PHYSICALLY INTERACTIVE EDUCATIONAL GAME DESIGN FOR CHILDREN: DEFINING DESIGN PRINCIPLES

YAVUZ İNAL

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PHYSICALLY INTERACTIVE EDUCATIONAL GAME DESIGN FOR CHILDREN: DEFINING DESIGN PRINCIPLES

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ABSTRACT

PHYSICALLY INTERACTIVE EDUCATIONAL GAME DESIGN FOR CHILDREN: DEFINING DESIGN PRINCIPLES

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Physically Interactive Games (PIGs) have emerged as a new game genre and potential as an educational tool in classrooms. In PIGs, children are allowed to interact with game environment and solving problems by using their bodily movements and voices without using mouse or keyboard by being active physically and cognitively. Designing PIGs is critical and difficult process because it is vital that educational content and entertainment parts of a game should be balanced properly considering interaction between children and game environment.

The current dissertation aims to explore principles of designing and developing physically interactive educational games for children. Mainly, qualitative data collection techniques were used in the study. Also, Reeves' Development Research Model was administered under the Design-Based Research.

Both Mathematics and Physical Education subjects were integrated within the game environments. Totally four physically interactive games were designed and developed. During the design and development phases, field experts, subject-matter experts and children's expectations, needs and recommendations were taken into account.

During the development phase, 5 teachers with 3 Mathematics and 2 Physical Education teachers as subject matter experts participated to the study. Also, 10

children with 5 boys and 5 girls participated to the design phase. In the implementation phase, 30 children with 17 boys and 13 girls participated in Pilot Implementation and 50 children with 27 boys and 23 girls participated to the Final Implementation phase.

The study revealed that camera screen was the main deterministic factor in order to play physically interactive educational games properly. Girls and boys had different considerations about the developed games. The bigger camera screen physically interactive games had, the higher motivation children had during gameplay. At the end of the study, design principles of physically interactive educational games were defined.

Keywords: Physically Interactive Educational Games, Physical Education, Mathematics, Human-Computer Interaction

ÖZ

ÇOCUKLAR İÇİN FİZİKSEL ETKİLEŞİMLİ EĞİTSEL OYUN TASARIMI: TASARIM PRENSİPLERİNİN BELİRLENMESİ

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Fiziksel etkileşimli oyunlar eğitim ortamlarında eğitsel materyal olarak kullanılabilecek potansiyele sahip ve yeni bir oyun türü olarak ortaya çıkmış oyunlardır. Fiziksel etkileşimli oyunlarda, çocuklar fiziksel ve bilişsel olarak aktif şekilde fare veya klavye kullanmaksızın vücut hareketlerini ya da seslerini kullanarak oyun ortamı ile etkileşime geçmekte ve kendilerine sunulan problemleri çözmektedirler. Çocukların oyun ortamı ile etkileşimini dikkate alarak oyundaki eğitsel içerik ve eğlence bölümleri doğru şekilde dengelenmesinin öneminden dolayı, fiziksel etkileşimli oyunların tasarımı kritik ve zor bir süreçtir.

Bu çalışma çocuklar için fiziksel etkileşimli eğitsel oyunların tasarımı ve geliştirilmesi ile ilgili prensipleri araştırmayı amaçlamaktadır. Bu çalışmada temel olarak nicel araştırma yöntemi kullanılmıştır. Bunun yanında, Reeves'in geliştirme araştırma modeli, tasarım temelli araştırma kapsamında kullanılmıştır.

Matematik ve Beden Eğitimi konuları oyun ortamına birlikte entegre edilmiştir. Çalışma kapsamında toplamda dört adet fiziksel etkileşimli oyun tasarlanmış ve geliştirilmiştir. Tasarım ve geliştirme süreçlerinde, alan uzmanları, konu uzmanları ve çocukların beklentileri, ihtiyaçları ve önerileri dikkate alınmıştır.

Geliştirme aşamasında, 3 Matematik ve 2 Beden Eğitimi olmak üzere toplam 5 öğretmen ile konu uzmanı olarak görüşülmüştür. Tasarım aşamasında ayrıca, 5 erkek ve 5 bayan öğrenci katılmıştır. Uygulama aşamasında ise, pilot çalışmaya 17 erkek ve 13 bayan öğrenci olmak üzere toplam 30 öğrenci katılmıştır. Son çalışmaya ise, 27 erkek ve 23 bayan öğrenci olmak üzere toplam 50 öğrenci katılmıştır.

Bu çalışmada, kameranın fiziksel etkileşimli eğitsel oyunların doğru biçimde oynanabilmesi için temel belirleyici faktörlerden birisi olduğu belirlenmiştir. Bayan ve erkek öğrencilerin geliştirilen oyunlar ile ilgili farklı bakış açılarının olduğu tespit edilmiştir. Fiziksel etkileşimli oyunlar ne kadar büyük kamera ekranına sahip olurlarsa, çocukların motivasyonlarını o derece arttırdıkları görülmüştür. Çalışmanın sonunda, fiziksel etkileşimli eğitsel oyunlara ilişkin tasarım prensipleri ortaya konulmuştur.

Anahtar Kelimeler: Fiziksel Etkileşimli Eğitsel Oyunlar, Beden Eğitimi, Matematik, İnsan-Bilgisayar Etkileşimi

To Whom It May Concern,

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CHAPTER 1

INTRODUCTION

This chapter presents background of the study, purpose of the study, statement of research questions, significance of the study and definitions of terms.

1.1 Background of the Study

Technology and education are two inseparable parts of human life influencing each other for many years. In order to organize educational settings to provide better learning environments, implementations basing on technological developments have mostly been employed during teaching and learning process. This interaction between technology and education has been making some changes on the dynamics of educational settings concerning various aspects such as using educational technologies in classrooms. Not only fundamental characteristics of schools are changing drastically regarding students' perceptions on technology use, expectations from technology and experiences in technology use during the past years, but also students are becoming different. Frand (2000) stated that "students with an information-age mindset expect education to emphasize the learning process more than a canon of knowledge. They want to be a part of learning communities, with hubs and spokes of learners, rejecting the broadcast paradigm of television" (p.24). Therefore, in today's world, more user centered designs encountering students' expectations are gaining much importance in educational settings.

One of the latest technological developments, computer games, has been arising for approximately 30 years becoming an important leisure time activity of people,

especially young kids. Although some researchers (i.e. Egenfeldt-Nielsen, 2003; Van Eck, 2006b) believe that integration and implementation of an educational game is difficult process with regard to both of teacher and student sides; many educators, researchers or subject matter experts are advocating educational potential of computer games and game-based learning for many years (i.e. Mumtaz, 2001; Subrahmanyam, Greenfield, Kraut & Gross, 2001; Hanna, Neapolitan & Risden, 2004; Kiili, 2005a; Van Eck, 2006a; Nenonen et al., 2007; Gros, 2007). Due to the popularities of computer games, several studies (i.e. Din & Calao, 2001; Barendregt, Bekker & Speerstra, 2003; Ogletree & Drake, 2007; Robertson & Howells, 2008) emphasizing on educational values of games and their integration and implementation within classrooms have been conducted.

Swain (2007) stated "games are well-suited to communicating a shared understanding of a problem because they allow users to experiment with potential solutions in a safe setting and generate their own mental frames for how it works" (p.806). Concerning educational aspects of computer games, they might be effective educational materials because of their prominent characteristics like holding learning process in a meaningful context (Van Eck, 2006a). In order to get high benefits from games, new gameplay approaches, new interaction ways and new design techniques or methods about different educational subjects have been needed to perform in the use of computer games in classrooms.

In this respect, physically interactive serious games have emerged as a new computer and video game genre allowing players interact with game environment using bodily movements. Regarding physically interactive games, Höysniemi (2006) stated;

> "These games are usually controlled with large body movements, and they aim at involving the player in exertion or developing motor abilities during the course of game play. This new way of controlling games poses challenges for game

> designers not only from the technological point of view but, more importantly, from the user perspective" (p.2).

Physically interactive games allow players to control game environment by using their bodily movements and interact with game environments without using keyboard and mouse. Höysniemi (2006) stated that physically interactive games are controlled by using bodily movements and players involve in game environment in a different way than other types of game genres. Like other game genres, physically interactive games have also an educational potential due to their various characteristics such as presenting different ways of interactive environment, providing high motivation, keeping attention and constructing highly enjoyable and educational learning environment for children.

However, educational power and capability of games depend on various internal and external factors. Prominent factors for physically interactive games, which have a new kind of interaction with specific gameplay characteristics, are interactive attributes of these games between children and game environment considering bodily movements and appropriateness of game design issues according to children's physical and cognitive levels considering educational content.

In parallel to this, educational game design is an important issue that should be taken into consideration properly. Because using computer games might present enjoyable and meaningful learning environment for children, designing the most appropriate educational computer games for target audience is very critical process. Pannese and Carlesi (2007) stated "the perception of games as valuable training and educational instruments is generally very high; people seem to appreciate this innovative and unconventional training tool more than traditional exercises" (p.451). Therefore, designing and developing computer games considering needs of teachers and students and implementing these innovative educational technologies within classrooms are very important.

It seems difficult to implement the most appropriate computer games to teach an educational topic (Egenfeldt-Nielsen, 2003; Van Eck, 2006b). Although Van Eck (2006a) proposes three approaches that are students' participation to the game design process as game designers, teachers' participation to the game design process with game developers, and using commercial-off-the-shelf games in learning process, to teachers for using computer games in classrooms, implementation of commercial games within educational settings is a difficult process.

Because "commercial games are not designed to teach" (Van Eck, 2006b, p.32), they have many weaknesses and failure for improvement of learning process. It is mostly stressed that better way to have beneficial educational game is to give importance to the points of views of subject matter experts and target audiences and take their considerations into account during design and development processes. Therefore, it might be the best way to design and develop an educational game by considering both teachers and learners points of views.

Pannese and Carlesi (2007) stated "the typical high interactivity of the games assures a high degree of attention while playing the game and consequently increases the effectiveness of training and the involvement of players" (p.451). Interactive game environments allowing children interact and communicate with game interface might increase their motivation and keep attention during gameplay. Focusing innovative interactive characteristics of physically interactive games, well-designed and beneficial educational game environment might present children. In the present study, totally four physically interactive educational games were designed and developed considering points of views of both teachers as subject-matter experts and children as target audience.

1.2 Purpose of the Study

With the ongoing developments in the use of computer games in educational settings, not only teachers are mostly encouraged to take advantages of computer games, but also students are encouraged to make educational practices by playing games. In today's educational settings, applications about game-based learning aiming to get maximum benefits from educational computer games have been applied in classrooms. In parallel to this, educational game design approaches or methods with new computer game genres have been a need to develop the most appropriate and beneficial educational computer games for teaching and learning processes.

Under the light of aforementioned statements, the main purpose of the present study is to determine design principles of physically interactive educational games. In order to reach this aim, first, points of views, considerations and suggestions of Mathematics and Physical Education teachers as subject matter experts and children as target audience were elicited. Second, in addition to design part of educational games, designed and developed games were played by children to conduct in depth analysis and figure out design principles of physically interactive educational games.

1.3 Research Question

During the study, following research question was investigated to figure out the design principles.

> How could design principles for physically interactive educational games be defined basing on teachers' and children's considerations?

In order to figure out the main research question, teachers' and children's points of views on physically interactive educational game use in educational settings were examined. Also, teachers' and children's considerations about game design issues and game components were taken into account.

1.4 Significance of the Study

Educational technologies have been influenced by technological developments that bring new face to teaching and learning processes. Computer games are one of the popular technological developments that have being implemented within classrooms for many years. Physically interactive educational games have been emerged as a new computer and video game genre allowing players interact with game environment using bodily movements.

It is easy to see that many applications have been appeared about implementation of games in game-based learning or game-like learning environments by instructional designers, educators and game researchers in the field (i.e. Gee, 2004; Squire, 2005; Van Eck, 2006a; Dickey, 2006; Tuzun, 2007). However, Höysniemi, Hamalainen and Turkki (2003) stated "there has been little research investigating the use of perceptual control mechanisms such as computer vision or hearing that do not attach children directly to the computer" (p.204) with a limited number of studies focusing on physically interactive game design and implementation. Debates about effectiveness and efficiency of designed and developed educational games are mostly appeared among scholars, educators and practitioners. It has been basically stressed that the most important challenge in terms of figuring out the most beneficial gameplay characteristics for students is working together with all of these actors during design and development processes.

There has been little research on physically interactive games and their design issues (Höysniemi, Hamalainen & Turkki, 2003). It is concluded that children liked playing physically interactive games (Höysniemi et al., 2004). Taking advantageous of working with small target group with eight and nine-year old children (Hanna, Neapolitan & Risden, 2004) in order to define design principles of physically interactive educational games, children's considerations regarding what they need and expect from educational games should be taken into account (Barendregt, Bekker & Speerstra, 2003). In addition to children's points of views, what teachers

expect from educational potentials of computer games are very important factor during design process of educational games (Mumtaz, 2001; Gros, 2007). Teachers' involvement during game design process taking their considerations into account should be very important, although it is hard to get adequate feedback from teachers about game design (Gros, 2007).

