 kutuyu yerden 1 metre yükseğe, **(y)** ikinci durumda 2 kutuyu yerden yine 1 metre yükseğe, **(z)** son durumda ise 2 kutuyu yerden 2 metre yükseğe çıkarıyor. Buna göre iş makinasının yaptığı işleri büyükten küçüğe doğru sıralayalım.

…Yapılan işin büyüklüğünün **kuvvet** ve **yer değiştirme** ile doğru orantılı olduğunu hatırla. Buna göre öncelikle **(a)** I. ve II. durumları inceleyelim. İş makinası ilk durumda **(b)** 1 kutu çıkarırken ikinci durumda **(c)** 2 kutu çıkarıyor. Gördüğün gibi İş makinası iki durumda da kutuları **(d)**1 metre yükseğe çıkarıyor. **Aynı** yüksekliğe **(e) 2 kutu** çıkarmak için gerekli olan kuvvetin **(f) 1 kutu** çıkarmak için gerekli olan kuvvetten daha fazla olması gerektiğini biliyorsun. Bu nedenle iş makinasının **(g)** ikinci durumda birinci durumdakine göre daha fazla iş yaptığını söyleyebiliriz.
Sıra geldi **(h)** II. ve III. durumları incelemeye. İş makinasının III. durumda kutuları **(ı) 2 metre** II. durumda ise **(i) 1 metre** yükseğe çıkardığını görüyorsun. İş makinasının çıkardığı kutu sayısını dikkatlice incele. İş makinası her iki durumda da **(j) 2 kutu** çıkarıyor değil mi? Eşit miktardaki özdeş kutuları **(k)** 2 metre yükseğe çıkarmak için yapmamız gereken işin **(l)** 1 metre yükseğe çıkarmak için yapmamız gereken işten daha fazla olacağını biliyorsun. Öyleyse iş makinası **(m)** III. durumda II. duruma göre daha fazla iş yapmıştır. Buna göre iki sıralamayı birleştirirsek iş makinasının yaptığı işler arasındaki sıralamayı **(n) III>II>I** ("*Üç büyük, iki büyük, bir*" olarak seslendirilecek) olarak buluruz.

Table 19 (continued)

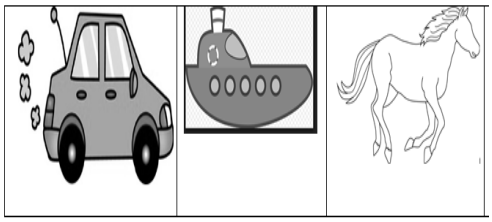
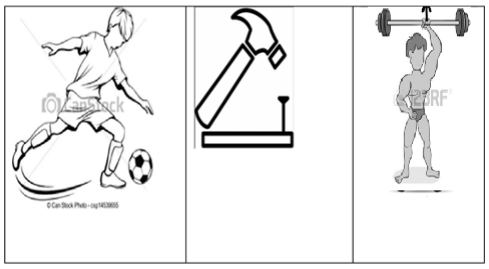
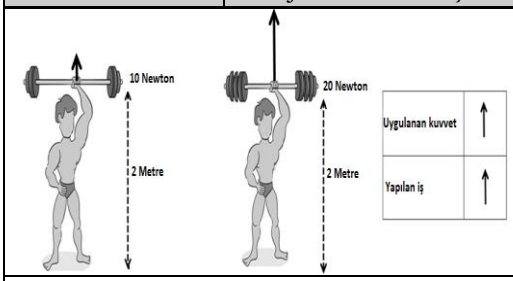
Senaryo: Bu bölümde animasyon kullanılmayacaktır. Animasyon sadece önemli bölümleri vurgulamak için kullanılacaktır. Seslendirme **(x)** bölümüne geldiğinde I. durumdaki iş makinasına kaldırdığı kutuyla beraber vurgu yapılır. Vurgulama işlemi ilgili görselin çok az bir miktar büyüyerek öne gelmesiyle sağlanabilir. Çok az bir şekilde büyüyerek ekranın önüne gelen görsel daha sonra küçülerek kendi yerine geçer. Seslendirme **(y)** bölümüne geldiğinde, aynı şekilde II. durumdaki görsele vurgu yapılır. **(z)** bölümüne gelindiğinde III. şekildeki görsele vurgu yapılır. Soru sorulduktan sonra çözüme geçilir. Seslendirme **(a)** bölümüne geldiğinde I. ve II. durumdaki görseller büyür, ekranın ortasına gelir, odaklanılacak ana görseller haline gelir. Seslendirme **(b)** bölümüne geldiğinde I. durumdaki iş makinasının çıkardığı kutuya vurgu yapılır (vurgulama işi kutunun resim kenarlığının yanıp sönmesiyle gerçekleştirilecektir). **(c)** bölümüne gelindiğinde II. durumdaki iki kutuya vurgu yapılır (vurgu şeklin resim kenarlığının yanıp sönmesi efekti ile yapılır). Seslendirme **(d)** bölümüne geldiğinde 1 metrelik yüksekliklere vurgu yapılır (yanma sönme efekti ile). Seslendirme **(e)** bölümüne geldiğinde iki kutunun üzerinde kalın bir ok işareti belirir. **(f)** bölümüne gelindiğinde birinci şekilde bulunan 1 adet kutunun üzerinde diğer oka göre daha ince bir ok işareti belirir. Seslendirme **(g)** bölümüne geldiğinde görseller küçülerek eski yerine geçer. Hemen ardından I. ve II. şeklin hemen altında II>I ifadesi yazdırılır. Seslendirme **(h)** bölümüne geldiğinde II. ve III. durumdaki görseller beraber büyür, ekranın ortasına gelir, odaklanılacak ana görseller haline gelir. **(ı)** bölümüne gelindiğinde 2 metrelik yüksekliğe vurgu yapılır. **(i)** bölümüne gelindiğinde 1 metrelik yüksekliğe vurgu yapılır. **(j)** bölümüne gelindiğinde II. ve III. durumdaki kutulara aynı anda vurgu yapılır (resim kenarlığının ışıklandırılması ile). **(k)** bölümüne gelindiğinde 2 metrelik yüksekliğe vurgu yapılır. **(l)** bölümüne gelindiğinde 1 metrelik yüksekliğe vurgu yapılır. **(m)** bölümüne gelindiğinde ilgili görseller küçülerek eski yerine geçer. Görsellerin hemen altında III>II ifadesi yazdırılır. **(n)** bölümüne gelindiğinde diğer ifadelerin altına **III>II>I** ifadesi yazdırılır.	
Ekran Numarası	18
Konu	ENERJİ NEDİR?- GÜNLÜK HAYATTA ENERJİ
	Günlük hayatta enerji kavramını sıkça kullanırız. Örneğin (a) bir araba bir yerden bir yere **giderken** enerji harcar değil mi? (b)Bir vapur **suda ilerlerken**, (c) bir at dörtnala **koşarken** enerji harcar (d)
	Bir topa (e) **vururken** enerji harcarız. Aynı şekilde (f) çekiç ile çivi **çakarken,** (g) ağırlık **kaldırırken** enerji harcarız. Öyleyse, sence (h) enerji nedir?

Table 19 (continued)

Senaryo: Seslendirme başladığında ekranda hareketsiz duran dört adet görsel bulunmaktadır. Bu görseller sıra kendilerine geldiğinde büyüme efekti yaparlar, görsele yakınlaşma olur ve burada animasyonla ilgili görsel anlatılır. Örneğin seslendirme (a) bölümüne geldiğinde araba görseli ekranda yakınlaşır ve araba bir miktar sağa doğru hareket eder. Seslendirme sırayla (b) (c) bölümlerine gelir. Hangi bölüme gelinirse o bölümdeki görsel büyüme efekti yapar ve ilgili görsel animasyonla çok kısa bir süre hareket ettirilir. Örneğin görsel (b) bölümüne geldiğinde vapur görseli ekranda büyür, odaklanacak ana görsel haline gelir, kısa bir süre hareket eder ve sonra küçülerek eski haline döner. Bu durum diğer görseller için de geçerlidir. Seslendirme (d) bölümüne geldiğinde araba, vapur ve at üçlüsünden oluşan görsel grubu ekrandan kaybolur. Bunların yerine topa vuran futbolcu, çivi çakan çekiç ve ağırlık kaldıran sporcu üçlüsünden oluşan görsel grubu ekrana gelecektir. Karakterler hareketsiz olarak beklemektedir (üç adet görsel yan yana hareketsiz beklemektedir). Seslendirme (e) bölümüne geldiğinde topa vuran çocuk karakteri ekranda büyür, odaklanılacak ana görsel haline gelir. Çocuk topa vurur. Daha sora küçülerek yerine döner. Bu sırada seslendirme (f) bölümüne gelmiştir. Burada da aynı durum söz konusu olacaktır. İlgili görsel büyür, animasyonla hareket anlatılır, görsel küçülerek yerine geçer. Seslendirme **(**g) bölümüne geldiğinde de aynı durum söz konusu olur. İlgili görsel büyür. Kısa bir süre animasyonla hareketini yapar ve daha sonra küçülerek eski yerine geçer. Seslendirme (h) bölümüne geldiğinde görsellerin hemen altında "Enerji nedir" ifadesi yazdırılır.

Ekran Numarası	19
Konu	Enerji Kavramının İş Kavramı İle İlişkilendirilmesi

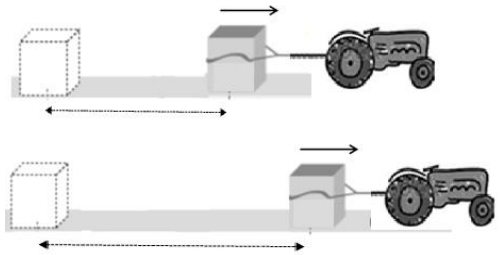


Seslendirme: Daha önce incelediğimiz Cem'in yapmış olduğu işi dikkatlice tekrar inceleyelim. (a) Gördüğün gibi Cem, 10 Newton ağırlığındaki halteri zorlanmadan kaldırıp indiriyor. Peki, (b)Cem 10 Newton ağırlığındaki bir halter yerine (c) 20 Newton ağırlığındaki bir halter ile aynı işi yapmayı denerse sence ne olur?
(d) 20 Newton ağırlığında bir yükü kaldırmak için (e) **daha büyük** bir kuvvet uygulamak gerektiğini biliyoruz. Bu nedenle Cem 20 Newton ağırlığındaki halteri kaldırıp indirebilmek için **daha fazla** yorulacak yani **daha fazla** enerji harcayacaktır.

Senaryo: Seslendirme başladığında sporcu halteri havada tutmaktadır. Sporcu bu esnada hareketsizdir. Halteri tek ile tepede tutarak hareketsiz beklemektedir. Seslendirme (a) bölümüne geldiğinde sporcu dirseğini bükmek suretiyle 10 Newtonluk halteri hızlı bir şekilde kaldırır ve indirir. Halterci bu hareketi zorlanmadan yapabilmektedir. Seslendirme (b) bölümüne geldiğinde 10 Newtonluk halteri kullanan sporcu, halter en tepede iken durur. Seslendirme (c) bölümüne geldiğinde duran haltercinin tam yanında aynı halterci belirir. Bu kez halterci 20 Newtonluk ağırlığı indirip kaldıracaktır. Halterci 20 Newtonluk ağırlığı kaldırıp indirmeye çalışır. Halterci daha büyük bir yükü kaldırıp indirmeye çalıştığı için zorlanmaktadır. Diğer halterci gibi kollarını bükerek halteri rahat bir şekilde kaldırıp indiremez. Seslendirme (d) bölümüne geldiğinde halteri tutan sporcunun hareketi duraklatılır. Seslendirme (e) bölümüne geldiğinde ikinci sporcunun tuttuğu halterin resim kenarlığı ışıklandırılarak bu haltere vurgu yapılır.

Table 19 (continued)

NO	20
Konu	Enerji Kavramının İş Kavramı İle İlişkilendirilmesi



Seslendirme: Daha önce incelediğimiz traktörün yaptığı işi dikkatlice tekrar inceleyelim. Hatırlarsan (a) traktör ilk olarak içi saman dolu bir arabayı 10 metre uzaklıktan ahıra taşımıştı. İkinci durumda ise (b) traktör aynı arabayla 20 metre uzaklıktan ahıra saman taşımıştı. Traktörün arabayla taşıdığı saman miktarlarının ve arabayı çekmek için uyguladıkları kuvvetlerin büyüklüklerinin aynı olduğunu belirtmiştik. Şimdi alınan yolları tekrar incele. Ne görüyorsun? Traktörün (c) 20 metre uzaklıktan saman taşıdığı durumda daha fazla yakıt enerjisi tükettiğini söyleyebiliriz değil mi? Çünkü burada traktör arabaya (d) daha fazla yol aldırmıştır. Dolayısıyla traktör ikinci durumda **daha fazla** enerji harcamıştır.
Buradan çıkarılacak sonuç şudur: Eğer iş yapabiliyorsak, başka bir deyişle bir cisme kuvvet uyguluyorsak ve o cismi uyguladığımız kuvvet doğrultusunda hareket ettiriyorsak mutlaka **enerji harcarız**. (e)Buna göre enerjiyi, **iş yapabilme yeteneği** olarak tanımlayabiliriz. Yapılan iş harcanılan enerji ile doğru orantılı olduğuna göre enerji biriminin iş birimi olan **joule** ile aynı olduğunu söyleyebiliriz.

Senaryo: Ekran ortadan ikiye ayrılmıştır. Ekranın sağında ve solunda bulunan traktör görsellerinin her ikisi de arkasına bağlı olan römork ve üzerindeki saman balyaları ile hareketsiz olarak beklemektedirler. Seslendirme (a) bölümüne geldiğinde soldaki traktör arkasına iple bağlı olan römork üzerindeki 5 adet saman balyasını 10 metre sağa doğru çeker ve durur. Sandığın son konumu ile ilk konumu arasındaki mesafe kesikli çizgili ok işareti ile belirtilir. Ok işaretinin altına “10 Metre” ifadesi yazdırılır. Seslendirme (b) bölümüne geldiği an sağ taraftaki traktör, römork ve üzerindeki saman balyalarını çekme işlemine başlar ve römorku 20 Metre çeker. İlk durumdakine benzer bir şekilde traktör durur durmaz ilk konum ve son konum arasındaki mesafe kesikli çizgili ok işareti ile belirtilir ve ok işaretinin altına da alınan yol “20 Metre” yazdırılır. Her iki durumda da çekilen yüklerin ilk konumları kesikli çizgiler ile yerini muhafaza edecektir. Seslendirme (c) bölümüne geldiğinde 20 metrelik uzaklığa vurgu yapılır. Seslendirme (d) bölümüne geldiğinde bu uzaklığa tekrar vurgu yapılır. Seslendirme (e) bölümüne geldiğinde ekranın uygun bir yerine “Enerji iş yapabilme yeteneğidir” ifadesi yazdırılır.

APPENDIX C

CLT AND CTML PRINCIPLES APPLIED TO THE SCREENS

Table 20 CLT and CTML Principles applied to the screens (from screen 12 to 20)

Ekran Numarası	**12**
Gereksizlik ilkesi (Redundancy principle):	Resimlerin ve animasyonların anlatımında sesli anlatım tercih edilmiştir. Fazladan yazılı anlatım kullanılmasından kaçınılmıştır.
Dikkat bölünmesi (Split Attention)	Görseller ve bağlı oldukları sesli anlatım unsurları birbirleri ile eş zamanlı olarak öğrenenlere sunulmuştur. Örneğin seslendirme *"ilk olarak A seçeneğini inceleyelim"* dediğinde ilgili görsel büyüyerek ekranın ortasına gelir ve odaklanılacak ana görsel halini alır. Ses ve görsel arasındaki zamansal yakınlık uyumu diğer görseller için de geçerlidir. Görseller ve yazılı ekran metinleri arasındaki mesafenin birbirlerine yakın olacak şekilde ayarlanması ile uzamsal yakınlık ilkesine uyulmuştur. Örneğin kuvvet ve hareket gibi vektörel büyüklükleri temsil eden ok işaretleri ve bunlara ilişkin etiketler (kuvvet ve hareket yazıları), bilgisayar ekranında ilgili görselin hemen yanında olacak şekilde sunulmuştur.
Tutarlılık ilkesi (Coherence principle):	Öğretimi ilgi çekici hale getirmek adına tutarlığı bozacak nitelikte öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılmıştır.
Dikkat çekme ilkesi (Signaling principle):	Vurgu hem anlatım sesi hem de görseller üzerinden yapılmıştır. Önemli bölümler daha vurgulu seslendirilmiştir. Buna ek olarak, animasyonlar ile de vurgu yapılmıştır. Örneğin, seslendirme *"adamın uyguladığı kuvvetin ve topladığı meyvenin hareket doğrultusunun aynı olduğunu görüyorsun değil mi?"* cümlesindeki *"aynı"* kelimesini seslendirdiği an kuvvet ve hareketi temsil eden okların kenarlıkları ışıklandırılmıştır.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Uygulanabilir değil.
Biçem ilkesi (Modality principle):	Öğretim içeriğinin aktarımında işitsel kanal kullanılmıştır. Sözcüklerin yazılı metin ile değil ses ile aktarılması sağlanmıştır.

Table 20 (continued)

Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.
Bireyselleştirme ilkesi (Personalization principle):	Kullanıcı ile konuşuyormuş hissi veren içten bir üslup benimsenmiştir. Bu doğrultuda, *"haydi, şimdi öğrendiklerimizi pekiştirelim", "dikkatlice incele", "değil mi?"* gibi ifadeler anlatım metni içerisinde kullanılmıştır. Edilgen yapıların yerine etken yapıların bulunduğu cümlelere ağırlık verilmiştir.
Çözümlü örnekler ilkesi (Worked examples principle):	Uygulanabilir değil.
Animasyon ilkesi (Animation principle):	Bilimsel iş kavramı, animasyonlarla ayrı ayrı anlatılmıştır.
Etkileşim ilkesi (Interactivity principle)	Kullanıcılar ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahiptir. Ayrıca, kullanıcılar doğru olduğunu düşündükleri şıklardan birini seçme ve sorunun çözümünü görmek için yanıt göster düğmesine basma imkânına sahiptir.
Ekran Numarası	**13**
Gereksizlik ilkesi (Redundancy principle):	Resimlerin ve animasyonların anlatımında sesli anlatım kullanılmış, fazladan yazılı ekran metinlerine yer verilmemiştir.
Dikkat bölünmesi (Split Attention)	Anlatım sesi ile görsellerin sunumu birbirleri ile eş zamanlıdır. Ayrıca görseller, görselleri anlatan yazılı metin ifadeleri, kuvvet ve hareketi anlatan oklar, birbirlerine yakın olacak şekilde ayarlanmıştır.
Tutarlılık ilkesi (Coherence principle):	Tutarlığı bozacak nitelikte öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılmıştır.
Dikkat çekme ilkesi (Signaling principle):	Seslendirme metninde koyu yazı tipi ile belirtilen önemli bölümlerin seslendirilmesi diğerlerine göre daha vurgulu bir tonda yapılmıştır. Ayrıca, I. Şekildeki aracın hareketi anlatılırken seslendirme *"kutuya uygulanan kuvvetin ve cismin hareket doğrultusunun aynı olduğunu görüyoruz"* cümlesindeki *"aynı"* kelimesini seslendirdiği an kuvvet ve hareketi temsil eden oklara aynı anda yanıp sönme (blinking) efekti ile vurgu yapılmıştır. Bu kural, II, III ve IV. Şekillerin ilgili bölümleri için de geçerlidir. Son olarak, iş yapılan durumlarda, ekranda, doğru cevap anlamında onay işareti (tick), iş yapılmayan durumda ise ekranda yanlış cevap anlamında (çarpı) işareti belirmiştir.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Uygulanabilir değil.
Biçem ilkesi (Modality principle):	Görsel ve işitsel kanalların dengeli kullanılabilmesi adına öğretim içeriğinin aktarımında sadece sesli anlatım kanalı kullanılmıştır.
Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.