In parallel to this, in the present study, what teachers expect from physically interactive educational games and what children's points of views regarding physically interactive educational games are very critical questions that should be investigated. In this study, focusing on teachers' and children's considerations, design principles of physically interactive educational games were attempted to determine. Findings of the study might give valuable clues to not only teachers trying to integrate and implement physically interactive educational games, but also practitioners trying to design and develop physically interactive educational games for educational settings.

In this study, the researcher worked with Mathematics and Physical Education teachers, as subject-matter experts, and children, as target audience, in the design and development phases. Similarly, in addition to examine educational aspects of design principles of physically interactive games, it is important to examine how they "should be designed such that they are entertaining, usable, and physically suitable for players" (Höysniemi, 2006, p.3). It was concluded in previous studies (i.e. Höysniemi & Hamalainen, 2005), investigating effectiveness and efficiency of physically interactive serious games that children enjoy physically interactive games and they enjoy making bodily movement interaction with game environment. These types of games allow children perform variety of new movement skills during gameplay.

In the present study, designed and developed physically interactive educational games have been divided into two different categories, which are motion-driven

physically interactive educational games and motion-controlled physically interactive educational games, according to their gameplay characteristics and camera use differences. Motion-driven games allow children to control game environment according to their movement ranges. Basing on a captured high or low interactivity in game, children interact and control environment and play the game through these types of interactions. In motion-controlled games, children interact and control game environment by touching any object in the game or showing bodily movements in an expected physical space. Range of the movements in terms of high or low pace is not considered.

1.5 Definitions of Terms

Game: "…as an activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive in that the activity does not produce any goods of external value, and governed by rules" (Caillois, 1962 cited in Garris, Ahlers & Driskell, 2002, p. 442)

Play: "…is an activity which proceeds within certain limits of time and space, in a visible order, according to rules freely accepted, and outside the sphere of necessity or material utility. The play-mood is one of rapture and enthusiasm, and is sacred or festive in accordance with the occasion. A feeling of exaltation and tension accompanies the action, mirth and relaxation follow" (Huizinga, 1955 cited in Smed & Hakonen, 2003).

Gameplay: "…as an ensemble made up of the player's sensations, thoughts, feelings, actions and meaning-making in a gameplay setting" (Erni & Mayra, 2005, p.2).

Computer Game: "…as a game that is carried out with the help of a computer program" (Smed & Hakonen, 2003, p.3).

Educational Game: "The promise of educational games is to engage and motivate players through direct experiences via the challenges included in the game world. Educational games should provide possibilities for reflectively exploring phenomena, testing hypotheses, solving problems and constructing knowledge" (Kiili, 2005b, p. 13).

Physically Interactive Game: Physically interactive games "are usually controlled with large body movements, and they aim at involving the player in exertion or developing motor abilities during the course of game play" (Höysniemi, 2006, p.2).

Motion-Driven Interaction: Motion-driven interaction allows children to control game environment according to their movement ranges. Basing on a captured high or low interactivity in game, children interact and control environment and play game through these types of interactions.

Motion-Controlled Interaction: In motion-controlled interaction, children interact and control game environment by touching any object in game or showing bodily movements in an expected space. Range of the movements in terms of high or low pace is not considered.

CHAPTER 2

LITERATURE REVIEW

This chapter will include theoretical framework of the current study. It will be composed of eight main sections: (1) Technology in Education, (2) Computer Games, (3) Educational Values of Computer Games, (4) Children's Interaction Patterns in Playing Computer Games, (5) Physically Interactive Games, (6) Educational Values of Physically Interactive Games, (7) Physically Interactive Educational Game Design and (8) Summary.

2.1 Technology in Education

Innovative technologies like computers and the Internet have been diffusing almost all parts of daily lives influencing social life of people and gaining importance drastically. Like most of other fields such as business, military, entertainment etc, in educational settings, recent technological developments have been used in order to not only make both educators and students work easy but also present meaningful teaching and learning environments for both. Since computer technologies are being integrated and implemented within classrooms pervasively (Albirini, 2005) and home computers are being pervaded through all society, using effective information and communication technologies for educational purposes are becoming valuable (Murphy & Beggs, 2003). Drawing increasingly more attention in recent years, information and communication technologies like computers and Internet have been utilized in teaching and learning processes (Hong, Ridzuan & Kuek, 2003).

Many educators prefer using new information and communication technologies in order to organize better learning environments. There are lots of educational

materials, software or programs that are being used in educational settings. Computer supported instructional materials are specifically preferred by educators in classrooms because of their beneficial characteristics for students (Antonietti & Giorgetti, 2004) such as developing new teaching strategies (Galanouli, Murphy & Gardner, 2004), increasing students' information presenting them more meaningful content (Lam, 2000), feeling more comfortable while using technology (Kersaint, Horton, Stohl, & Garofalo, 2003), increasing students' motivation (Sugar, Crawley & Fine, 2004) and drawing their attention.

Teachers may have positive feelings toward using educational technologies that help them to teach an educational subject better than classical approaches like lecturing. Educational technologies such as computer-supported instructional tools may have power to enhance students' learning capabilities improving their imagination and visually thinking abilities (Sandberg, 2002). Integrating and implementing educational technologies may make them improve their teaching style positively (Antonietti & Giorgetti, 2004).

Outcomes of previous studies focusing on educators' points of views about using educational technologies in classrooms revealed that many educators prefer to give a chance to technology (i.e. Kersaint, Horton, Stohl, & Garofalo, 2003). Integrating and implementing an educational technology within classrooms might give positive outcomes to teaching and learning process, helping students to acquire instructional outcomes efficiently. This belief is important for diffusion of innovative educational technologies and their dissemination throughout classrooms.

Educators play key role in terms of acceptance of an educational technology (Albirini, 2005). They directly influence easy adaptation and widely use of any innovative technologies in schools. It is seen that what teachers think about using educational technologies is important to integrate a technology within classrooms. Concerning the previous studies related teachers considerations about computer

supported instructional tools, it is concluded that teachers' acceptance of a technology and their decisions about using it for educational purposes are critical (i.e. Bullock, 2004; Sugar, Crawley & Fine, 2004).

Although teachers are important factors in terms of diffusing educational technologies through classrooms, internal and external factors influencing their preferences and expectations might be taken into account. Background of teachers, beliefs, opinions, cultural and social influences, experiences in technology use might impact on their considerations. Shapka and Ferrari (2003) concluded that there are clear differences among teachers about their points of views of using technology in education. Besides, teachers need to use developed educational technology easily without encountering any difficulties, because this influences directly their considerations about the technology use (Demetriadis et al., 2003; Can & Cagiltay, 2006).

Therefore, it might be the best way to take teachers' considerations and expectations during development of an educational technology. This might help practitioners to overcome the barriers in terms of teachers' rejection of developed educational technology when they are being pushed to implement an educational technology in classrooms.

2.2 Computer Games

Computer games are one of the most popular leisure time activities of youngsters in today's world. After the first appearances of computer games in the world, tremendous growing was observed in gameplay and people's attention to games. First computer games were seen in 1970s with basic gameplay characteristics. Afterwards, with the growing interest and popularity in home computers, games reached widespread popularity and awareness (Aguilera & Mendez, 2003). Technological developments in graphics and artificial intelligence in 2000s, 3D computer games were developed with new competitive and challenge features. This

causes interest of scholars to computer games and their influences on people, especially children. Höysniemi, Hamalainen and Turkki (2003) concluded that "the increasing amount of time children spend with computers and video games has raised questions about how the use of computer technology affects the lives of children" (p.203).

There are a wide variety of genres of games in game markets and Internet. Game genres might be classified as classification of Gros (2007). In addition to this classification, new game genres like physically interactive games might be added to the classification;

- Action games (also called platform games) - These games are reaction-based; most of the games of the first generation are action games.
- Adventure games - The player solves a number of tests in order to progress through a virtual world.
- Fighting games - These games involve fighting against computer-controlled characters or those controlled by other players.
- Role-playing games - Human players assume the characteristics of some person or creature.
- Simulations - The player has to succeed within some simplified reaction of a place or situation to achieve a particular goal.
- Sport games - These games are based on sports.
- Strategy games - These games that recreate a historical or frictional situation to allow a player to devise an appropriate strategy to achieve a goal. (p.26)
- Physically interactive games - These games allow players to control game environment and play the game by using bodily movements without using mouse or keyboard (Höysniemi, 2006).

The question about what a computer game is was defined in the previous studies. According to Garris, Ahlers and Driskell (2002), computer game is voluntarily and

enjoyable activity that is different from the real life and organized by defined rules. Since they have been pulling great attention of people for many years, their powerful and beneficial characteristics are needed to be investigated. Boyle, Connolly and Hainey (2011) stated that "games provide voluntary, enjoyable and challenging activities with varying conditions which can specify goals, objectives, rules, moves, constraints, feedback, payoffs and consequences" (p.73). Malone (1981) determined four specific motivational characteristics of computer games. They are "Fantasy" (1), "Curiosity" (2), "Challenge" (3), and "Control" (4). Johnston and de Felix (1993) specified four main characteristics that are "Dynamic Visuals" (1), "Rules" (2), "Goal" (3), and "Interaction" (4). Garris, Ahlers and Driskell (2002) defined six main characteristics of computer games. They are "Fantasy" (1), "Arousal" (2), "Social Interaction" (3), "Diversion" (4), "Challenge" (5), and "Competition" (6).

It is mostly figured out in the literature that especially young people like playing computer games in their leisure times. It is clearly claimed in today's world that "computer games play an integral part in children's lives" (Höysniemi, Hamalainen & Turkki, 2004, p.27). The reasons of why people prefer playing games have been investigated by most of the researchers (i.e. Malone, 1981; Johnston & de Felix, 1993; Serry & Lucas, 2003; Garris, Ahlers & Driskell, 2002; Tuzun, 2004; Karakus, Inal & Cagiltay, 2008). For instance, it was concluded that escape from stress, spending leisure times and aiming to relax are main reasons (Sherry & Lucas, 2003). Karakus, Inal and Cagiltay (2008) examined Turkish high school students' gameplay preferences, game habits, considerations and expectations. They found that entertainment, relaxation, improving thinking skills and spending leisure time are main reasons of young people why they prefer playing computer games. According to Sherry and Lucas (2003), spending leisure time, trying to get relaxed and avoiding from stress or difficulties of real life are mainly reasons of why people prefer playing computer games.

2.3 Educational Values of Computer Games

From the first computer games to the last, with enormous developments of computer game technology, they have been diffusing through many fields speedily. Computer games keep the popularity since they were designed and developed first in the world. In today's world, computer games have been used in several factors, such as business, entertainment, military, education (Kirriemuir, 2002). In addition to schools, there are several well-known applications and excessive amount of use of games in institutions, workplaces, society, military etc. (Schaefer & Warren, 2004; Gee, 2004).

Depending on the technological developments and changes in games, computer game studies examining different aspects of games have been conducted by researchers. Because games have a widespread popularity and interest that almost all ages of community prefer playing for different reasons, it is mostly being questioned how computer technology might influence children's lives (Höysniemi, Hamalainen & Turkki, 2003) and how computer game might be adapted within classrooms. Therefore, it is important to focus on influences of computer games and beneficial aspects of them for children.

Two different points of views among researchers have been declared in the literature regarding whether computer games are beneficial or not. On the one hand, studies focusing on positive aspects of computer games concluded that games have significant positive impacts on children's cognitive, mental, academic and social development. On the other hand, studies focusing on negative effects of computer games concluded that games have negative effects regarding causing aggressive behaviors, spending times and harmful psychological influences.

Concerning harmful effects of computer games, most of studies focused on violence in computer games and making children physically passive in games. Lee and Peng (2006) concluded that negative effects of games were divided into two parts.

Computer games with violent characteristics cause aggressive behaviors, psychological responses regarding heart rate, blood pressure. Games having non-violent characteristics cause addicting and physical health problems. Concerning entertainment games, Boyle, Connolly and Hainey (2011) stated that "they promote violence, are gender stereotyped and potentially addictive" (p.69). Funk, Buchman, Jenks and Bechtoldt (2003) investigated relationships of video games including violence when children were exposed either short-term exposure or long-term exposure. They concluded that although all children in the study playing computer games with a violent theme revealed negative outcomes clearly, long-term exposure to violent video games caused lower empathy. It is frequently stressed in the literature that aggressive behaviors and physically harmful effects of games were two major negative effects of playing computer games.

Playing computer games have significant positive influences from children to adults. Children playing computer games were better than children who don't prefer playing games in visual motor skills and motor coordination (Griffith, Voloschin, Gibb & Bailey, 1983). Concerning adolescents or adults, playing computer games in a long time among adolescents causes much developed motor abilities with greater reflexes and visual abilities (Dorval & Pepin, 1986). By performing observation, making practice and reinforcement, children attempt to acquire expected behaviors (Funk, 2003). In addition to behavioral benefits of games, they have power to help children learn basic educational subjects or skills that they had difficulties in learning (Greenfield, 1984).