Table 20 (continued)

Bireyselleştirme ilkesi (Personalization principle):	İçten, samimi, kullanıcı ile konuşuyormuş havası veren bir üslup kullanılmıştır. Bu kapsamda, anlatım sesinde "*bulalım*", "*inceleyelim*", "*ne görüyorsun*?", "*söyleyebiliriz*", "*diyebiliriz*" gibi ifadeler kullanılmıştır.
Çözümlü örnekler ilkesi (Worked examples principle):	Kuvvet ve hareketin birbirlerine dik olduğu durumlarda bilimsel anlamda iş yapılmaz. Bu durum, çözümlü örnek ile anlatılmıştır.
Animasyon ilkesi (Animation principle):	Karakterlerin yaptığı işler animasyonlar ile gösterilmiştir.
Etkileşim ilkesi (Interactivity principle)	Kullanıcılar, ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahiptir.
Ekran Numarası	**14**
Gereksizlik ilkesi (Redundancy principle):	Yazılı metinler, sadece önemli olaylara vurgu yapmak için ve bazı görselleri etiketlemek için kullanılmıştır.
Dikkat bölünmesi (Split Attention)	Animasyonun içerisindeki unsurların oynatılma zamanı ile ilgili bölümlerin seslendirilmesi zamanı birbirleriyle aynıdır. Örneğin, seslendirme "*yaptığımız işin büyüklüğü cisme uyguladığımız kuvvetin büyüklüğüne*" ifadesinde yer alan "*kuvvetin*" kelimesini seslendirdiği an ekranın sol tarafından gelen bir "futbolcu ayağı" topa vurur. Bunlara ek olarak, görseller ve görselleri tanımlayan yazılı ifadelerin ekran üzerindeki konumları birbirleriyle yakın olacak şekilde ayarlanmıştır.
Tutarlılık ilkesi (Coherence principle):	Tutarlığı bozacak nitelikte öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılmıştır
Dikkat çekme ilkesi (Signaling principle):	Ekranda "*kuvvet*" kelimesi seslendirildiği an kuvveti temsil eden ok işaretine, "*yol*" kelimesi seslendirildiği an yolu temsil eden ok işaretine yanma sönme efekti ile vurgu yapılmıştır. Ayrıca anlatım metninde belirtilen önemli yerlerin okunması sırasında daha vurgulu bir ses tonu kullanılmıştır.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Uygulanabilir değil.
Biçem ilkesi (Modality principle):	Görsel ve işitsel kanalların dengeli kullanılabilmesi için öğretim içeriğinin aktarımında sadece sesli anlatım kanalı kullanılmıştır.
Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.
Bireyselleştirme ilkesi (Personalization principle):	Ekran genelinde içten, kullanıcı ile konuşuyormuş hissi veren bir anlatım üslubu benimsenmiştir.
Çözümlü örnekler ilkesi (Worked examples principle):	Uygulanabilir değil.

Table 20 (continued)

Animasyon ilkesi (Animation principle):	Yapılan işin uygulanan kuvvet ve alınan yola bağlı olması durumu yuvarlanan top animasyonu ile anlatılmıştır.
Etkileşim ilkesi (Interactivity principle)	Kullanıcılar ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahiptir.
Ekran Numarası	**15-16**
Gereksizlik ilkesi (Redundancy principle):	Animasyonları anlatmak için fazladan yazılı ekran metni kullanılmamıştır.
Dikkat bölünmesi (Split Attention)	Seslendirme ile görsel sunumu eş zamanlıdır. Örneğin, seslendirme "*Cem ilk durumda 10 newtonluk halteri yerden 2 metre yükseğe kaldırıyor*" ifadesini seslendirdiği an karakter yerde duran 10 Newtonluk halteri kaldırmaya başlamıştır. Ayrıca, halter görseli ile halterin ağırlığını belirten yazılı ekran metni birbirlerine yakın olacak şekilde konumlandırılmış, bu sayede uzamsal yakınlık ilkesine bağlı kalınmıştır.
Tutarlılık ilkesi (Coherence principle):	Öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılmıştır.
Dikkat çekme ilkesi (Signaling principle):	Her iki bölümde de seslendirme metninde koyu yazı tipi ile belirtilen yerler diğer bölümlere göre daha vurgulu bir ses tonu ile okunmuştur. Ayrıca, farklı ağırlıklara sahip görsellere vurgu yapılırken ilgili görsellerin resim kenarlıkları ışıklandırılmıştır.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Yapılan işin kuvvete ve alınan yola bağlı değişimi iki ayrı bölümde anlatılmıştır İlk bölümde yapılan işin kuvvete bağlı değişimi anlatılırken, ikinci bölümde yapılan işin alınan yola bağlı değişimi anlatılmıştır.
Biçem ilkesi (Modality principle):	Görsel kanalda işlenecek olan animasyonlar ile beraber işitsel kanalda işlenecek olan sesli anlatım metni kullanılmıştır. Bu sayede işitsel ve görsel kanalların dengeli kullanılması sağlanmıştır.
Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.
Bireyselleştirme ilkesi (Personalization principle):	Her iki bölümde de samimi bir üslup kullanılmıştır. "*Ekrandaki örneği dikkatlice incele*", "*ekrandaki traktörün hareketini dikkatlice incele"* gibi ifadeler bu duruma örnek olarak verilebilir. Buna ek olarak her iki bölümde de edilgen yapılı cümleler yerine etken yapılı cümleler kullanılmıştır.
Çözümlü örnekler ilkesi (Worked examples principle):	Uygulanabilir değil.
Animasyon ilkesi (Animation principle):	Halteri kaldıran karakterin ve kutuyu çeken traktörün yaptıkları hareketler animasyon yardımı ile anlatılmıştır.

Table 20 (continued)

Etkileşim ilkesi (Interactivity principle)	Kullanıcılar ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahiptir.
Ekran Numarası	**17**
Gereksizlik ilkesi (Redundancy principle):	Animasyon ile beraber sesli anlatım kullanılmıştır. Yazılı metinlerin ekranda fazladan kullanılması bilişsel yük oluşturacağı için bu metinlerin kullanılmasına yer verilmemiştir.
Dikkat bölünmesi (Split Attention)	Anlatım sesi ile görsel sunumu birbirleriyle eş zamanlı olacak şekilde ayarlanmıştır. Örneğin, seslendirme "*buna göre öncelikle I. ve II. durumları inceleyelim*" ifadesini seslendirdiği anda I. ve II. durumdaki görseller büyümüş, ekranın ortasına gelmiş ve odaklanılacak ana görseller haline gelmiştir. Ayrıca uzamsal yakınlık ilkesine uygun olarak vektörel büyüklükleri temsil eden yazılı ekran metinleri ile vektörler arasındaki mesafeler birbirlerine uzamsal olarak yakın olacak şekilde ayarlanmıştır. Benzer yaklaşımlar ilgili ekranın diğer bölümlerinde mevcuttur.
Tutarlılık ilkesi (Coherence principle):	Öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılmıştır.
Dikkat çekme ilkesi (Signaling principle):	Her durumda iş makinalarının kaldırdıkları kutu miktarlarına vurgu yapılmıştır. Vurgulama işlemi kutu görsellerinin resim kenarlığının ışıklandırılması ile gerçekleştirilmiştir. Ayrıca seslendirme metninde koyu yazı tipi ile belirtilen yerler diğer bölümlere göre daha vurgulu bir ses tonu ile okunmuştur.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Uygulanabilir değil.
Biçem ilkesi (Modality principle):	Görsel kanalda işlenecek olan animasyonlar ile beraber işitsel kanalda işlenecek olan sesli anlatım metni kullanılmıştır. Bu sayede işitsel ve görsel kanalların dengeli kullanılması sağlanmıştır.
Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.
Bireyselleştirme ilkesi (Personalization principle):	Sesli anlatım metni için samimi bir dil kullanılmıştır. Anlatım metninde kullanılan "*iş makinasının yaptığı işlerin büyüklüklerini büyükten küçüğe doğru sıralayalım mı?"*, "*kuvvet ve yer değiştirme ile doğru orantılı olduğunu hatırla*" gibi ifadeler bu durumu örnek olarak verilebilir.
Çözümlü örnekler ilkesi (Worked examples principle):	Çözümlü örnek ile iş makinasının yaptığı işlerin büyüklükleri karşılaştırılmıştır. Öncelikle*, "…buna göre iş makinasının yaptığı işleri büyükten küçüğe doğru sıralayalım"* ifadesi ile soru sorulmuş, daha sonra cevap çözümlü olarak öğrenciye aktarılmıştır.

Table 20 (continued)

Animasyon ilkesi (Animation principle):	Uygulanabilir değil.
Etkileşim ilkesi (Interactivity principle)	Kullanıcılar ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahiptir.
Ekran Numarası	**18**
Gereksizlik ilkesi (Redundancy principle):	Animasyon ile beraber sesli anlatım kullanılmıştır. Yazılı metinlerin ekranda fazladan kullanılmasına yer verilmemiştir.
Dikkat bölünmesi (Split Attention)	Anlatım sesi ile görsel sunumu birbirleriyle eş zamanlıdır. Örneğin, anlatım sesi *"bir araba bir yerden bir yere giderken enerji harcar değil mi?"* cümlesindeki *"bir araba"* ifadesini seslendirdiği anda araba görseli ekranda yakınlaşmış ve bir miktar sağa doğru hareket etmiştir.
Tutarlılık ilkesi (Coherence principle):	Öğretimi ilgi çekici hale getirmek adına tutarlığı bozacak nitelikte öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılmıştır.
Dikkat çekme ilkesi (Signaling principle):	Anlatım metni içerisinde koyu yazı tipi ile belirtilen önemli sözcüklerin diğer sözcüklere göre daha vurgulu bir ses tonu ile okunması sağlanmıştır.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Uygulanabilir değil.
Biçem ilkesi (Modality principle):	Görsel kanalda işlenecek olan animasyonların anlatımda işitsel kanalda işlenecek olan sesli anlatım kullanılacaktır. Bu sayede işitsel ve görsel kanalların dengeli kullanılması sağlanacaktır.
Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.
Bireyselleştirme ilkesi (Personalization principle):	Edilgen yapılı cümleler yerine etken yapılı cümleler kullanılarak samimi, kullanıcı ile konuşuyormuş hissi veren bir üslup kullanılmıştır. Kullanılan *"bir araba bir yerden bir yere giderken enerji harcar değil mi" "sence enerji nedir"* gibi ifadeler bu üsluba örnek olarak verilebilir.
Çözümlü örnekler ilkesi (Worked examples principle):	Uygulanabilir değil.
Animasyon ilkesi (Animation principle):	Her varlığın yaptığı iş animasyon ile kısaca anlatılmıştır.
Etkileşim ilkesi (Interactivity principle)	Kullanıcılar ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahip olacaktır.

Table 20 (continued)

Ekran Numarası	**19-20**
Gereksizlik ilkesi (Redundancy principle):	Animasyon ile beraber sesli anlatım kullanılacaktır. Yazılı metinlerin ekranda fazladan kullanılması bilişsel yük oluşturacağı için bu metinlerin kullanılmasına yer verilmeyecektir.
Dikkat bölünmesi (Split Attention)	Animasyondaki unsurların sunum sırası ve anlatım sesi birbirleriyle eş zamanlı olacak şekilde ayarlanmıştır. Örneğin, seslendirme "*gördüğün gibi sporcu, 10 kilo gramlık halteri zorlanmadan kaldırıp indiriyor*" cümlesini seslendirmeye başlar başlamaz sporcu da 10 kilo gramlık halteri hızlı bir şekilde kaldırma ve indirme işine başlar. Aynı prensip ekranların diğer bölümlerinde de uygulanmıştır.
Tutarlılık ilkesi (Coherence principle):	Öğretim kazanımları ile doğrudan ilişkili olmayan unsurların kullanılmasından kaçınılacaktır.
Dikkat çekme ilkesi (Signaling principle):	Seslendirme metnindeki önemli bölümlerin diğerlerine göre daha vurgulu bir ses tonu ile okunması sağlanmıştır. Bu sayede bu bölümlerin önemine vurgu yapılmıştır Ayrıca, ilk bölümde kütlesi büyü olan halterin bu büyüklüğüne vurgu yapmak için ağırlığın resim kenarlığı ışıklandırılmıştır.
Parçalara bölme/mantıksal sıralama ilkesi (Segmenting/sequencing):	Uygulanan kuvvetin ve alınan yolun büyüklüğünün enerjiye etkisi iki ayrı bölüm halinde anlatılmıştır.
Biçem ilkesi (Modality principle):	Yazılı anlatım metni yerine sesli anlatım metni kullanılmıştır.
Ön alıştırma ilkesi (Pre-training principle):	Uygulanabilir değil.
Bireyselleştirme ilkesi (Personalization principle):	Kullanıcı ile konuşuyormuş hissi veren bir üslup kullanılmıştır. Kullanılan *"şimdi alınan yolları tekrar incele", "biliyoruz", "değil mi", "ne görüyorsun?"* gibi ifadeler bu duruma örnek olarak verilebilir.
Çözümlü örnekler ilkesi (Worked examples principle):	Uygulanabilir değil.
Animasyon ilkesi (Animation principle):	Hem uygulanan kuvvet hem de alınan yol ile ilgili örneklendirmelerin anlatılmasında animasyonlar kullanılmıştır.
Etkileşim ilkesi (Interactivity principle)	Kullanıcılar ekranın akışını kontrol etme, akışı durdurabilme, duraklatabilme, geri sarma, ileri alma, bir sonraki ekrana geçme, bir önceki ekrana dönme gibi imkânlara sahiptir.

APPENDIX D

WORK, ENERGY AND ENERGY CONSERVATION ACHIEVEMENT TEST

A. Recall Test

Bu bölümde cevaplaman gereken 20 adet çoktan seçmeli soru bulunmaktadır. Bu bölüm için sana ayrılan süre 20 dakikadır. Her soru eşit puan değerindedir. Yanlış cevaplar, doğru cevapları etkilemeyecektir. Şıklardan sana en yakın geleni seçip soru kâğıdı üzerinde işaretlemelisin. Başarılar…

Numara:

Sınıf/Şube

1. Bilimsel olarak iş ile ilgili aşağıdaki bilgilerden hangisi **doğrudur?**

A) Günlük hayatta yorulduğumuz bütün durumlarda iş yapmış sayılırız.

B) Günlük hayattaki iş kavramı ile bilim insanlarının tanımladıkları iş kavramı her zaman aynıdır.

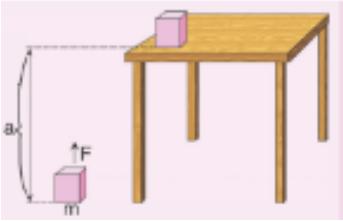
C) Bir cisme kuvvet uyguladığımızda onu kendi doğrultusunda hareket ettiriyorsak iş yapmış oluruz

D) İş yapabilmek için bir cisme kuvvet uygulamak yeterlidir.

2. İşin birimi aşağıdakilerden hangisidir?

A) Newton B) Kilogram C) Metre **D) Joule**

3. Şekildeki "m" kütleli cisme "F" kuvveti uygulanarak cismin "a" kadar yer değiştirmesi sağlanıyor. Buna göre F kuvvetinin yaptığı iş aşağıdakilerden hangisine bağlı **değildir?**



I. Cismin şekline

II. Cisme uygulanan kuvvetin büyüklüğüne

III. Cismin yer değiştirmenin miktarına

A) **Yalnız I** B) Yalnız II C) I, III D) I, II, III

4. Aşağıdaki cümlelerde verilen bilgilerden hangisi **yanlıştır**?

A) Günlük hayatta enerji harcadığımız bütün durumlarda bilimsel olarak iş yaparız.

B) İş yapabilme yeteneğine enerji denir.

C) Enerjinin birimi Joule'dür

D) İş yapabilmek için enerjiye ihtiyaç vardır

5. Varlıkların **hareketinden** dolayı sahip olduğu enerjiye _____ denir. Boş bırakılan yere gelmesi gereken ifade aşağıdakilerden hangisidir?

A) Esneklik potansiyel enerjisi

B) Çekim potansiyel enerjisi

C) Güneş enerjisi

D) Kinetik enerji

6. Aşağıdaki yargılardan hangisi ya da hangileri **doğrudur**?

I. Durmakta olan bir uçağın kinetik enerjisi vardır.

II. Ağaçtan düşen elmanın kinetik enerjisi vardır

III. Sabit süratle hareket eden bir köpeğin kinetik enerjisi vardır

A) I-II-III B) Yalnız II C) Yalnız III **D) II-III**

7. Varlıkların bulundukları **yükseklikler nedeniyle** sahip oldukları enerjiye_____denir. Boş bırakılan yere gelmesi gereken ifade aşağıdakilerden hangisidir?

A) Kinetik enerji

B) Esneklik potansiyel enerjisi

C) Çekim potansiyel enerjisi

D) Sürtünme enerjisi

8. Esnek cisimleri gerdiğimizde ya da sıkıştırdığımızda cisimlerde enerji depolanmasını sağlarız. Bu enerjiye ne denir?

A) Kinetik enerji

B) Esneklik potansiyel enerjisi

C) Çekim potansiyel enerjisi

D) Sürtünme enerjisi

9. Aşağıdaki verilen durumların hangisinde esneklik potansiyel enerjisi kinetik enerjiye dönüşür?

A) Okun yaydan fırlatılması

B) Taşıtların fren yapması

C) Lambaların yakılması

D) Elmanın ağaçtan düşmesi

10. Esneklik potansiyel enerjisi aşağıdakilerden hangisine ya da hangilerine bağlıdır?

I. Esnek cismin sıkıştırılma ya da gerilme miktarına

II. Esnek cismin rengine

III. Esnek cismin cinsine

A) I-II B) I-II-III C) Yalnız I **D) I-III**

11. Bir top belirli bir yükseklikten serbest bırakılıyor. Topun hareketi boyunca sahip olduğu çekim potansiyel enerjisi, kinetik enerji ve mekanik enerji nasıl değişir? (Sürtünmeler önemsizdir)

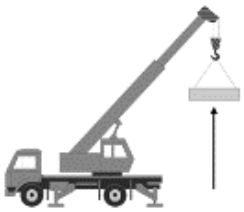
	Çekim potansiyel enerjisi	Kinetik enerji	Mekanik enerji
A)	Azalır	Azalır	Değişmez
B)	Azalır	Artar	Artar
C)	Artar	Azalır	Azalır
D)	**Azalır**	**Artar**	**Değişmez**

12. Kinetik enerji aşağıdakilerden hangisine bağlı olarak değişir?
A) Kütle ve yol
B) Kütle ve sürat
C) Kütle ve yükseklik
D) Sürat ve yol

13. Aşağıdaki tabloda sürtünmenin az ya da çok olması istenen durumlar verilmiştir. Hangi seçenekte bu durum **yanlış** verilmiştir?

A)	**Dağcıların dağa tırmanması**	**Az**
B)	Paraşütçülerin güvenli bir şekilde yere inmesi	Çok
C)	Taşıtların fren yaparak durması	Çok
D)	Sporcunun buz pateni ile kayması	Az

14. Şekilde bir yükü bir yerden daha yüksek bir konuma kaldıran bir iş makinesi görmektesin. Buna göre bu iş makinesi için aşağıdaki yargılardan hangisi ya da hangileri **doğrudur**?