It is frequently declared in previous studies that games have potential to enhance children's school success and computer use capabilities (Natale, 2002). Computer games may have beneficial aspects on children's mental and physical development. Games might present critical thinking environment for children by making them foster their mental capabilities. By playing computer games, children may solve complex problems that might help them in courses. Critically thinking constructing a

connection between real life in outside and fantasy world in games, computer games might be beneficial for children (Turvey, 2006).

Computer game implementations have revealed that there are lots of beneficial aspects when educators prefer using them as educational materials. It is becoming easier to see computer game applications in classrooms so as to enhance students' learning abilities and develop their cognitive thinking styles by providing better and meaningful learning environment. Therefore, they have been attempted to integrate within educational settings as a new technological approach by educators (Kiili, 2005a) in order to draw students' attention and keep their motivation high during teaching and learning process. Boyle, Connolly and Hainey (2011) stated that "games provide highly engaging activities which are stimulating, generate strong emotions, require complex information processing, provide challenges and can potentially support these more serious purposes of learning, skill acquisition and attitude and behavior change" (p.73).

Computer games have been evolved and present enjoyable and motivational environment. As a result of the developments in graphical technologies, 3D gameplay environments have become much closer to the real life. Players have chance to not only select a ready-made avatar but also design their own avatar appearance according to their interest. Most of the researchers believe that with a well-designed computer games including appropriate educational content presenting students efficient learning environment with an effective interaction and collaboration support, not only all kind of students prefer playing games (i.e. Gee, 2004), but also games might be used as powerful and beneficial learning materials in schools (i.e. Jasinski & Thaigarajan, 2000). During gameplay, collaboration among children and socially interactive game environment might be supported easily by computer games (Chou & Tsai, 2007) with a high motivation and attention.

Physically interactive games that are one of the last appeared game genres may have beneficial characteristics and potential to overcome negative aspects of playing computer games. Because of the natural characteristics of the physical interactive games, critics regarding making children physically passive in games might be eliminated. In physically interactive games, children are supposed to play the game actively using bodily movements (Höysniemi, Hamalainen & Turkki, 2003).

It is seen that games might have strong educational characteristics that help children to learn an educational content very effectively and efficiently. Computer games are supposed to motivate children and keep their concentration while they are playing (Kiili, 2005a). Focusing on only enjoyable characteristics of games might cause misunderstanding or misleading of educators. Well-designed computer games in which an educational content are embedded properly are generally accepted and adapted by educators within classroom settings. Main point is putting the ground one of the best appropriate and beneficial educational computer games for students.

2.4 Children's Interaction Patterns in Playing Computer Games

Each innovative technology brings a new user interface and interaction features. Acceptance of a technology directly depends on user-friendly interaction design for target group. Thus, interaction of human with computer interface is being crucial. Children's considerations and points of views are very valuable regarding especially computer game design and development studies. It is clearly expected that children have different preferences and characteristics regarding interacting with computers. Children's needs are supposed to satisfy clearly by taking their specific characteristics into considerations (Bruckman & Bandlow, 2003).

By new technological developments, interactions between children and computers have been changing. Limitations of mouse or keyboard while using computer to play games are decreasing in today's world. Interaction patterns are shaped under various factors by affecting both human-computer and human-human interaction while

children are interacting with computers. Sundar (1994) stated that computers are playing very important role on human-computer and human-human interaction patterns which are affected directly by the different factors. One of these factors is computer software that children behave differently when they tackle with different types of software such as computer games, programs and so on.

Another factor which affects children's interaction is that their interests in technology changing according to their demographics (Markopoulos & Bekker, 2003) and the frequency of the computer use which shapes their social interaction and developmental progression (Höysniemi, Hamalainen & Turkki, 2003). Besides, human-computer interaction mainly affects human-human interaction in classroom environment among children. These interaction diversities have direct relationship with their learning and achievement in educational environments. Thus, human-computer interaction studies as a new research field have been reaching widespread areas (Partala & Surakka, 2004).

In the literature, it is stated that children prefer working with one of their friends than being alone while they are studying on given tasks (Clements, 1999). Students have tendency in terms of being or forming groups around computers, especially while playing computer games (Inkpen, Gribble, Booth & Klawe, 1995) and they naturally aim to enlarge their interaction space during gameplay. However, the most important point here is how children do interact with each other and computer environment while they are working with computers, and how children construct collaboration by taking given-task into consideration in virtual environment. Factors such as social presence, and affective interaction and communication in a virtual environment might have effects on their collaboration and interaction patterns as it is stated in the previous studies (Höysniemi, Hamalainen & Turkki, 2003).

Interaction with computers is mostly related to the play activities such as computer games among children (Markopoulos & Bekker, 2003). According to Vygotsky,

children interact with each other when they are faced with difficult tasks which they cannot complete alone (as cited in Lomangino, Nicholson & Sulzby, 1999). Because face-to-face collaboration with children in the classroom is essential issues for themselves in their daily life activities (Scott, Mandryk & Inkpen, 2003), it is easily said that not only interacting with computers, but also interacting with their friends are important.

Children in classroom construct their own interaction space. This interaction space might affect children's academic performances positively. Interaction space might provide children for accomplishing given tasks by taking help from their friends. Children, who are novice computer users, firstly interact with computer interface and then they use their prior experiences or get help from their friends when they try to complete given educational tasks. When human-human interaction is considered, this might change according to classroom dynamics (Davis & Wiedenbeck, 1998) such as activities done in the classroom or children's characteristics. Physically interactive games have power in terms of combining physical classroom environment and computer. Children might work collaboratively by playing physically interactive educational games. In physically interactive games, children use physical space to interact with game environment. They have chance to use not only game environment but also physical environment during gameplay. Therefore, playing physically interactive games might give valuable interaction environment to children.

In the literature, there are several studies focusing on human-computer interaction and human-human interaction aiming to investigate the most effective and efficient interaction types. Diaper and Sanger (2006) conducted a study which is mainly about the reinterpretation of human-computer interaction work by considering a general theory of tasks. Carpendale and Lewis (2004) focused the influences of interaction on children's understanding. They concluded that social interaction might have direct relationship with the development of children's mental understanding process. Partala and Surakka (2004) focused on "psychophysiological effects of positive and

negative affective interventions in human-computer interaction" (p.295). Markopoulos and Bekker (2003) attempted to investigate different interest of children by considering their interaction issues with technology.

Höysniemi, Hamalainen and Turkki (2003) stated in their study that they were searching for different controlling and interacting ways with computers. They also stated that interaction patterns and factors affecting that interaction process offer children to make comparisons with traditional interaction patterns. Davis and Wiedenbeck (1998) used three general interaction patterns which are direct manipulation, menu and command which are playing key factors in the software learning process. Rhee and Bhavnagri (1991) investigated social interaction patterns of children while they were playing with computers. They concluded that "when children play with a computer in the natural setting of a preschool, they have extensive social interaction with their peers".

2.5 Physically Interactive Games

Physically interactive games have been appeared in game market or Internet as a new computer and video game genre in recent years. In physically interactive games, there is no need to use mouse or keyboards as the main requirements to play the game. Bodily movements are the one that players need to interact with the game environment. As Höysniemi (2006) stated that physically interactive games are played by performing physical movements with a new perspective from both game designers and players. "The daily activities of children have changed tremendously over the last decade, e.g. sitting in front of screens instead of playing outside." (Bekker, van den Hoven, Peters & Hemmink, 2007). Physically interactive games give chance to children to combine computer games with outside of computers during gameplay. They might use physically environments while they are playing physically interactive games.

There have been studies focusing on efficiency and effectiveness of physically interactive games regarding game preferences, game design, players' expectations and interaction patterns of physically interactive games in the literature. However, Höysniemi, Hamalainen and Turkki (2003) stated that "there has been little research investigating the use of perceptual control mechanisms such as computer vision or hearing that do not attach children directly to the computer" (p.204) with a limited number of studies focusing on physically interactive game design and implementation. Designing physically interactive game research is relatively new area (Kostomaj & Boh, 2009), since it is a new genre in game world.

Figure 2.1: A Gameplay Session of PIGs in the study by Lu et al. (2010)

Concerning studies focusing on physically interactive games, Lu, Fan, Liu and Chuang (2010) aimed to investigate teaching local dialect to middle-graded students in Taiwan elementary school by implementing and integrating physically interactive games (see Figure 2.1). They developed two physical interactive games that were basing on "the game/toy-based e-learning theory" (p.372) so as to identify "local dialect characters and phonics" (p.373). At the end of the study, they figured out that "teachers and students agreed with applying these physically interactive games to support instruction. Also, students' learning motivation was high" (p.373).

Figure 2.2: A Gameplay Session of PIGs in the study by Höysniemi et al. (2005)

Höysniemi, Hamalainen, Turkki and Rouvi, (2005) designed and developed a game called QuiQui's Giant Bounce (see Figure 2.2) and focused on "presenting the movement styles children preferred for the different game contexts and how these findings have affected the game design" (p.46). Höysniemi and Hamalainen (2003) defined the QuiQui's Giant Bounce game project that;

> "The goal of our project to provide an immersive and physically engaging alternative to traditional computer games: the game activates children to use their whole body and develops their physical abilities, such as coordination and balance. Compared to other physical games based on sensory devices or game controllers, our perceptive user interface is full-body and wireless, and does not require and contact with the input devices during gameplay" (p.164)

The game that they developed was designed for children who are between 4-9 year olds. The game also required very simple and basic bodily movements and interaction during the gameplay. At the end of the study, they concluded that "controls for vision-based action games must be intuitive and physically appropriate" (p.50). They also defined main requirements for these games that are "robustness, responsiveness, intuitiveness, and physical appropriateness" (Höysniemi, Hamalainen, Turkki & Rouvi, 2005).

Shadow Boxer is another physically interactive game that is about fitness and aerobics. The game was designed and developed by Höysniemi, Aula, Auvinen, Hannikainen and Hamalainen (2004) and controlled via bodily movements. They conducted a research focusing on the Shadow Boxer game. They divided the game within three main parts that are respectively training part that aimed to make children perform some practices before the game, instruction part that aimed to give adequate information regarding gameplay via written text and video to children and game part. Results of the study revealed that "playing the game significantly increased the participants' heart rate and for most of the participants, the heart rate was at the optimal exercise level after playing the game. Thus the game can be effectively used as an exercise method" (p.389).

Kostomaj and Boh (2009) investigated evaluation of full bodily interactive games. They used Kroflic and Laban's framework of Body, Space, Time and Relationship. Totally 8 participator participated to their study and they played 10 games during 20 minutes. They concluded that physical space in physically interactive games is an important part of physical activities that influences directly users' experiences and gameplay. Another study of physically interactive games was conducted by Höysniemi and Hamalainen (2005) aiming to draw a framework regarding designing considerations of physically interactive mixed-reality marital arts game for children. Basing on observations and interviews of children, they figured out that children

liked making bodily interaction and they enjoyed playing physically interactive games.

2.6 Educational Values of Physically Interactive Games

Most of children have been exposed to computers at early ages (Inkpen, Booth & Klawe, 2001) at home or at school because computers have been integrated and implemented in early childhood educational environments (Clement, 1999). Bauckhage and Thurau (2004) stated that computer games have been becoming an indispensable part of the modern societies' popular cultures. They declared that computer games are also drawing extreme attention of educators and instructors because of their entertainment and enjoyable characteristics. Höysniemi, Hamalainen and Turkki (2003) stated "the increasing amount of time children spend with computers and video games has raised questions about how the use of computer technology affects the lives of children" (p.203). Physically interactive games bring new features to educational environments making children physically active during gameplay.

On the one hand, it is stated in some of studies (i.e. Sherry, Holmstrom, Binns, Greenberg & Lachlan, 2001; Carnagey & Anderson, 2005) focusing on negative aspects of computer games in the literature that games might be harmful regarding children's physical development. According to Höysniemi, Hamalainen, Turkki and Rouvi (2005) stated that "one factor causing these effects is the use of traditional human-computer interaction styles and input devices, such as a keyboard, mouse, or game pad that promote a sedentary lifestyle" (p.45).

On the other hand, computer games have been integrated and implemented within classrooms for many years. A new game genre, physically interactive games, has different gameplay and interaction characteristics. They have great potentials regarding using these games in educational settings. Using beneficial sides of physically interactive games, better educational environments might be presented to

students that might give chance to them to learn educational context more meaningfully. It is stressed that "physically interactive games have been increasingly utilized to enhance learning" (Lu, Fan, Liu & Chuang, 2010, p.368).