I. Yük havada sabitken hareketsizdir. Bu nedenle yükün enerjisi yoktur
II. Yük serbest bırakıldığında ağırlığı nedeniyle iş yapar
III. İş makinesinin yükü kaldırırken yaptığı iş yükte çekim potansiyel enerjisi olarak depolanır

A) II-III B) I-II-III C) Yalnız III D) Yalnız II

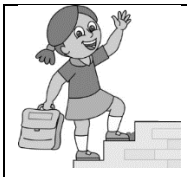
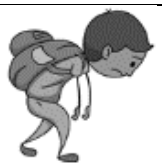
15. Sürtünme kuvveti ile ilgili aşağıdakilerden hangisi ya da hangileri **doğrudur**?
I. Varlıkların hareketini engelleyici özelliğe sahiptir
II. Yüzeyin cinsine bağlıdır
III. Her zaman zararlıdır

A) I-II-III B) Yalnız II **C) I-II** D) II-III

16. Belirli bir yükseklikten bırakılan bir top bir süre zıpladıktan sonra durur. Top her zıplayışında topun enerjisi daha çok hangi enerji türlerinden aşağıdakilerden hangisine dönüşür?

A) Ses enerjisi
B) Çekim potansiyel enerjisi
C) Kinetik enerji
D) Isı enerjisi

17.

		
I. Çocuk çantasıyla merdiven çıkıyor	II. Çocuk düz yolda sırtında çanta taşıyor	III. Çöp, çöp tenekesine bırakılıyor

Yukarıdaki durumların hangisi ya da hangilerinde bilimsel olarak iş yapılmıştır?

A) I-II-III B) Yalnız III C) I-II **D) I-III**

18. Aşağıdakilerden hangisi bir cismin hareketi boyunca sahip olduğu toplam enerji olarak adlandırılır?

A) Genel enerji B) Isı enerjisi **C) Mekanik enerji** D) Çekim potansiyel enerjisi

19. Çekim potansiyel enerjisi aşağıdakilerden hangisine bağlı olarak değişir?

A) Kütle ve yükseklik
B) Kütle ve sürat
C) Kütle ve yol
D) Sürat ve hacim

20. Seçil topu şekilde görüldüğü gibi yukarı doğru fırlatıyor. Top "K", "L", "M", "N" yörüngelerini izleyerek yere çarpıyor. Cisim hangi noktadayken **<u>sırasıyla</u>** çekim potansiyel ve kinetik enerjileri en büyük değerde olur?

A) N,L **B) L,N** C) K,M D) M,N

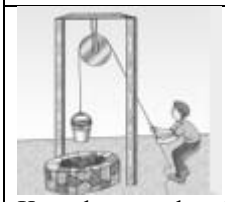
B. Transfer Test

Bu bölümde cevaplaman gereken 14 adet açık uçlu soru bulunmaktadır. Bu bölüm için sana ayrılan süre 20 dakikadır. Soruların cevaplarını boş bırakılan yerlere yazmalısın. Başarılar…

Numara:

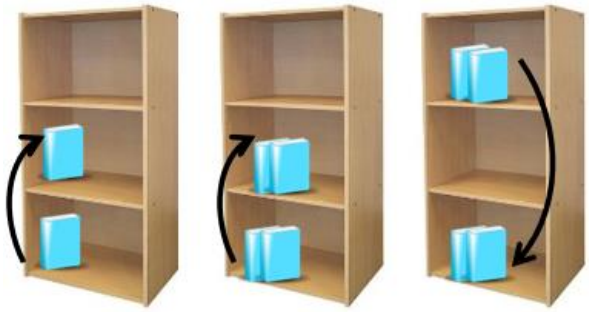
Sınıf/Şube

1. Aşağıda kişilerin yaptıkları eylemleri incele. Hangi kişi ya da kişiler bilimsel anlamda iş yapmıştır? Nedenini fotoğrafların karşısındaki boşluklara yaz.

 Bavulu çekerek sürükleyen Mert	Mert ……. Çünkü……... ……..
 Kuyudan su çeken Selim	……. ……. …….
 Elindeki tepsiyi taşıyan Nur	……. ……. …….

2. Bir fare bir aslan ve bir kedi sürtünmesiz bir ortamda eşit süratle hareket etmektedir. Bu varlıkları sahip oldukları kinetik enerji bakımından karşılaştır ve yaptığın karşılaştırmanın nedenini açıkla.

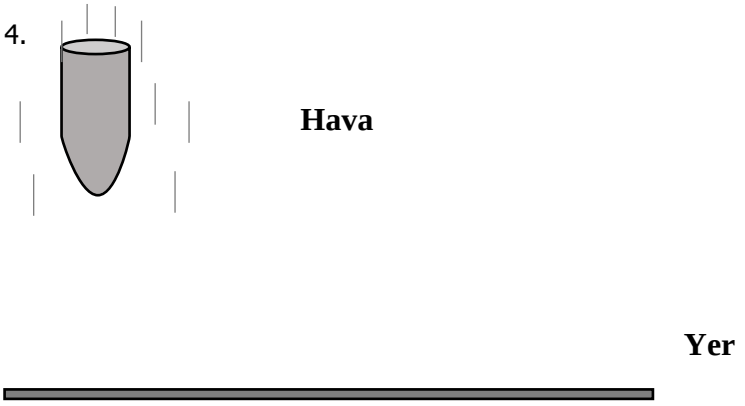
3.



I. **II.** **III.**

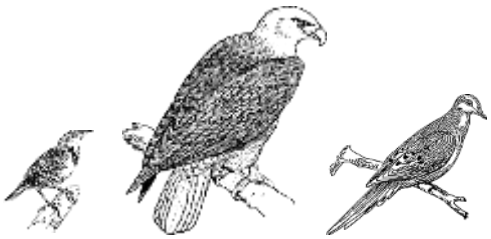
Rafta duran özdeş kitapların yerleri yukarıda verilen numaralandırılmış durumlardaki gibi değiştiriliyor. Buna göre yapılan işler arasında nasıl bir sıralama vardır? Sebebini açıkla.

4.



Silindir şeklindeki bir cisim hava ortamında serbest bırakılıyor. Cismin yere daha yavaş inmesi için neler yapılabilir? Aklına gelen her şeyi yaz.

5.

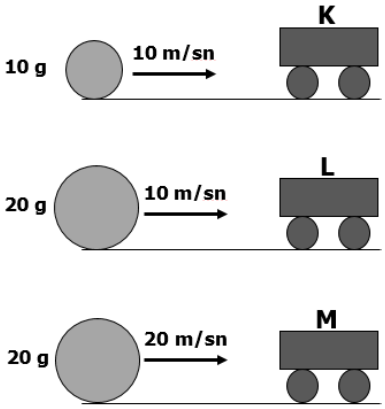


Serçe Kartal Güvercin

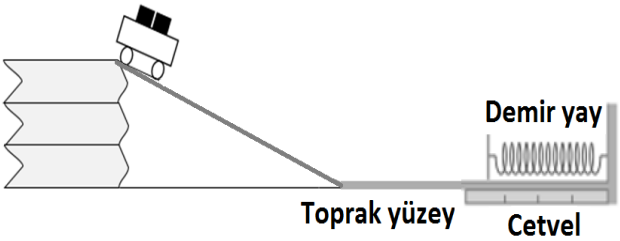
Yukarıdaki resimde **<u>aynı yükseklikteki</u>** bir ağacın dalında hareketsiz olarak beklemekte olan serçe, kartal ve güvercin görmektesin. Bu varlıkları sahip oldukları çekim potansiyel enerjisi bakımından karşılaştır ve yaptığın karşılaştırmanın nedenini açıkla

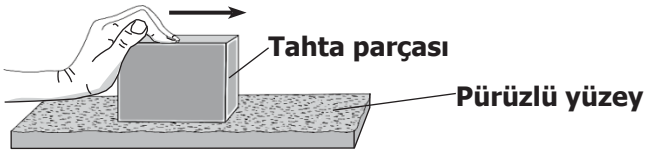
6. Babası, İrem'e hareket halindeki bir aracın frenine basıldığında enerji kaybı olacağını söylüyor. Fakat İrem, "hayır baba enerji kaybolmaz" diyerek bunun tam tersini iddia ediyor. Sence kim haklı? Neden? Açıkla.

7. Sürtünmelerin önemsenmediği bir ortamda kütleleri ve süratleri verilen bilyeler, özdeş arabalara çarparak arabaların yol almasını sağlıyor. Buna göre; Arabaların aldıkları yollar arasında nasıl bir sıralama vardır? Neden?



8. Aşağıdaki düzenekte üzerinde tahta takozlar bulunan bir araba serbest bırakılarak yayın sıkışması sağlanıyor. Yayın daha fazla sıkışması için sistemde ne gibi değişiklikler yapılmasını önerirsin? Aklına gelen her şeyi yaz.



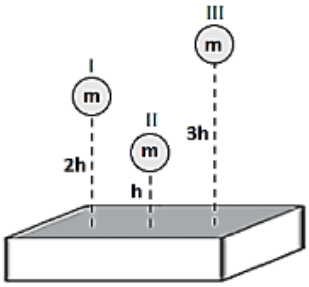


Yukarıdaki deneyde bir tahta parçası pürüzlü yüzey üzerinde bir miktar itiliyor. Buna göre;

9. Tahta parçasının bir süre sonra ısınmasının sebebi nedir?

10. Tahta parçasının daha az ısınmasını sağlamak için sistemde ne gibi değişiklikler yapılabilir?

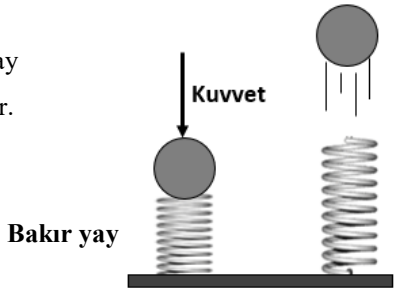
11. Aşağıdaki deneyde sürtünmesiz ortamda kütleleri eşit olan numaralandırılmış toplar belirtilen yüksekliklerden serbest bırakılıyor. Topların kum havuzundaki gömülme miktarlarının III>I>II olduğu gözleniyor. Buna göre bu deneyde araştırılmak istenen şey nedir?



12.

Yukarıdaki şekilde görülen cisim serbest bırakılıyor. Bu sırada hangi enerji türleri arasında dönüşüm gerçekleşir? Açıkla (Sürtünmeler önemsizdir)

13. Ucunda top bulunan bakır yaya bir miktar kuvvet uygulanarak yayın sıkışması sağlanıyor. Bir süre sonra yay serbest bırakıldığında topun havada yükseldiği gözleniyor. Topun daha fazla yükselmesi için **topun kütlesini değiştirmeden** sistemde ne gibi değişiklikler yapılmasını önerirsin? Aklına gelen her şeyi yaz.



14. Aşağıda bulunan cisme farklı yönlerde kuvvetler uygulanmaktadır. Bu kuvvetler hangi durumlarda iş yapabilir? Vermiş olduğun cevabın nedenini fotoğrafların karşısındaki boşluklara yaz.

	…… …….
	……. …….
	……. …….
	……. …….

APPENDIX E

MENTAL EFFORT TEST

Numara:

Sınıf/Şube:

1. Aşağıdaki anket, bilimsel iş konusu ile ilgili eğitim yazılımını kullandığın sırada harcadığın zihinsel çabayı ölçmektedir. “Bilimsel iş” konusunu öğrenirken ne kadar çaba sarf ettin?

Çok çok az	Çok az	Az	Kısmen az	Ne az ne fazla	Kısmen fazla	Fazla	Çok fazla	Çok çok fazla
1	2	3	4	5	6	7	8	9
◯	◯	◯	◯	◯	◯	◯	◯	◯

2. Aşağıdaki anket, enerji türleri (kinetik enerji, çekim potansiyel enerjisi ve esneklik potansiyel enerjisi) konuları ile ilgili eğitim yazılımını kullandığın sırada harcadığın zihinsel çabayı ölçmektedir. Enerji türleri konusunu işlerken ne kadar çaba sarf ettin?

Çok çok az	Çok az	Az	Kısmen az	Ne az ne fazla	Kısmen fazla	Fazla	Çok fazla	Çok çok fazla
1	2	3	4	5	6	7	8	9
◯	◯	◯	◯	◯	◯	◯	◯	◯

3. Aşağıdaki anket, enerji dönüşümleri ve sürtünme ile enerji kaybı konusu ile ilgili eğitim yazılımını kullandığın sırada harcadığın zihinsel çabayı ölçmektedir. Enerji dönüşümleri ve sürtünme ile enerji kaybı konularını işlerken ne kadar çaba sarf ettin?

Çok çok az	Çok az	Az	Kısmen az	Ne az ne fazla	Kısmen fazla	Fazla	Çok fazla	Çok çok fazla
1	2	3	4	5	6	7	8	9
◯	◯	◯	◯	◯	◯	◯	◯	◯

APPENDIX F

INTERVIEW PROTOCOL

Tarih ve saat:

TANITIM:

Merhaba, benim adım Ahmet Murat UZUN. Afyon Kocatepe Üniversitesi, Eğitim Fakültesi, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü'nde araştırma görevlisi olarak çalışmaktayım. Yürütmekte olduğum çalışma (doktora tezi) kapsamında "Çoklu ortam Öğretiminde Duygusal ve Motivasyonel Faktörlerin Öğrenmeye ve Hissedilen Duygu Durumları ve Öğrenme Başarısına Etkisi" adlı bir çalışma yürütmekteyim. Çoklu ortamda kullanılan duygusal ve motivasyonel tasarımın kullanımı hakkında sizlerin görüşlerine ihtiyaç duymaktayım.

Görüşme sırasında söyleyeceklerinin tamamı gizli tutulacak olup sonuçlar sadece bilimsel amaçlı kullanılacaktır. Ayrıca araştırma sonuçlarının sunumunda ya da raporlanmasında kesinlikle ismin kullanılmayacaktır. Görüşmeye başlamadan önce sormak ya da eklemek istediğin şeyler var mı? Görüşmemizi daha iyi yorumlamak için görüşmeyi kayıt altına almak istiyorum. Bunun sence bir sakıncası var mı? Bu görüşmenin yaklaşık olarak 20 dakika süreceğini tahmin ediyorum. İzin verirsen görüşme sorularına başlamak istiyorum.

1. Genel olarak kuvvet ve enerji ile ilgili konu anlatımını nasıl buldun?

2. Eğitim yazılımı (video) hakkında ne düşünüyorsun?
   - Renkler?
   - Varlıkların hareket ederken çıkardığı sesler?
   - Cansız varlıklar (iş makinası, araba, top, yay, kutular, traktör)?
   - İnsanların yüzlerindeki ifadeler?
3. Eğitim yazılımında en çok sevdiğin ya da en çok hoşuna giden bölüm(ler) neydi?

   [Eğitim yazılımı [video] içerisinde "iyi ki kullanılmış" diyebileceğin şeyler var mıydı? Neden?]
   - Cansız varlıklar (iş makinası, araba, top, yay, kutular, traktör)? [gruba göre]
   - İnsanlar [gruba göre]
   - Varlıkların çıkardığı sesler? [gruba göre]
   - Renkler [gruba göre]
4. Eğitim yazılımda sevmediğin ya da hoşuna gitmeyen bölüm(ler) neydi?

   [Eğitim yazılımı [video] içerisinde "keşke olmasaydı" diyebileceğin şeyler var mıydı? Neden?]
   - Cansız varlıklar (iş makinası, araba, top, yay, kutular, traktör)? [gruba göre]
   - İnsanlar [gruba göre]
   - Varlıkların çıkardığı sesler? [gruba göre]
   - Renkler [gruba göre]

5. Dersi dinlerken genel olarak kendini nasıl hissettiğini sorsam bana ne söylersin?
   - Sıkılmış? Nedeni?
   - Eğlenmiş
   - Heyecanlı

- Mutlu? Nedeni?
- İlgili? Nedeni?
- Mutsuz? Nedeni?
- Rahatsız edici? Neden

6. Eğitim yazılımı(video) kuvvet ve enerji ile ilgili konuları öğrenmeni nasıl etkiledi?
    - Konuları öğrenmeni kolaylaştıran şeyler?
    - Konuları öğrenmeni zorlaştıran şeyler?
    - Dikkatini çeken ve dikkatini sürdüren şeyler?
    - Merak uyandıran bölümler?
    - Dikkatini dağıtan şeyler?
    - Cansız varlıklar (iş makinası, araba, top, yay, kutular, traktör)? [Gruba göre]
    - İnsanlar [gruba göre]
    - Varlıkların çıkardığı sesler? [gruba göre]
    - Renkler [gruba göre
7. Derse katılımını değerlendirmeni istesem kendine 10 üzerinden kaç verirsin? Neden?

APPENDIX G

ASSUMPTIONS OF PARAMETRIC TESTS

Before conducting the main analysis, the data were examined whether parametric tests were appropriate for the data analysis. Some of the assumptions of the parametric tests could be listed as independence of the observations, measuring dependent variable at the interval or ratio level, homogeneity of the variances and the normality of the population from which the sample is selected (Pallant, 2010). The following, assumptions were tested for each hypothesis.

Assumptions for Students' Positive Emotion Scores

In order to test whether students' positive emotions scores meet the assumptions of the parametric tests, first, normality assumption was tested. In order to explore whether the data for the groups (ND, CD, ED and EDSE) were normally distributed for positive emotion scores, first Kolmogorov-Smirnov and Shapiro-Wilk normality tests were conducted. Kolmogorov-Smirnov and Shapiro-Wilk normality tests are null hypothesis significance tests used for testing normality assumption (Field, 2013). The results of the Kolmogorov-Smirnov and Shapiro-Wilk tests were given in the following table:

Table 21 Results of Kolmogorov-Smirnov and Shapiro-Wilk Normality Tests Regarding Students' Positive Emotion Scores

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ND	.12	28	.20	.94	28	.09
CD	.22	25	**.00**	.80	25	**.00**
ED	.12	28	.20	.96	28	.31
EDSE	.12	25	.20	.98	25	.92

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Table 21 shows the results of Kolmogorov-Smirnov and Shapiro-Wilk tests. As can be seen from the table, the Kolmogorov-Smirnov test is significant for CD group. In other words, data for this group are significantly different from being normal, D (25) = .22, p = .00. In the same way, the Shapiro-Wilk test is significant for CD group, D (25) = .80, p = .00. Both of these results could be interpreted as indicators of the violation of the normality. However, one should be careful in reporting the results of Kolmogorov-Smirnov and the Shapiro-Wilk tests to conclude that the data are normally distributed or not, since these tests are too conservative and are based on the null hypothesis significance testing (Field, 2013). The problem for null hypothesis significance testing is that for large sample sizes the test results may be significant, even though the data indicates small and unimportant changes and for small sample sizes the test is not powerful to detect whether the test is significant or not. As a result, Field (2013) suggested: "in small samples, pay attention if your significance tests are significant but resist being lulled into a false sense of security if they are not" (p. 336). Given this rationale, in addition to Kolmogorov-Smirnov and the Shapiro-Wilk tests, the skewness and kurtosis values of the distribution were also computed to provide additional evidence regarding normality. Ideally, the more skewness and kurtosis values are deviated from zero, the more likely that the data are deviated from normality (Field, 2013). The skewness and kurtosis values calculated by the IBM SPSS statistics could be converted into standard z scores. For small sample sizes, z scores could be useful to determine if skewness and the kurtosis values are significantly deviated from zero (Field, 2013).