Basing on the results of the studies conducted by Höysniemi and Hamalainen (2005), it might be concluded that physically interactive games allow children learn variety of new movement skills during gameplay. The physically interactive game that they designed has basic motor and cognitive skills requirements, which are;

- Locomotor skills (that move the body from point A to B) are needed to move forward and backward on the playfield,
- Nonlocomotor skills (e.g. balance and body stability) such as turning and rotating the whole body towards the most appropriate screen, for example, when the opponent appears in the back of the avatar,
- Manipulative skills (i.e. controlling objects using the limbs) which include handling the weapons such as the batons,
- Movement awareness (the ability to conceptualize then respond to a stimulus), for example the ability to move forward in order to position one's self to deliver a kick from the right distance at a right time,
- Body awareness (knowledge of one's body and it's parts and their movement capabilities) is needed to estimate how far kicks and punches reach, kicking backwards of the body,
- Spatial awareness (being aware of one's body and it's movement and orientation in space) how the player is located in the playfield,
- Focusing attention and distinguishing one's own avatar from the rest of the visual information,
- Observing the visual feedback of the game and planning actions,
- Ability to do 90 degrees remapping of one's movements, i.e., moving forward to move the avatar to the right (p.8-9).

2.7 Physically Interactive Educational Game Design

Designing an educational game is a difficult process that should be taken into account several factors. While designing an educational game, several factors should be considered by game designers. As Höysniemi, Hamalainen and Turkki (2003) stressed that "the design of children's computer products must be careful and considerate in order to prevent computers from being physically and socially harmful to children" (p.204). Educational values of games have been increasing speedily in educational settings and it is becoming easy to see educational game implementations in classrooms. Fisch (2005) concluded that "both systematic research and anecdotal evidence have demonstrated that educational games can hold significant benefits for children-enriching knowledge, fostering skills, and stimulating motivation and interest" (p.60).

As a new game genre, physically interactive games have been diffusing rapidly in both game markets and Internet. In physically interactive games, players involve in game environment in a different way than other types of games, and this gives attractive characteristics to physically interactive games. Educational use of physically interactive educational games, especially for physical education, have a big potential in terms of making students move their body according to desired movements while controlling game environment. By using hands or bodily movements, requirements that physical education wants might be done easily in an enjoyable game environment. As Höysniemi (2006) stated that physically interactive games are played by performing physically movements with a new perspective from both game designers and players.

In addition to physical education, game environment basing on physically interactive game concept might be designed and developed by taking into consideration other fields such as Mathematics, Science Education with an interdisciplinary approach. Combination of Physical Education and one of the aforementioned disciplines in

physically interactive game environment might be a good solution for educational settings.

Concerning the designing and developing the physically interactive physically games, very carefully design process should be taken into account because of the specific characteristics of these games. Placements of camera screen and interaction patterns of children with game interface are needed to be determined according to characteristics of children and their needs. “When designing a physically interactive and collaboration enabling computer game for children, usability studies must be carried out to ensure that the game fulfils the requirements set for physical appropriateness and social interaction” (Höysniemi, Hamalainen & Turkki, 2003, p.204). It is very important that physical bodily movements are supposed to encounter the expected requirements, physically. The balance between physically movement and gameplay are important because children might focus physically movements merely rather than the gameplay.

Previous research about gameplay of physically interactive games revealed that playing computer games by using bodily movements instead of mouse or keyboard are liked by children (Höysniemi et al., 2004; Höysniemi & Hamalainen, 2005). However, in the literature, it is seen that there is not large amount of studies focusing on design characteristics of physically interactive games (Höysniemi, Hamalainen & Turkki, 2003). How physically interactive games should be designed for players considering the most enjoyable, functional and bodily appropriate game is critical question that should be needed to investigate (Höysniemi, 2006). How a computer game should be designed best for children is critical question that points of views of all stakeholders like children and teachers are needed to be taken into account. Teachers’ expectations from computer games and their educational potentials are needed to be examined and understood properly during designing of a computer game for educational purposes (Mumtaz, 2001; Gros, 2007), in addition to children’s considerations regarding design issues of an educational computer game.

2.8 Summary

There are many endeavors about integrating computer games within educational settings in order to present better learning environment to children. However, there are design and development problems of computer games that encounter not only teachers' expectations but also children's needs. With a limited research focusing on design issues of computer games, there have been attempts to integrate and implement each new computer game genre in classrooms.

Physically interactive games, as a new game genre, are needed to be studied regarding defining design principles. There is huge potential of physically interactive games in both schools and sportive activities. Because physically interactive games are very new game genre and there is very limited research focusing on design principles of physically interactive games, there is a need regarding putting design principles of physically interactive games on the ground in order to use these games for educational purposes. With the lack of adequate design principles that are determined considering both educators and students, it might be hard to design and develop the most beneficial and appropriate physically interactive games for children. Finally, stakeholders, practitioners, educators and scholars need a guideline regarding implementing beneficial computer games in educational settings.

CHAPTER 3

METHODOLOGY

This chapter presents the purpose of the study, design of the study, participants, data collection and analysis, trustworthiness issues such as reliability, internal validity, external validity, ethical issues and limitations of the study.

3.1 Purpose of the Study and Research Question

The purpose of the present study is to determine design principles of physically interactive educational games considering points of views of all stakeholders that are teachers, as subject-matter experts and learners, as target audience. During the study, following research question was investigated to figure out the design principles.

> How could design principles for physically interactive educational games be defined basing on teachers' and children's considerations?

In order to figure out the main research question, teachers' and children's points of views on physically interactive educational game use in educational settings were examined. Also, teachers' and children's considerations about game design issues and game components were taken into account.

3.2 Design of the Study

In the present study, qualitative data collection techniques were used to determine design principles of physically interactive educational games and investigate research questions by figuring out both teachers' and children's considerations. Also, Reeves'

Development Research Model was administered under the Design-Based Research. Descriptive questionnaire results and researcher's observation notes were aimed to strengthen and support findings of the qualitative research results.

In order to figure out research questions and gather objectives of the research, highly in-depth analysis of the subject-matter experts and target audiences need to be performed. Basing on well-defined outcomes of the present study, it was targeted that results of the study might help practitioners to design, develop and implement physically interactive educational games according to defined design principles.

Characteristics of qualitative research and its use aim to help figure out answers for research problem and understand the phenomena in the present study. Concerning a common accepted description of the qualitative research, Strauss and Corbin (1990) stated that qualitative research includes "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (p.17). They also categorized major components of qualitative research. According to Strauss and Corbin (1990), data, procedures and written and verbal reports are three major components in qualitative research that help researchers to handle whole process including collecting, interpreting, analyzing and reporting data. Data can be gathered from various sources. For instance, researchers can collect data by conducting interviews, observations or examining documents, records and films. Data gathering takes some time for researchers and gathered data are needed to be conceptualized elaborated and reduced. At the end of the qualitative research process, written and verbal reports are presented to explain the study.

Basing on Hoepfl (1997) statements about characteristics of qualitative research, following implementations that dominated the current study were performed during the data collection and analysis processes;

- Natural classroom environment was used as the source of data

- Inductive analysis technique was used during data collection process
- Uniqueness of designing physically interactive educational game were predominantly paid attention as the main research case of the study
- An emergent design was focused concentrating on design and implementation process of physically interactive educational games from both educators and practitioners points of views
- Experiences of teachers and children on educational games were examined and interpreted in order to gather design principles of physically interactive educational games.

In order to implement the qualitative research, design-based research methodology was administered in the present study. Hoepfl (1997) stated that "the particular design of a qualitative study depends on the purpose of the inquiry, what information will be most useful, and what information will have the most credibility" (p.50). To draw a methodological framework and collect data in a systematic way, design-based research methodology was implemented.

Wang and Hannafin (2005) described Design-Based Research as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development and implementation, based on collaboration among teachers and practitioners in real world settings, and leading to contextually sensitive design principles and theories" (p.6-7). Concerning main characteristics of Design-Based Research, they summarized that;

- Pragmatic research goal
- Grounded research methodology
- Interactive, iterative, and flexible research process
- Integrative research methods
- Contextual research results

In order to gather design principles basing on research questions, principles of development research guided the current study. During the study, analysis, design, development, implementation and evaluation phases were performed by Design-Based Research (Reeves, 2000). Iterative research process was mostly encouraged and refining design principles during the entire research process in a systematic way was focused in a cycle of research (Amiel & Reeves, 2008). Reeves, Herrington and Oliver (2004) explain that as development research, Design-Based Research;

- Focuses on broad-based, complex problems critical to education,
- Involves intensive collaboration among researchers and practitioners,
- Integrates known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems,
- Conducts rigorous and reflective inquiry to test and refine innovative learning environments as well as to reveal new design principles,
- Requires long-term engagement that allows for continual refinement of protocols and questions,
- Maintains a commitment to theory construction and explanation while solving real-world problems (p.59).

Design-Based Research methodology aims to find solutions about problems between educational research and real life. Design-Based Research first aims to figure out real life problems (Barab & Square, 2004) and to set a valuable link between research and outside of the world (Amiel & Reeves, 2008) in order to develop effective and efficient learning environments (Sandoval & Bell, 2004). Researchers are not expected to just evaluate and interpret their data to find solution about the real life problems (Amiel & Reeves, 2008). Real life problems are needed to be expected structurally to help all stakeholders that are influenced from the problem. Therefore, in the present study, gathering data from teachers and children, a solution regarding designing and developing physically interactive educational games were figured out

focusing on design principles that were expected to help both educators and practitioners.

As cited in Amiel and Reeves (2008), concerning main principles of design-based research, Reeves (2006) stated "… addressing complex problems in real contexts in collaboration with practitioners; integrating known and hypothetical design principles with technological advances to render plausible solutions to these complex problems; and conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles" (p. 58). Similarly, in the current study, by aiming to figure out design principles of physically interactive educational games having innovative gameplay and interaction approach, it was attempted to set a connection between theoretical implications and designing and developing an educational game in order to construct effective and efficient learning environment.

Dede et al., (2004) stated five main characteristics of good design-based research identified by Design-Based Research Collective, and they were taken into account during the design and implementation phase in the present study. They are;

- Goals of designing learning environments and developing theories or "prototheories" of learning are intertwined.
- Development and research take place through continuous cycles of design, enactment, analysis, and redesign.
- Research leads to theories that communicate relevant implications to practitioners and other educational designers.
- Research accounts for how designs function in authentic settings, not only document success or failure but also focusing on interactions that refine our understanding of the learning issues involved.
- Research relies on methods that can document and connect process of enactment to outcomes of interest (p.159).

Figure 3.1: Research Design and Data Collection Methods in the Present Study

In this study's data collection and analysis process, Reeves' Development Research Model that was constructed under the theoretical framework of Design-Based Research was specifically followed (see Figure 3.1). In the model, four phases of the development research process are needed to perform. According to the model, analysis of practical problems by researchers and practitioners are needed to be handled. In the present study, design principles of physically interactive educational games about analysis, design, development, implement and evaluation were main focus that could be considered as practical problems (see Figure 3.2).

Development of solutions with a theoretical framework is needed to be performed basing on the analysis according to Reeves. In the study, basing on teachers' and children's considerations, four physically interactive educational games with two motion-controlled interactive games and two motion-driven interactive games were designed, developed and implemented. Reeves focuses on evaluation and testing solutions in the practice in his model. Similarly, children played all designed and developed games and gave feedback after each gameplay session to evaluate the games. In addition, Development Research Model aims to help practitioners about practical problems stated at the first part of the model. In the study, design principles were refined and finalized at the end.

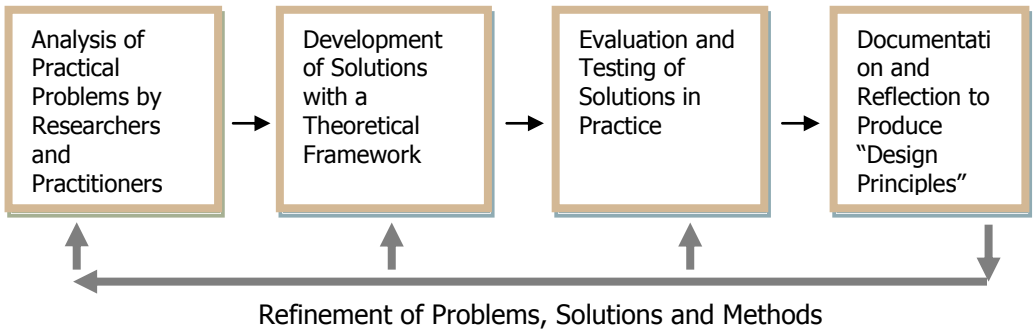


Figure 3.2: Reeves' Development Research Model (Reeves, 2000, p. 9)

As it was stressed before, in order to be able to collect data and conduct in-depth analysis, Reeves' Development Research Model was elaborated and detailed according to the research problems of the study (see Figure 3.3). First, previous studies in the literature were examined and "need analysis", "learner analysis", "content analysis", and "game analysis" were conducted in the **Phase 1**. In this phase, it was aimed to identify what type of issues or problems that teachers and practitioners might encounter when they try to design, develop and implement physically interactive educational games. Basing on literature, field experts considerations and analysis conducted, preliminarily design principles were determined. During the whole process, analysis phase in the current study continued to the end iteratively between each Phase as it was stressed in key principles of Design-Based Research.

In the **Phase 2**, two computer-based and two paper-based physically interactive game prototypes were designed by taking into account outcomes gathered in the previous phase. Teachers as subject-matter experts were interviewed in the **Phase 3**. Semi-structured interviews were conducted with specific focus on their considerations on designed game prototypes and expectations from physically interactive games in terms of their educational potentials. Paper-based prototypes were explained and teachers were informed according the designed paper-based prototypes. Teachers were informed about how to play developed prototypes and they played before the

interviews. In this phase, evaluation and testing processes of designed prototypes were performed with expert reviews.

In the **Phase 4**, first versions of games were developed by considering the teachers' feedbacks. Two motion-driven and two motion-controlled physically educational interactive games were developed in this phase. In the **Phase 5**, gameplay sessions were organized. Children, as target audience, played each developed games and they were interviewed after each gameplay session. During the semi-structured interviews conducted with children, children's points of views and expectations concerning physically interactive educational games were attempted to figure out. At the end of this phase, outcomes of reviews of teachers were consolidated to refine design principles that were determined preliminary at the beginning of the study (**Phase 4.1**).

In the **Phase 6**, high fidelity versions of games were developed by considering children's feedbacks. Design phases were finalized with this phase. In design phases, both teachers and children gave feedback and joined to the study. At the end of this phase, outcomes of reviews of children were consolidated to refine design principles. After the design phase, two implementation phases were conducted with children. In the **Phase 7** and **Phase 8**, gameplay sessions were organized with different target audiences. **Phase 7** was a pilot study and **Phase 8** was final implementation study. Game evaluation questionnaire were applied as interviews with children after each gameplay session. Children played all developed physically interactive games before the interviews. Same data collection technique was used in the **Phase 7** and **Phase 8**. In addition, observation notes that were taken while children were playing the games to be able to reach in-depth analysis about the phenomena. At the end of the implementation phases, design principles were finalized (**Phase 8.1**).

Briefly, in the present study, both teachers' and children's considerations and points of views on physically interactive gameplay and expectations from physically

interactive games were investigated. Concerning from subject-matter experts and target audiences considerations, elaborated design principled were attempted to determine at the end of the study. It was expected that the emerged design principles might help educators and practitioners to design, develop and implement physically interactive educational games in educational settings.

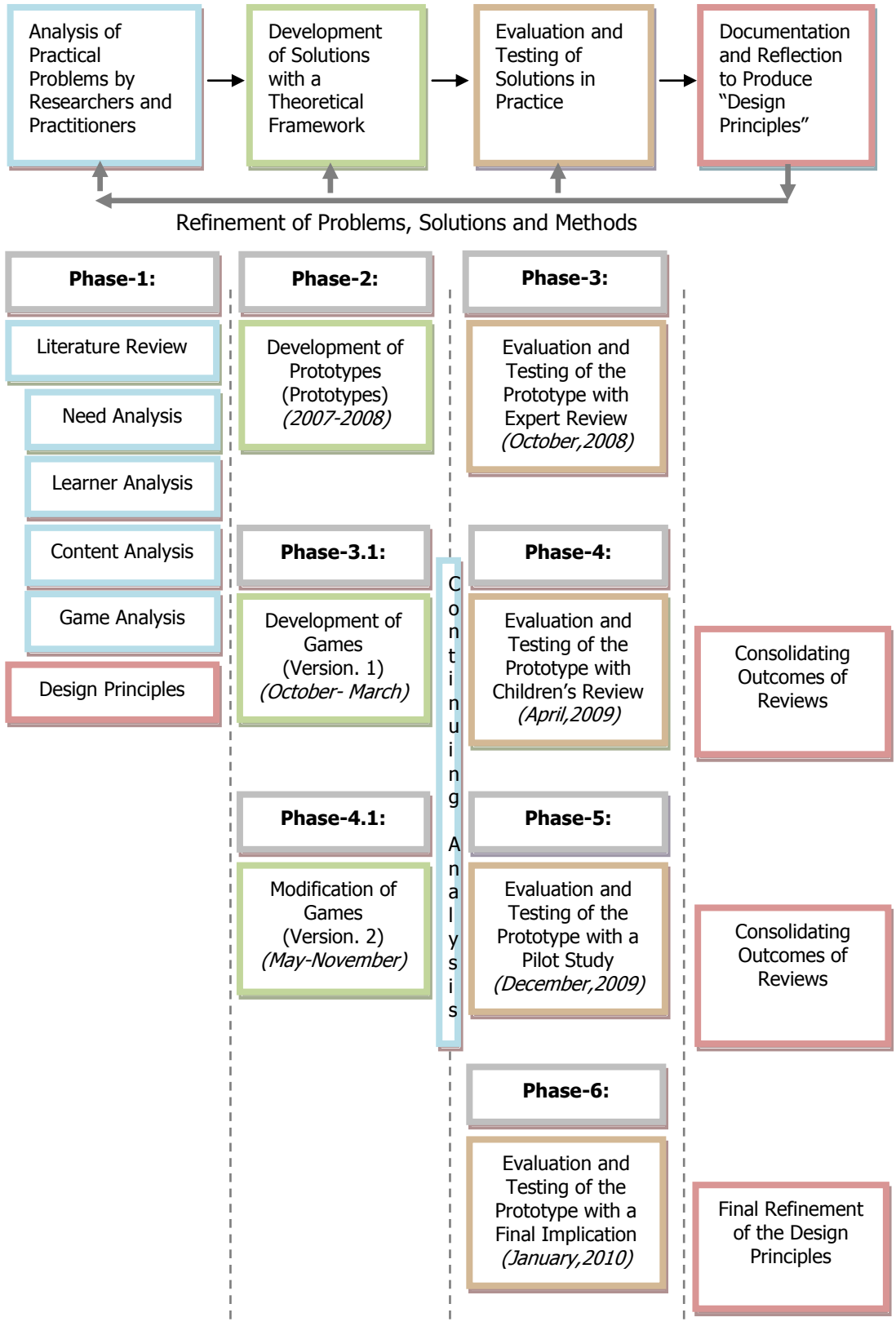


Figure 3.3: The Study based on Reeves' Development Research Model

3.3 Participants

Sampling in the present study refers to individuals who participated to the research actively, voluntarily and purposively during the data collection process. In terms of sample selection criteria, purposeful sampling strategies were administered in the study. Purposeful sampling is the most common (Patton, 1990) and dominant (Hoepfl, 1997) strategy in qualitative research. Patton (1990) emphasized purposeful sampling that it aims to investigate information rich cases in a research that are conducted deeply and in detail. Main point in purposeful sampling is to figure out and release significant cases or events instead of aiming to reach population from the selected sample by generalizing (Patton, 1999).

Concerning determination of educational subjects embedded within physically interactive game environment, four different game concepts were determined taking scholar field experts' considerations into account. With the feedback of one Mathematics field expert and one Physical Education field expert, games were conceptualized considering both Mathematics and Physical Education.

Under the light of the purposeful sampling strategies, in the analysis and design phase of the study, teachers as subject matter experts and children as target audience participated. In order to understand design principles of physically interactive educational games from subject matter experts as practitioners' points of views, 3 Mathematics and 2 Physical Education teachers of a public elementary school participated to design phase of the study (see Table 3.1).

Table 3.1: Information about Teachers as Subject Matter Experts

No	***Subject Area***	***City***	***School***
M1	Mathematics	Ankara	Public School
M2	Mathematics	Ankara	Public School
M3	Mathematics	Ankara	Public School
PE1	Physical Education	Ankara	Public School
PE2	Physical Education	Ankara	Public School

One-day workshop session were organized with subject matter experts that two paper-based and two computer-based game prototypes were used. In the workshop session, all teachers were informed about concepts of games including how to play games, aims and stories, pedagogical goals, expectations from students, camera use and interaction patterns.

Children as target audience participated to the study in the design phase. Totally 10 children with 5 boys and 5 girls were selected as purposive samples. Children were 7-9 years old from a private school in Ankara district. All children were second graders. Children were coded like CM as Child-Male and CF as Child-Female with a sequence number. Only two males had experiences on playing physically interactive games and the rest of them had no experiences. All children had computer at home and all of them stated that they played educational games before either in classroom or at home (see Table 3.2).

Table 3.2: Information about Children as Target Audience

No	***Experience on PIGs***	***Computer at Home***	***Experience on Educational Games***	***School***
CM1	Yes	Yes	Yes	Private School
CM2	No	Yes	Yes	Private School
CM3	No	Yes	Yes	Private School
CM4	Yes	Yes	Yes	Private School
CM5	No	Yes	Yes	Private School
CF1	No	Yes	Yes	Private School
CF2	No	Yes	Yes	Private School
CF3	No	Yes	Yes	Private School
CF4	No	Yes	Yes	Private School
CF5	No	Yes	Yes	Private School

Pilot Implementation and Final Implementation were conducted with different target groups in the implementation phase. Totally 30 children with 17 boys and 13 girls voluntarily participated to the Pilot Implementation. Children were from a public school that is a public school in Ankara. 19 of the children were 2nd graders and rests of them (11 children) were 3rd graders. Almost all of the children (n=26) had

computer at home. Most of the children (n=21) use computer approximately between 0 and 2 hours per day. Almost all children (n=27) stated that they play computer games either at home or at school. Concerning children's experiences in playing camera-based games, only 4 boys stated that they played webcam games before. Rests of the children had no experiences in playing games with a webcam.

Table 3.3: Information of Participants for Design and Implementation Phases

Participant	***Phase***	***Number of Participants***
Teacher	Design Phase	5 teachers (3 Mathematics, 2 Physical Education)
Children	Design Phase	10 children (5 boys, 5 girls)
Children	Implementation Phase	30 children (17 boys, 13 girls)
Children	Implementation Phase	50 children (27 boys, 23 girls)

Totally 50 children with 27 boys and 23 girls voluntarily participated to the Final Implementation. Children were from a public school in Ankara. 33 of the children were 2nd graders and rests of them (17 children) were 3rd graders (see Table 3.3). Concerning webcam game experiences, most of the children had no experiences. Only 4 boys and 1 girl stated that they played webcam games before.

3.4 Data Collection

3.4.1 Instruments

Interview Schedules: One of the mostly used interview strategies in qualitative studies, semi-structured interviews were used in the study. Marshall and Rossman (1999) stated that with interview, researcher might have chance to collect vast amount of data. In the current study, main data gathering process were considered as making interviews not only with teachers but also with children. Interview schedules were prepared about designing physically interactive educational games for both teachers and children separately basing on limited numbers of research in the literature about physically interactive games. Concerning conducting semi-structured interviews with interview schedules, Hoepfl (1997) stated that "although it is

prepared to insure that basically the same information is obtained from each person, there are no predetermined responses, and in semi-structured interviews the interviewer is free to probe and explore within these predetermined inquiry areas" (p.52). Similarly, during the interviews, new topics and questions related to research problems were investigated although they were not asked in the interview schedules. By this way, different and unexpected outcomes were attempted to figure out at the end of the study.

Semi-structured interviews were conducted with each participant because predetermined inquiry field of physically interactive games has recently appeared. With semi-structured interview, unexpected or unpredictable findings might be emerged after the interviews. Two different interview schedules were applied that are respectively Game Design Interview with subject matter experts (*GDI-SME*), and Game Design Interview with target audience (*GDI-TA*). All interview questions (Appendix A and Appendix C) were designed considering the participants' age characteristics and education level. Designed questions were asked to an elementary school teacher and a scholar colleague and revised basing on feedbacks and comments about the questions. It was clearly observed that questions of the interview schedules worked during the interviews and both teachers and children didn't suffer from any difficulties or misunderstandings.

Game Design Interview with Subject-Matter Experts (GDI-SME): Mathematics and Physical Education teachers as subject matter experts were interviewed after the workshop session. Semi-structured interviews were conducted with teachers. Each interview session was divided into four parts that were related to designing physically interactive educational games and using educational games in educational settings.

Before the workshop session, teachers were informed about the study and main characteristics of physically interactive games. Because physically interactive games

are new game genre appearing recently in game markets, major gameplay issues, interaction patterns, different gameplay characteristics and camera use aims were explained in detail to teachers. With the workshop session, all teachers played two computer-based physically interactive educational games, and they were informed about how to play regarding two paper-based prototypes of physically interactive educational games.

Teachers were interviewed for each game separately according to four game design categories that are (1) Educational Content, (2) Visual Design, (3) Camera Use, and (4) Interaction. Game design categories were determined basing on the characteristics of the present study. The main aim of the study was to design and develop the most appropriate and beneficial educational games for children. Educational aspects of games were needed to be strengthened by visual design of games. Especially for children, visual design, animations and sound effects were very important that have power to attract children's attention. Besides, camera use was prominent activity in physically interactive educational games that children had to use to control and play these games. With new gameplay aspects of physically interactive games, they had innovative characteristics and made children interact game environment more different than classical games. Therefore, these key features of physically interactive educational games were determined as game design category in the present study.

Each design category has five different sub questions (Appendix A). Concerning Educational Content, teachers' experiences about educational game use in classrooms were investigated. Their points of views about educational game use, needs and expectations of target audience in terms of playing an educational game and getting instructional benefits from these games were inquired. Concerning designed games, teachers' considerations on educational content, presentation of the content and performance measurement issues were asked.