The calculated $z_{skewness}$ and $z_{kurtosis}$ values are compared to zero using the *z* distribution. A *z* value greater than 3.29 indicates that the shape of the distribution is significantly different from zero at $p = .001$ level (Field, 2013; Tabachnick & Fidell, 2007). Based on this criterion, first, the values of skewness and kurtosis and standard error of the skewness and kurtosis were found. Then, dividing skewness and kurtosis values by standard error of the skewness and kurtosis, $z_{skewness}$ and $z_{kurtosis}$ values were obtained. Skewness, kurtosis and $z_{skewness}$, $z_{kurtosis}$ values calculated for students' positive emotion scores are shown in the following table:

Table 22 Skewness and Kurtosis Values Regarding Students' Positive Emotion Scores

	Skewness	Kurtosis	SE of Skewness	SE of Kurtosis	$z_{skewness}$	$z_{kurtosis}$
ND	.77	.23	.44	.86	1.75	.27
CD	2.26	8.37	.46	.90	**4.87**	**9.28**
ED	.46	1.01	.44	.86	1.04	1.18
EDSE	.00	.37	.46	.90	.00	.41

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates *z* values beyond acceptable range.

As can been seen from the table, the $z_{skewness}$ and $z_{kurtosis}$ values calculated for ND, ED and EDSE groups are in the acceptable range ($-3.29 < z < 3.29$). However, $z_{skewness}$ and $z_{kurtosis}$ values for the CD group are found to be greater than 3.29 and significant at $p = .001$ level. For CD group, *z* values of skewness and kurtosis are 4.87 and 9.28 respectively, which are quite high. As a result, based on the normality tests, it could be argued that for CD group, the population from which the sample was selected did not distribute normally. Hence, in order to investigate whether students' positive emotion scores were affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), Kruskal-Wallis test, a non-parametric form of a one way analysis of the variance (ANOVA), was decided to be used for further analysis.

Assumptions for Students' Mental Effort Ratings

As for the students' positive emotion scores, the data were subjected to testing the assumptions of parametric tests for students' mental effort ratings. Hence, before conducting main statistical analysis, normality tests were conducted to test whether data met the normality assumption. First, Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted. The results of the tests are tabulated as follows:

Table 23 Normality Tests Regarding Students' Mental Effort

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ND	.11	28	.20	.97	28	.60
CD	.19	25	**.02**	.93	25	.10
ED	.15	28	.09	.87	28	**.00**
EDSE	.09	25	.20	.96	25	.40

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Table 23 demonstrates the results of Kolmogorov-Smirnov and Shapiro-Wilk tests. As the table shows, Kolmogorov-Smirnov test is significant for CD group (p = .02). In addition, Shapiro-Wilk test is significant for ED group (p = .00). These results together indicated that the normality assumptions for both CD and ED groups were not satisfied. For further exploration, the skewness and kurtosis values of the data were also examined. Skewness, kurtosis and related $z_{skewness}$, $z_{kurtosis}$ values for students' mental effort ratings are given as follows:

Table 24 Skewness, Kurtosis and Standardized Skewness, Kurtosis Values Regarding Students' Mental Effort

	Skewness	Kurtosis	SE of Skewness	SE of Kurtosis	$z_{skewness}$	$z_{kurtosis}$
ND	.26	-.07	.44	.86	.59	-.08
CD	-.51	-.51	.46	.90	-1.11	-.57
ED	-1.56	3.17	.44	.86	**-3.55**	**3.70**
EDSE	-.51	-.56	.46	.90	-1.10	-.62

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates z values beyond acceptable range.

Table 24 demonstrates the results of skewness, kurtosis and standardized skewness, kurtosis values. As can be seen from the results, for ND, CD and EDSE groups, the *z* scores calculated for skewness and kurtosis values are in the acceptable range ($-3.29 < z < 3.29$). As a result, the data for these groups are not deviated from the zero significantly ($p > .001$). However, *z* scores calculated for ED group show that both $z_{skewness}$ and $z_{kurtosis}$ are not in the acceptable range ($-3.29 < z < 3.29$) and are significant at p=.001 level. As a result, data distribution significantly differed from zero for ED group, which could be interpreted as an indicator of deviation from the normality. Since the normality assumption for ED group was violated, parametric tests were not able to be conducted. Instead, in order to compare students' mental effort ratings across different design groups (ND, CD, ED, and EDSE), Kruskal-Wallis, a non- parametric alternative of ANOVA, was decided to be conducted.

Assumptions for Students' Learning Achievement Scores

The third hypothesis of the study was to test whether students' achievement scores (as measured by recall and transfer of learning) are significantly affected by use of different levels and complexity of emotional design in multimedia (ND, CD, ED and EDSE), after controlling for the effect of prior knowledge and working memory capacity. To test the hypothesis, a one way ANCOVA was planned to be used for both post recall of learning and post transfer of learning scores. As for most of the parametric tests, ANCOVA test necessitates satisfaction of the assumptions given as follows:

- Normality,
- Homogeneity of the variances,
- Independent observations,
- Independence of the covariate and treatment effect
- No high correlation between covariate(s) and the independent variable (multicollinearity)
- Linear relationship between covariate(s) and the dependent variable
- Homogeneity of regression slopes (parallelism of the regression planes if there are two or more covariates)

Assumptions for Students' Recall of Learning Scores

The first assumption is the normality assumption which states that the collected data come from a population that is normally distributed. First, normality tests were conducted to spot if the grouped data met the assumptions of normality and suitable for parametric tests. First of all, the Kolmogorov-Smirnov and Shapiro-Wilk normality tests were conducted. The results of the tests were tabulated as follows:

Table 25 Normality Tests Regarding Students' WMC, Pretest and Posttest Recall

Tests of Normality							
		Kolmogorov-Smirnov			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
WMC	ND	.07	28	.20	.99	28	.96
	CD	.15	25	.15	.97	25	.71
	ED	.16	28	.09	.96	28	.31
	EDSE	.09	25	.20	.97	25	.75
Pretest Recall	ND	.14	28	.19	.97	28	.48
	CD	.14	25	.20	.94	25	.16
	ED	.16	28	**.05**	.94	28	.14
	EDSE	.14	25	.19	.92	25	**.05**
Posttest Recall	ND	.14	28	.17	.94	28	.11
	CD	.15	25	.19	.92	25	.06
	ED	.13	28	.20	.95	28	.22
	EDSE	.16	25	.11	.95	25	.25

Note. ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects, WMC = Working Memory Capacity. Boldface indicates significant difference.

Table 25 shows the results of the normality tests regarding students' WMC, pretest and posttest recall scores. As can be seen from the results, considering pretest recall, the Kolmogorov-Smirnov test is significant for the ED group, D (28) = .16, p =. 05 and Shapiro-Wilk test is significant for the EDSE group, D (25) = .92, p =. 05. From these results, it appears that the data are not normally distributed for pretest recall scores. However, as noted before, Kolmogorov-Smirnov and Shapiro-Wilk tests are based on the null hypothesis testing and regarded to be conservative (Field, 2013). For this reason, standardized skewness and kurtosis values regarding the distribution of the data were also provided.

Table 26 Standardized Skewness and the Kurtosis Values Regarding Students' WMC, Pretest and Posttest Recall Scores

	Group	Skewness	Kurtosis	SE of Skewness	SE of Kurtosis	$z_{skewness}$	$z_{kurtosis}$
WMC	ND	-.22	.09	.44	.86	-.50	.11
	CD	.43	.41	.46	.90	.92	.46
	ED	.52	-.21	.44	.86	1.18	-.25
	EDSE	-.08	-.80	.46	.90	-.17	-.89
Pretest Recall	ND	.14	-.20	.44	.86	.32	-.23
	CD	-.80	1.79	.46	.91	-1.72	1.98
	ED	.36	-.76	.44	.86	.82	-.88
	EDSE	-.91	.65	.46	.90	-1.95	.72
Posttest Recall	ND	-.25	-1.20	.44	.86	-.56	-1.39
	CD	-.29	-1.19	.46	.90	-.62	-1.32
	ED	.02	-1.13	.44	.86	.05	-1.31
	EDSE	-.44	-.42	.46	.90	-.94	-.46

Note. WMC = Working Memory Capacity, ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects

Table 26 shows the standardized skewness and the kurtosis values regarding students' WMC, pretest and posttest recall scores. The results showed that all *z* scores calculated for skewness and kurtosis values were in the acceptable range ($-3.29 < z < 3.29$, $p > .001$). Hence, no variables were significantly deviated from zero reflecting that sampling distributions of means are normal within each group.

The second assumption is the homogeneity of the variance. The Levene test was used to test if there was a difference in variance across groups. According to the results, the test was not significant ($F = 1.18$, $p = .32$) indicating that the error variances of the dependent variable was equal across each group. This finding was assessed as an indicator of meeting the assumption of the homogeneity of the variance.

Independence of observations are related to the unexplained variance (error) in the model. In order to meet the assumption, the error variances should be independent of each other (Field, 2013). This assumption was tried to be met by the researcher

during the data collection process by controlling the students to assure that they were completing the data collection tools independently without cheating.

One of the most important assumptions of ANCOVA is the independence of the covariates and the treatment. The purpose of conducting ANCOVA is to eliminate within-group error variance by using covariates. However, covariate is functional only if it is independent from the experimental effect. If the covariate(s) overlap with the experimental effect, the experimental effect is obscured and the pure experimental effect cannot be computed properly. This is because the covariates share some of the variance with the experimental intervention (Field, 2013). Citing Miller and Chapman (2001) and Lord (1967, 1969), Field (2013) indicated that "when treatment groups differ on the covariate, putting the covariate into the analysis will not 'control for' or 'balance out' those differences" (p. 800). For this reason, it has been suggested that before proceeding with ANCOVA, one could perform a one way ANOVA to ensure that treatment groups did not differ on the covariates (Field, 2013).