Concerning Visual Design, teachers' opinions and suggestions about design of physically interactive educational games were investigated. In order to determine design principles, subject-matter experts' considerations on visual design of games were important. Written and verbal components, sound effects and location of camera screen and navigation parts were asked to teachers. Designed games had avatars that had different appearances, and teachers views about avatar selections and animations used in the games were also asked.

Concerning Camera Use, teachers' expectations about appropriateness of camera use were investigated. Their suggestions in terms of children's correct camera use during gameplay and expectations of camera use from children when they were playing the games were examined. Teachers were also interviewed about instructions including how to play the games and presentations of the instructions in games.

Concerning Interaction, appropriateness of interaction patterns in camera screen and educational content were investigated. Interactions patterns that are necessary in games to make practices related to both Mathematics and Physical Education were asked to teachers. Expected bodily movements that children were supposed to perform while playing the games were inquired in terms of appropriateness of children's physical and educational levels and difficulties of bodily movements for target audience.

Game Design Interview with Target Audience (GDI-TA): Children as target audience were interviewed in the design phase of the study. Semi-structured interviews were conducted with children. Each interview session was divided into five parts that were related to common gameplay issues of educational games and design of physically interactive educational games.

Children were interviewed after each gameplay session. They were interviewed for each game separately according to five game design categories that are (1) General

Issues, (2) Educational Content, (3) Visual Design, (4) Camera Use, and (5) Interaction. Each design category has different questions (Appendix C). Concerning General Issues, children were mainly asked about their experiences on playing physically interactive games with positive and negative sides of games. In addition, potentials of physically interactive educational games for educational purposes were investigated from children's points of views.

Concerning Educational Content, children's considerations about embedded educational subject within game environments were asked. Beneficial aspects of designed games and presentation ways of educational content were examined basing on target audience's perspectives. Gameplay duration, game score concept, lives to play and difficulties of games were also investigated during the interviews.

Concerning Visual Design, appropriateness of presentations of visual design components was mainly investigated by taking children's considerations into account. Especially color selection, avatar preferences, screen design, understandability of gameplay duration, how to play instructions and size of gameplay part were asked. In addition, sound effects, animations and any components, applications or objects bothering children were inquired.

Concerning Camera Use, children's feedbacks about using camera screen in physically interactive games were very important. Camera screen is vital game component in these games because children needed to play physically interactive games by using camera. Therefore, difficulties or challenges in game related to camera screen while playing were investigated. Children were asked about size of camera screen, difficulties of controlling the camera and playing games simultaneously, fixing body in camera screen during gameplay and their suggestions for effective and efficient camera use.

Concerning Interaction, children were asked about main interaction patterns of physically interactive educational games. It was expected before the interviews that most of the children had no experiences on playing similar camera-based games. Difficulties of making interaction between gameplay environment and educational content and children's preferences about using mouse/keyboard or camera screen were asked to children. In addition, it was investigated whether children preferred playing physically interactive games with one of their friends or not.

Questionnaires: Two questionnaires were administered in the study. One is about demographics of children including 14 questions. The questionnaire was used in the study (Inal & Cagiltay, 2007) aiming to investigate flow experiences of 7 to 9 year old children in an interactive social game environment. In that study, totally 33 children were given the demographic questionnaire. For the present study, only 2 questions were added that are about playing physically interactive educational games and using educational games in classrooms. In addition, with the same questions of the previous study, questionnaire in the present study divided into two parts having different questions groups and criteria.

Another questionnaire is about evaluating designed and developed physically interactive educational games. The questionnaire was developed considering both the interview questions applied in the design phase and similar studies (i.e. Höysniemi, Hamalainen & Turkki, 2003; Höysniemi & Hamalainen 2005; Höysniemi, 2006) in the literature.

Children Demographics Questionnaire (CDQ): Children's demographics information were collected in both design and implementation phases. Like Game Evaluation Interview Questionnaire conducted with target audience (*GEQ-TA*), Questions in Demographic Questionnaire were asked to children verbally and their answers were written by the researcher in an interview session. Demographic

Questionnaire had 14 questions including “Yes/No” questions, “Multiple questions” and “Open-ended questions” (Appendix B).

Game Evaluation Interview with Target Audience (GEI-TA): Children were interviewed in Pilot and Final Implementation Phase separately to evaluate designed and developed physically interactive educational games. In order to provide consistency between design and implementation phases, questions of game evaluation questionnaire had mainly same content with game design interview conducted with target audience. Children were asked 25 questions categorized as (1) Educational Content, (2) Visual Design, (3) Camera Use, and (4) Interaction. Game Evaluation Interview Questionnaire (*GEI-TA*) was 3-point Likert scale type including “I don’t agree”, “Neutral” and “I agree” format (Appendix D). Questions in the questionnaire were asked children in an interview session. Because children might have difficulties in answering written documents effectively and properly, questions were asked to children by the researcher and their answers were written in the questionnaire.

Observation Notes: Observation notes of researcher were also used in data analysis process. While teachers were playing computer based prototypes, their gameplay characteristics were collected. In which part of the games that they encountered difficulties were aimed to analyze and observation notes were taken. Similarly, while children were playing developed physically interactive games, observations regarding children’s gameplay characteristics, challenges that they encountered and their reactions toward gameplay and educational content were gathered.

During gameplay sessions of teachers and children, observation notes were written via Notebook (PC). Game design categories that are Educational Content, Visual Design, Camera Use and Interaction were used during observation. Specifically reactions of teachers and children were aimed to taken because almost all of them had no experiences in playing physically interactive games before.

3.4.2 Data Collection Process

In order to determine educational subjects, two scholars that are field experts of Mathematics and Physical Education joined in the study. Concerning determination of educational subjects, four different game concepts were defined considering scholar field experts' points of views. After the feedback of one Mathematics field expert and one Physical Education field expert, games were conceptualized considering both Mathematics and Physical Education.

Semi-structured interviews were conducted with both subject-matter experts and target audience in different public and private schools in Ankara district. Initially, teachers as subject-matter experts were informed in a workshop session. 3 Mathematics and 2 Physical Education teachers participated to the workshop session and they were interviewed (see Table 3.4). All Mathematics and Physical Education teachers played computer-based game prototypes separately and informed in detail about paper-based game prototypes. In the workshop session, teachers were informed about concepts of games that were how to play games, aims and stories, pedagogical goals, expectations from students, camera use and interaction patterns.

Table 3.4: Information about Interview Process with Teachers

Participant	***School***	***Study Phase***	***Interview***	***Duration***
M1	Public School	Design	GDI-SME	25-30 min.
M2	Public School	Design	GDI-SME	25-30 min.
M3	Public School	Design	GDI-SME	25-30 min.
PE1	Public School	Design	GDI-SME	25-30 min.
PE2	Public School	Design	GDI-SME	25-30 min.

After the workshop session, semi-structured interviews were conducted with each teacher and questions were asked about each designed physically interactive educational game prototypes. Teachers were presented two paper-based and two computer-based games. Each interview sessions were divided into four parts that were related to designing physically interactive educational games and using educational games in educational settings. Totally 20 questions were asked during

the interview sessions including four game design categories that are (1) Educational Content, (2) Visual Design, (3) Camera Use, and (4) Interaction.

Teachers were experienced on computer-based game prototypes by playing games. For paper-based prototypes they gave feedback on screenshots of games in terms of gameplay rules, camera-use, educational contents etc. All interviews were recorded by getting permission from subject-matter experts. Each interview took approximately 25-30 minutes and conducted in teacher room in school.

Recording data has more advantageous than note-taking when there were lots of data to obtain. Similarly, Hoepfl (1997) stated recording data has some advantages that "recordings have the advantage of capturing data more faithfully than hurriedly written notes might, and can make it easier for the researcher to focus on the interview." (p.53). Therefore, because teachers might give more feedback during both workshop and interview sessions about game prototypes, tape recorder was used after getting their permission.

In the design phase of the current study, 10 children with 5 males and 5 females were interviewed about design issues of physically interactive educational games. Interviews were conducted after each gameplay session. In order to get children's feedback as target audience, firstly they played all developed games. This gameplay session took approximately 20 minutes. After the gameplay session, children were interviewed that took approximately 15-20 minutes. Therefore, to get feedback from each participant, nearly 35-40 minutes were taken (see Table 3.5).

During the whole interview process with children, note-taking methods were used with a notebook (PC). Children's feedback basing on the semi-structured interviews was noted by the researcher. Note taking is one of the common data recording ways of the qualitative research. Because of avoiding from destructing children's attention and bothering them during interview sessions, note taking method was used in the

interviews. All interview sessions were performed in an empty classroom in the school. Children participated to the study when they had either Mathematics course or Computer course in course schedule. 5 boys and 5 girls were called respectively. The whole interview process took two weeks.

Table 3.5: Information about Interview Process with Children (Design)

Participant	***School***	***Study Phase***	***Interview***	***Duration****
CM1	Private School	Design	GDI-TA	15-20 min.
CM2	Private School	Design	GDI-TA	15-20 min.
CM3	Private School	Design	GDI-TA	15-20 min.
CM4	Private School	Design	GDI-TA	15-20 min.
CM5	Private School	Design	GDI-TA	15-20 min.
CF1	Private School	Design	GDI-TA	15-20 min.
CF2	Private School	Design	GDI-TA	15-20 min.
CF3	Private School	Design	GDI-TA	15-20 min.
CF4	Private School	Design	GDI-TA	15-20 min.
CF5	Private School	Design	GDI-TA	15-20 min.

* Interview duration for each child

Each interview session was divided into five parts that were related to common issues of educational games and design of physically interactive educational games. Children were interviewed for each game separately according to five game design categories that are (1) General Issues, (2) Educational Content, (3) Visual Design, (4) Camera Use, and (5) Interaction.

For implementation phase of the study, Pilot and Final Implementation were administered with different target audience. Pilot Implementation was organized in a public school in Ankara district. Totally 30 children with 17 boys and 13 girls participated to the implementation.

Interview questions had mostly similar content with *GDI-TA* and included 25 questions categorized as (1) Educational Content, (2) Visual Design, (3) Camera Use, and (4) Interaction. Questions in the questionnaire were asked children in an

interview session and each interview took approximately 15-20 minutes. Interviews were conducted after each gameplay session. Each gameplay session took approximately 20 minutes. Therefore, the whole pilot implementation process for each child took nearly 35-40 minutes (see Table 3.6). All interview sessions were performed in computer class in the school. Computer teacher arranged children's participation and children were called respectively to play the games and conduct interviews. The whole data collection process took three weeks.

Table 3.6: Information about Interview Process with Children (Implementation)

Participant	***School***	***Study Phase***	***Interview***	***Duration****
30 Children (17 M / 13 F)	Public School - 1	Pilot Implementation	GEI-TA	15-20 min.
50 Children (27 M / 23 F)	Public School - 2	Final Implementation	GEI-TA	15-20 min.

* Interview duration for each child

In the Final Implementation Phase, same data collection methods were administered with the Pilot Implementation. Implementation was organized in a public school in Ankara district. Totally 50 children with 27 boys and 23 girls participated to the implementation.

With the same questionnaire, each interview took nearly 15-20 minutes. Interviews were conducted after each gameplay session. Each gameplay session took approximately 20 minutes. Therefore, the whole pilot implementation process for each child took approximately 35-40 minutes. All interview sessions were performed in computer class in the school. Like pilot implementation, computer teacher arranged children's participation and children were called respectively to play the games and conduct interviews. The whole data collection process took four weeks.

In both of the design and implementation phases, a demographic questionnaire was administered in order to figure out in depth information about target audience in terms of their gameplay characteristics and considerations on computer games.

Questions in demographic questionnaire were asked to children before the interview sessions of game design and evaluation parts.

3.5 Data Analysis Procedure

Data analysis is the process of representing gathered sources in a meaningful manner. As cited in Hoepfl (1997), Bogdan and Biklen (1982) define qualitative data analysis as "working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others" (p.145). In the present study, data was attempted to analyze during the data collection process at the same time by conducting inductive analysis of data with both descriptive and content analysis.

Data analysis started with data gathered from teachers as subject matter experts after the workshop session. Inductive analysis of data was preferred in the study because of the nature of the present research. In the present research, each data gathering process gave significant feedback to the next data gathering process. More specifically, that each outcome of a step was used for each input of another one. Therefore, each next step was triggered and shaped after analyzing gathered data for each previous step.

Recorded data were transcribed and written in MS Word document. Afterwards, written data were categorized and grouped by predetermined sub categories that are Educational Content, Visual Design, Camera Use, and Interaction. Transcribed data were coded as axial coding that categories were determined before. Therefore, basing on gathered data, axial coding was performed. In axial coding, researcher needs to start to see and realize the big phenomena (Hoepfl, 1997). Codes in the study were defined before the analysis. Each questions for each categories were considered as codes for axial coding (Appendix E, Appendix F).

Concerning researchers' capabilities in the current study, he is competent enough for inductive data analysis. The researcher is a Ph.D candidate in the Computer Education and Instructional Technology department of Faculty of Education. He has conducted similar research before with similar target groups. He has taken "Qualitative and Quantitative Research in Education" and "Research Methods in Computer Education" courses during his Ph.D education.

3.6 Trustworthiness

During the data collection and analysis process in the current study, trustworthiness issues that are validity and reliability were taken into consideration in order to figure out research questions properly and validly. As Patton (1999) stressed that reliability and validity issues are very important for any qualitative research that should be taken into account during not only analyzing the outcomes but also evaluating the excellence of a study. According to Lincoln and Guba (1985), crucial factors should be needed to consider catching trustworthiness in qualitative research, and they are credibility, transferability, dependability and confirmability.

3.6.1 Reliability

Reliability mainly questions whether a conducted research might be replicable in any similar circumstances or not. Concerning reliability quality of a conducted research, it was mostly stated that "the more times findings of a study can be replicated, the more stable or reliable the phenomenon is thought to be" (Merriam, 1995, p.55). To ensure this, Bogdan and Biklen (1998) stressed that "accuracy and comprehensiveness" are two significant factors that needed to be paid attention during a research. In order to provide reliability issues of the current study, considerations given above were taken into consideration before and during the study. Lincoln and Guba (1985) stressed that dependability characteristics of a conducted qualitative research are related to its trustworthiness that is mostly reliability. In order to handle dependability in the current study, following strategies were taken into consideration (Merriam, 1995):

- *Triangulation:* As a basic explanation of triangulation, it refers conducting multiple methods in a research during data collection and data analysis processes. Merriam (1995) stated that "the use of multiple methods of data collection, in particular, as well as other forms of triangulation, can lead to dependability or consistency." (p.56). Using different source of data in order to make more reliable and dependable qualitative research, it was aimed to reach outcomes of research that were consistent with data which was collected during data collection process in the current study. Data were gathered from interview schedules, demographic questionnaires and researcher's observation notes.
- *Peer examination:* In order to reach consistent results of a qualitative research, collected data were needed to be checked or examined by other people who are related to the research. Merriam (1995) stated that "again, this strategy provides a check that the investigator is plausibly interpreting the data; that is someone else can be asked whether the emerging results appear to be consistent with data collected" (p.56). In the present study, each data collection process were checked by field experts and teachers to get consistent outcomes.
- *Audit trail:* It was mostly stressed in the current study that physically interactive games have appeared as a new game genre with different gameplay and interaction characteristics. Therefore, studies aiming to investigate design, develop and implementation issues of physically interactive games might have potential to give clear and useful feedbacks to both educators and practitioners who need a theoretical framework about using appropriate physically interactive educational games in classrooms. As cited in Merriam's article, it was stated that "In order for an audit to take place, the investigator must describe in detail how data were collected, how categories were derived, and how decisions were made throughout the inquiry" (Merriam, 1988, p.172 cited in Merriam, 1995, p.56). In the current

study, explaining each phase of data collection and analysis part, it was aimed to guide researchers who aim to investigate similar issues, practitioners who aim to develop physically interactive games and educators, who aim to implement these types of games.

3.6.2 Internal Validity

Validity mainly questions whether outcomes of a conducted research investigated what they were really aimed to investigate. Credibility and confirmability characteristics of a conducted qualitative research are related to its trustworthiness that is mostly internal validity. In order to ensure internal validity issues with credibility and confirmability in the current study, following strategies given by Merriam (1995) were taken into account:

- *Triangulation:* Definitions and explanations about the triangulation were given in detail before. During the data collection process, different source of data with different participants were gathered.
- *Member checks:* Outcomes of collected data were shared with Mathematics and Physical Education teachers. In addition, interview results of children and outcomes of their gameplay sessions were given to their teachers.
- *Peer/colleague examination:* In all phases of the data collection and analysis processes, advisor's comments and considerations were taken into account.
- *Statements of researcher's experiences, assumptions, biases:* Adequate information about the researcher was given to clarify his theoretical background and academic orientation.

3.6.3 External Validity

External validity basically related to generalizabilty of a conducted qualitative research. Merriam (1995) defined external validity in qualitative research that "the extent to which the findings of a study can be applied to other situations refer to the questions of external validity, or generalizabilty" (p. 579). According to Lincoln and

Guba (1985), external validity of a qualitative research is related to its transferability characteristics. In qualitative studies, it was mostly stressed that making a generalization is a difficult process, unlike quantitative studies.

In order to generalize a conducted qualitative research, Merriam (1995) suggested four strategies that are thick description, multi-site designs, modal comparison, sampling within. Some of these strategies, which are appropriate to the nature of the current research, were specifically followed in order to enhance external validity in the current study:

- *Thick description:* The researcher explained clearly all of the phases of the current research in detail so that educators, practitioners or colleagues might be able to understand the investigated phenomenon.
- *Multi-site designs:* The researcher attempted to integrate all of the factors that are needed to get feedbacks. Field experts, subject matter experts and target audiences actively participated to the study.
- *Sampling within:* In the study, there are lots of different parts that are needed to involve effectively and efficiently. Therefore, all necessary samples were selected purposively and voluntarily in order to find chance to make a generalization to similar larger groups with the same context.

3.7 Ethical Issues

During data collection processes in the study, participants from four different elementary school participated. Permissions in terms of organizing gameplay sessions with children and workshop session with teachers were taken from the institutions where the research was conducted. All participants were informed about voluntarily participation issue. They were declared that their participation was basing on voluntarily participation. Therefore, they were able to withdraw from the research at any part of the gameplay or workshop sessions. Computer teachers were given information about purposes of the study and planned data collection processes. They

were demonstrated designed and developed physically interactive educational games before gameplay sessions. Outcomes of gameplay sessions were also shared with them.

3.8 Limitations

As the nature of qualitative studies, some limitations were needed to be declared in the current study that was limited by the following factors:

- Source of data were human beings and participants own views were used as data. Accuracy and trustworthiness of collected data were based on correct response of participants. The researcher trusted participants' responses that they explain their considerations honestly during the study.
- Sampling strategies might be a limitation of qualitative research. As its nature, purposive sampling was used and limited number of participants participated to the study.
- One of limitations of the study was the role of the researcher during both data collection and analysis processes.
- Another important limitation was generalization issue. It is well known that in qualitative studies, generalization might be possible in only very similar circumstances. Therefore, generalizing outcomes of a qualitative research from selected sampling to the population might not be appropriate.
- It was attempted to organize that participants played physically interactive educational games in relax and comfortable classroom environment. In some gameplay sessions, they were distracted because of some children who tried to enter the classroom.

CHAPTER 4

RESULTS

In the result section, first, preliminary design principles of PIEG are given. Development of two computer-based and two paper-based game prototypes considering preliminary design principles are explained. Respectively teachers', and children's feedbacks about designed and developed physically interactive educational games are analyzed in detail. At the end of the design phase, preliminary design principles are modified and refined basing on teachers' and children's feedbacks.

In the implementation phase, two different children groups played the developed games. At the end of the implementation phase, design principles were finalized. In the present section, some abbreviations were used to describe both teachers and children. For instance, M1 refers to first Mathematics teacher, PE2 refers to second Physical Education teacher, CM4 fourth boy and CF3 third girl.

In the present study, designed and developed physically interactive educational games were divided into two main parts that are motion-driven interactive games and motion-controlled interactive games. They have different gameplay and interaction characteristics regarding camera use.

Motion-Driven Interaction

As a new human-computer interaction type, motion-driven interactive game environments allow players control game environment according to their movement

ranges. Basing on a captured high or low interactivity in game environment, players interact and control the environment and play game with such interactions.

Motion-driven interface design is an effective design techniques used in physically interactive games. Main principle is to control game environment with bodily movements in a camera screen that is different from the gameplay part in the design. Motion-driven design techniques bring a new perspective to game control and interaction between player and game that is different from control of the classical games. Camera use in motion-driven interface design is necessary to merely control game environment. Because the camera screen needs to be different from the gameplay part in design, visual design should be taken into consideration that players can easily use camera screen in an effective and efficient way.

In motion-driven interface design, role of player and interaction between user and game interface have different characteristics when they are compared to the classical computer games. Player cannot influence game environment directly, on the contrary the role of player is controller of the game with physical movements by using a part of bodily interaction or whole bodily interaction in a camera screen.

In game environments basing on motion-driven interaction, players play the game at the different part of game interface. Role of player in motion-driven design techniques is to control game environment with a part of bodily interaction of whole bodily interaction. Player needs to make desired movements by using bodily actions in camera screen according to gameplay rules. The main point here is to prevent player from making difficult movements during controlling game environment. It is precisely important that player should control the game without facing any difficulties in motion-driven design techniques.

Interaction between player and game environment in motion-driven interface design techniques is not performed directly. Player controls game environment with bodily

interaction in a camera screen. Like classical games, player is not the main character or avatar of game because player is not expected to interact with game environment directly. However, camera use that is necessary to make an interaction during gameplay has different and special characteristics when it is compared to classical games. In game environments basing on motion-driven interaction, player interacts with game environment in a camera screen where is designed in different part of gameplay screen. This brings a new face of control to game environments for players.

Camera use in motion-driven interactive environments has similar functionality to the role of mouse or keyboard in classical games. In these environments, player only needs to make physical movements in camera screen so as to control game without using mouse of keyboard. Because camera screen is only necessary to control the game, this part is designed at the out of the gameplay screen in the interface. In other words, camera screen and gameplay screen are at the different part of the interface. However, these parts should be designed and developed properly and understandably, due to the player needs to control game environment in an effective and efficient way. When interface design is considered, camera screen is designed at the interface so as to allow player to control game easily during gameplay. Besides, concepts of games might change according to the severity, direction and position of movement in camera screen. Important point here is to present camera screen that player could control easily while playing the physically interactive game. Otherwise, it would be very difficult to control game which requires difficult physical movements to control for player.

There might be some advantageous of motion-driven interface design because of its new characteristics in terms of role of player and interaction type. In such designs, that player interact with game environments by making physical movements might be effective to make players make some specific or predetermined movements in the camera screen during gameplay. Besides, when the physical movements are

considered, it might be claimed that players are more active and dynamic in game environment basing on motion-driven interface designs in order to make desired movements specifically and clearly.

On the other hand, one of the most distinctive disadvantageous of motion-driven interface designs is that because of a new perspective that they bring to the game control, players might have difficulties to control game environment during gameplay. Camera screen and gameplay screen are at the different part at the interface. Players should care not only gameplay part but also camera screen in order to play game properly while they are playing the game. Therefore, players' motivation and attention might decrease in games which don't have effective and efficient interface designs or in which control of game has difficult characteristics for players.

Motion-driven interface design is an effective design technique in physically interactive game environments. These design environments bring a new perspective to the role of player and interaction type during gameplay. Therefore, it is very important that player needs to control game environment in an effective and efficient way. Design of motion-driven interfaces should be conducted appropriately by taking players' role, interaction type and game concept into account. That players need to play game without facing any difficulties will influence their motivation and attention during gameplay.

Motion-Controlled Interaction

In motion-controlled interactive game environments, players interact and control the game environment by touching any object in the game or showing bodily movements in a desired area in the game. Range of the movements in terms of high or low pace is not considered in motion-controlled interactive game environments.

Motion-controlled interface is one of the most efficient design techniques used in physically interactive game environments. The main principle here is to interact with game environment directly with physically bodily movements as an avatar of the game. Camera use that has a vital importance in physically interactive game environments is designed within the gameplay part. Because player needs to control and play the game in a camera screen, appropriately camera use gains importance during gameplay. Therefore, effective and efficient camera use should be provided to players in order to play game when motion-controlled interface is designed.

In motion-controlled interface designs, role of player and interaction between user and game interface have different characteristics when they are compared to classical computer games. Player directly effects game environment with physically bodily movements in a camera screen as an avatar of the game. Camera screen is not used to just control of the game, it is used as a gameplay part of the interface. In the present article, role of player, interaction between player and game interface, camera use and advantageous and disadvantageous of motion-controlled interface design techniques were discussed respectively.

Player is an avatar of the game effecting game environment directly with physically bodily movements in games basing on motion-controlled interface design. Player also makes physical movements by using a part of body or whole body actions in a camera screen in order to control the game. Interaction between player and game environment is occurred by a camera screen directly with touching objects which are the main element of the game. Important point here is to fix player's position during gameplay in the camera screen in order to control and play the game appropriately. Role of player shows big differences in terms of controlling and playing the game when it is compared to classical games. Besides, in motion-controlled game environments, player, as an avatar, has different mission in game with a new aspect of interaction. Therefore, these interface designs needs to be designed and developed properly for players so that they can control and play game environments easily and

make interaction with game objects to maintain gameplay with a high motivation and attention.

In game environments basing on motion-controlled interaction, player interacts with game environment directly by using a camera screen because of the aim of camera use that is not only to control the game but also to make a physical interaction with game objects. Unlike interaction type in classical games, this brings drastically change to the interaction type between player and game environment. Player, as either an avatar of the game or an important part of game environment, directly effects game environment with physically bodily movements in the camera screen where is in the gameplay part of the interface.