Given this rationale, first of all, a one way ANOVA was conducted to investigate if the treatment groups differed on the covariates. One of the covariate was pretest recall scores. The ANOVA test revealed that pretest recall scores did not differ significantly across treatment conditions (ND, CD, ED and EDSE) (F= .14, p = .94). In the same way, WMC scores did not significantly change across groups (F= .0.40 p = .76). As a result, it can be concluded from these results that each covariate is independent of the treatment effect.

Another assumption is related to correlations between the covariates. A high correlation (i.e., r >.8) between the covariates increases the likelihood of the multicollinearity problem (Field, 2013). To test if the multicollinearity problem existed between covariates, Pearson correlation coefficient between the covariates were calculated. The results indicated that the correlation coefficient between pretest recall and WMC was found to be below the suggested criterion (r = .42, r < .8).

Hence, no violation was observed regarding the assumption of "no high correlation" between the covariates.

Linearity assumption assumes that the relationship between the dependent variable and the each of the covariates is linear. This assumption should be tested for each of the treatment group (Pallant, 2010). One way to test the linearity is to graph the scatterplots. Scatterplots of posttest recall (dependent variable) against pretest recall (covariate) and posttest recall (dependent variable) against WMC (covariate) were created. The scatterplots among covariates and dependent variable showed that there was a linear relationship between the variables. As a result, there was no clear evidence of a curvilinear relationship between the covariates. Thus, the linearity assumption was deemed to be met.

Homogeneity of regression slopes assumption postulates that the relationship between covariates and the dependent variable is same across groups. That is, the regression slopes should be similar for each group. If the slopes are not similar, then it may be a significant interaction between the covariates and the dependent variable. In such situations, the results of the ANCOVA test may be inaccurate (Field, 2013). If there are two covariates, then the assumption is named as "parallelism of the regression planes" (Stevens, 2009, p. 294). A violation of homogeneity of the regression slopes for one covariate and parallelism of the regression planes for two covariates indicates a treatment-covariate interaction. Therefore, a non-significant interaction effect should be found in order to argue that the assumption is met. In the cases where there is more than one covariate, there should be an interaction effect for each covariate (Stevens, 2009). According to Stevens (2009), SPSS does not test parallelism of the regression planes directly. In order to test this assumption, use of SPSS MANOVA in syntax mode is suggested. The syntax which was used to test the assumption is given as follows:

Table 27 Testing Parallelism of the Regression Planes in Syntax Mode (Recall of Learning)

```
MANOVA posttest_recall BY group (1 4) WITH working_memory
pretest_recall/
ANALYSIS posttest_recall WITH working_memory pretest_recall/
PRINT = PMEANS
SIGNIF (EFSIZE)/
DESIGN/
ANALYSIS= posttest_recall/
DESIGN= pretest_recall + working_memory , group, pretest_recall BY
group + working_memory BY group.
```

In the syntax, the keyword "BY" denotes an interaction term and "+" means "lumping" the effects of the covariates together. The word "group" was used to represent the treatment groups (ND, CD, ED, EDIS) (Stevens, 2009). Based on the results of the syntax, non-significant interaction term was observed when the effects of pretest recall by group and WMC by group was lumped together (PRETEST_RECALL BY GROUP + WORKING_MEMORY BY GROUP), F (6,94) = 1.63, p = .15 Accordingly, the assumption could be made that the parallelism of the regression planes is tenable for the current dataset. In sum, it was concluded from testing the assumptions that the data for students' pretest recall, posttest recall and WMC were appropriate for conducting one way ANCOVA.

Assumptions for Students' Transfer of Learning Scores

As for the other tests, a preliminary analysis was conducted to spot if data met the assumptions of parametric tests for pretest transfer, posttest transfer and WMC scores. First, normality assumption was tested. Results of Kolmogorov-Smirnov and Shapiro-Wilk tests are presented in the following table:

Table 28 Normality Tests Regarding Students' WMC, Pretest and Posttest Transfer

Tests of Normality							
	Group	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
WMC	ND	.07	28	.20	.99	28	.96
	CD	.15	25	.15	.97	25	.71
	ED	.16	28	.09	.96	28	.31
	EDSE	.09	25	.20	.97	25	.75
Pretest Transfer	ND	.16	28	.07	.92	28	**.03**
	CD	.20	25	**.01**	.88	25	**.01**
	ED	.11	28	.20	.98	28	.94
	EDSE	.15	25	.15	.90	25	**.02**
Posttest Transfer	ND	.11	28	.20	.96	28	.37
	CD	.12	25	.20	.96	25	.35
	ED	.11	28	.20	.98	28	.75
	EDSE	.17	25	.07	.94	25	.12

Note. WMC = Working Memory Capacity, ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects. Boldface indicates significant difference.

Table 28 displays the results of the normality tests regarding students' WMC, pretest and posttest transfer scores. As can be seen from the results, Kolmogorov-Smirnov and Shapiro-Wilk tests are significant only for pretest transfer. More specifically, considering pretest transfer scores, Kolmogorov-Smirnov test is significant for CD group, D (25) = .20, p =. 01. On the other hand, Shapiro-Wilk is significant for ND, D (28) = .92, p =. 03, CD, D (25) = .88, p =. 01 and EDSE groups respectively D (25) = .90, p =. 02. In addition to Kolmogorov-Smirnov and Shapiro-Wilk tests, standardized skewness and kurtosis values were also calculated to provide additional evidence regarding normality. The results are tabulated as follows:

Table 29 Standardized Skewness and the Kurtosis Values Regarding Students' WMC, Pretest and Posttest Transfer Scores

	Group	Skewness	Kurtosis	SE of Skewness	SE of Kurtosis	$z_{skewness}$	$z_{kurtosis}$
WMC	ND	-.22	.09	.44	.86	-.50	.11
	CD	.43	.41	.46	.90	.92	.46
	ED	.52	-.21	.44	.86	1.18	-.25
	EDSE	-.08	-.80	.46	.90	-.17	-.89
Pretest Transfer	ND	.93	.79	.44	.86	2.11	.92
	CD	1.25	1.72	.46	.90	2.70	1.91
	ED	.23	.05	.44	.86	.52	.06
	EDSE	.59	-.69	.46	.90	1.27	-.77
Posttest Transfer	ND	.49	-.40	.44	.86	1.12	-.46
	CD	-.42	-.50	.46	.90	-.90	-.55
	ED	.26	-.05	.44	.86	.58	-.05
	EDSE	-.56	-.74	.46	.90	-1.20	-.82

Note. WMC = Working Memory Capacity, ND = Neutral Design, CD = Colorful Design, ED = Emotional Design, EDSE= Emotional Design and Sound Effects

Table 29 demonstrates the standardized skewness and the kurtosis values regarding students' WMC, pretest and posttest transfer scores. According to the results, it could be seen that all *z* scores calculated for skewness and kurtosis values are in the acceptable range ($-3.29 < z < 3.29$, $p > .001$). Therefore, none of the variables significantly deviated from zero showing that sampling distributions of means are normal within each group.

Another assumption of the ANCOVA test is homogeneity of the variances. Levene's test was used to test the assumption. Based on the result of the test, the test was not significant ($F = 1.38$, $p = .25$) indicating that the error variances of the dependent variable were equal across the groups. The assumption of the independence of observations was achieved by the researcher during data collection process ensuring that the students were not cheating and responding to the data collection instruments independently.

Covariates and the treatment conditions should be independent from each other to conduct ANCOVA test. A one way ANOVA was conducted to test whether treatment groups differed on covariates before the experiment. If so, there is a risk that covariates may overlap with experimental effect. The experimental effect may not be observed clearly, since the overlap between covariates and experimental effect may obscure the effect of the experiment (Field, 2013). The results of ANCOVA showed that covariates did not significantly differ across each group. Neither pretest transfer ($F = .64$, $p = .59$) nor WMC ($F = .40$, $p = .76$) significantly differed across treatment conditions.

The correlation between covariates should not be high. Otherwise there may be a multicollinearity problem. A high correlation (i.e., $r > .8$) between the covariates increases the probability of multicollinearity problem (Field, 2013). Pearson correlation coefficient between covariates was found .25 indicating that there was not a multicollinearity problem. Linearity assumption was tested by graphing the scatterplots. The graphs reveal that the relationships between the dependent variable and each covariate was linear.

Finally, parallelism of regression planes was tested by using syntax suggested by Stevens (2009). To test parallelism of regression planes the following syntax was used.

Table 30 Testing Parallelism of the Regression Planes in Syntax Mode (Transfer of Learning)

```
MANOVA posttest_transfer BY group (1 4) WITH working_memory
pretest_transfer/
ANALYSIS posttest_transfer WITH working_memory pretest_transfer/
PRINT = PMEANS
SIGNIF (EFSIZE)/
DESIGN/
ANALYSIS= posttest_transfer/
DESIGN=pretest_transfer + working_memory , group,  pretest_transfer
BY group + working_memory BY group.
```

According to the results of the analysis, it was found that parallelism of the regression planes assumption was met, F (6, 94) = 1.04, p = .41. In sum, based on the preliminary assumptions analysis, it could be argued that ANCOVA test was appropriate for students' transfer transfer of learning for further analysis.

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Uzun, Ahmet Murat

Nationality: Turkish (T.C.)

Date of Place and Birth: 29 July 1985, Sarıkaya

Marital Status: Married

Phone: 4440303-20382

email: ahmet.uzun@metu.edu.tr

EDUCATION

Degree	Institution	Year of Graduation
Ph.D.	Middle East Technical University, Computer Education and Instructional Technology	2017
BS	Selçuk University, Computer Education and Instructional Technology	2008
High School	Nuh Mehmet Baldöktü Anatolian High School	2003

WORK EXPERIENCE

Year	Place	Enrollment
2010-	Afyon Kocatepe University	Research Assistant
2008-2010	Ministry of National Education	Computer Education Teacher

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

Uğraş, G., **Uzun, A. M.,** Battal, A., & Kayaduman, H. (2016). An Examination of Instructional High School Chemistry Videos on EBA Portal in terms of Nine Events of Instruction. *Participatory Educational Research, 3* (1), 66-78

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