With the use of a camera screen, motion-controlled game environments have different characteristics on gameplay when they are compared to the classical games. Player's role is both controller and player of the game in a camera screen as well. Therefore, player's movements in camera screen are directly related to gameplay part because player is avatar of the game. Size and position in design of camera screen is very important during interface design in motion-controlled game environments. Because game is played in a camera screen and this effects players' gameplay directly with physical movements, camera screen and gameplay part of the game should be taken into consideration together.

In visual design, camera screen should be the main part of the interface that allows players to play game properly. Besides, player's control on navigation parts at the interface is important to play game easily. During gameplay, players are able to control game with the navigation parts without any difficulties. In motion-controlled game environments, camera-centered interface design should be preferred because of the importance of camera use and game parts surrounding the camera screen. Therefore, adaptation and integration of a camera screen, which is gameplay part of

motion-controlled game environments, within the game interface should be performed properly so that players can play the game in a camera screen easily.

There might be some advantageous of motion-controlled interface design because of its new characteristics in terms of role of player and interaction type like motion-driven interface design. In such designs, due to player is the main character of game, s/he interact game objects directly with bodily movements. Motion-controlled game environments make players dynamic and active by forcing them to make specific movements in a camera screen during game play. Players' motivation and attention in game should be very high in order to make specific desired movements and continue the gameplay. This makes players more active and more awake physically in game environment. Therefore, it might be claimed that such game environments might be very beneficial for making specific and detailed movements for players. Besides, one of the most prominent advantageous of motion-controlled game environments is that players immerse themselves into game because they are avatar of the game and they control game with physical bodily movements. Because camera screen is at the center part of the design, players' concentration on game will not be broken easily with high motivation and attention when it is compared to the motion-driven game environments.

On the other hand, one of the most well-known disadvantageous of motion-controlled game environments is that game interface design should be considered that camera screen should be designed at the center of the game with a camera-centered interface design because game is played in the camera screen. Here, place of a camera screen at the interface design should be determined basing on the game concept. Otherwise, players attempt to play game with a low motivation and attention because camera screen and gameplay part seen different part of the game. Therefore, adaptation of a camera screen is most important design principles in motion-controlled game environments so that players can play game properly.

Motion-controlled interface design is an effective design technique in physically interactive game environments. Like motion-driven interface design, these design environments bring a new perspective to the role of player and interaction type during gameplay. Because camera screen is very important for gameplay with a camera-centered interface design, adaptation and integration of camera screen within game environment should be taken into account clearly and properly. This effects players' motivation and attention during gameplay without breaking their concentration. Motion-controlled game environments might be preferred mostly to make players specific and detailed physical bodily movements.

4.1. PHASE 1 (Design Principles)

Concerning preliminary design principles of designing and developing physically interactive serious games, design principles of Educational Content, Visual Design, Camera Use and Interaction were defined. Preliminary design principles were determined basing on considerations of field experts and results of the previous studies focusing on characteristics of computer games and gameplay issues of computer games in the literature. Following design principles will be taken into account at the initial point of the process.

4.1.1 Educational Content

Educational content refers to educational part of games. Which instructional information, definitions or explanations will be given within the game is directly related to educational content. Children are supposed to get high benefits via interacting with educational content during gameplay sessions.

1) Educational content should be presented attractively considering children's age characteristics
2) Educational content should be embedded within game environment transparently

3) Feedbacks should be given to children with regard to their success or failure in game
4) Expected bodily movements should be explained clearly to help children to make bodily movements correctly
5) To attract children's attention and keep their motivation high, an appropriate story-based game concept should be determined

4.1.2 Visual Design

Visual design refers to any graphical interface and components of games. Which colors will be preferred, which type of navigations will be selected or size, position and placement of major game components such as gameplay screen and camera screen is directly related to visual design. In addition, sounds and animations will be considered in visual design.

1) Visual design should be attractive, simple, funny and usable for children
2) Camera-use in game should be stressed to help children to give importance to camera use for both control and gameplay
3) Visual and vocal components of game should be preferred considering children's age characteristics
4) Written texts, visual images, animations and sound effects should be preferred to increase educational benefits and playable characteristics of game
5) Navigation parts and other major game components should be designed and located considering children's age characteristics

4.1.3 Camera Use

Camera use refers to using camera during gameplay and placement and size of camera screen in game. Camera usage, size and placement are directly related to game concept and target audiences. They are all related to camera use and are needed to be determined clearly before designing and developing game.

1) Camera-use information such as camera-position, camera angle, and children's distance from camera should be instructed clearly
2) Camera-size should be determined considering game concept, children's age characteristics and educational content
3) Supporting visual images, animations, sound effects and written texts, simple and easily understandable camera-movements should be preferred for children
4) Effective and efficient camera-use should be provided to get high benefits from educational content
5) Navigations and major game components should be designed closely to each other to present children easily controllable game environment

4.1.4 Interaction

Interaction refers to any interaction patterns of children with either game interface or their friends. Interaction with educational content is also directly related to interaction. Because of innovative gameplay and interaction characteristics of physically interactive games, children are needed to guide clearly not only before starting the game, but also during gameplay sessions.

1) Interaction should be attractive for children to make them play game without getting bored
2) Children should be allowed to interact with gameplay part and educational content without having any difficulties and troubles via a camera-screen
3) Game concept should allow children to make an interaction with educational contents of both Mathematics and Physical Education jointly
4) Instructions should include directions about how to make bodily movements to play game, and what kind of bodily movements should be performed to control game objects

5) Interaction should be based on easily performable bodily movements in order not to distract children's attention and motivation in game

4.2. PHASE 2 (Development of Prototypes)

Under the light of the preliminary design principles, four different game concepts were determined taking scholar field experts' considerations into account. With the feedback of one Mathematics field expert and one Physical Education field expert, games were conceptualized considering both Mathematics and Physical Education. The most appropriate educational contents that might be embedded within physically interactive game environment effectively and efficiently were preferred. With determination of educational subjects of games and gameplay concepts, design phase was started.

After the determination of game concepts and preliminary designs, paper-based prototypes and computer-based prototypes were given to teachers and their feedbacks were analyzed in detail. Teachers played computer-based prototypes and paper-based prototypes were explained regarding educational content, interaction, camera use and visual design.

Two paper-based and two computer-based physically interactive game prototypes were designed and developed by taking scholar field experts' considerations into account. Concept of games, educational subjects and preliminary visual design were determined with scholar field experts about Mathematics and Physical Education.

4.2.1 First Game (EVEN vs. ODD)

Target: Educational goal of the "Even vs. Odd" game from Mathematical aspect was to make 6-9 year-old children practice on one and two digit numbers. For Physical Education, "basic movement knowledge and skills" like movement awareness and making specific movements with partial bodily movements were determined as main goals.

Following sub topics of natural numbers and learning goals of Mathematics from Board of Education and Discipline were considered during game design and development process;

a. Read numbers / be aware of numbers
b. Know even and odd natural numbers

Following sub topics of basic movement knowledge and skills and learning goals of Physical Education from Board of Education and Discipline were considered during game design and development process;

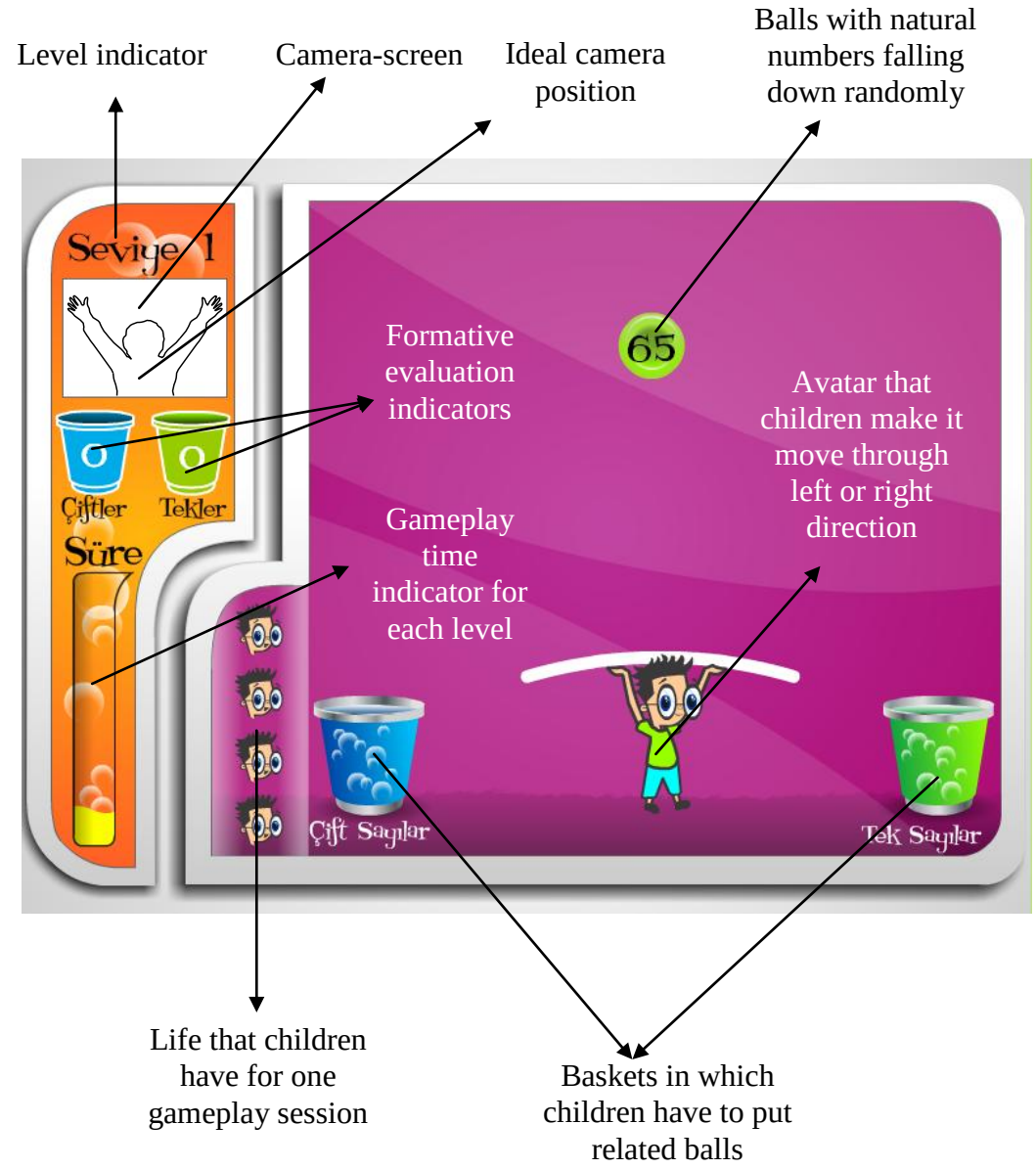
a. Development of body and space awareness during bodily movement
b. Perform rhythmic movements himself / with a parent / in a group / with an object / or without an object harmonically
c. Be aware of entertainment part of physical activities
d. Have self-confidence while performing physical activities

Mission: In the gameplay screen, even or odd numbers will fall down. Aim of the player is to put related/correct numbers into related basket. In order to put the numbers into correct basket, children have to make their avatar move to right or left side. Children also have to make movement or be static without making any movements in the camera screen to make avatar move right or left side. With these bodily movements, children maintain gameplay and remain dynamic while playing games with a strong self-control.

Scenario: Concerning the activities and interaction, making bodily movements and being static in camera screen in order to control avatar are two prominent requirements of game. The role of children is to take a decision about natural numbers which might be either even or odd while putting them in related basket.

Feedback: Immediate feedback as formative evaluation supported by sound effects and animations are presented to children. They get quick responses according to their actions. When children make a wrong decision about their selections on even and odd numbers, they find chance to realize their decision about whether it is correct or not. Besides, at the end of the game, a final evaluation as summative evaluation including total corrects in a given time is presented to make children get information about their gameplay results.

Figure 4. 1: Screenshot of Computer-Based Prototype



A computer-based prototype was designed and developed in order to get teachers' feedbacks. In the prototype, via a camera-screen, teachers were allowed to play the game and try the balls, which were falling down randomly, to put into correct baskets. At the beginning of the gameplay session, they were informed about camera-screen that it was only used to control gameplay part. They interacted with game indirectly by using camera-screen. Teachers also interacted with game

environment by using the avatar that is placed at the center of the gameplay screen. There were three levels in the game, and each level had approximately 1.5 minutes.

In addition, teachers were allowed to make their avatar to move through left or right directions according to even vs. odd issue of randomly given ball. There was a summative evaluation part that showed teachers' correct actions and increases when they put a number into correct basket. Totally, four lives were considered for a game session that when a ball touched at the bottom of the gameplay screen, player got lost a life in the game.

4.2.2 Second Game (DRIVE YOUR SHAPE)

Target: Educational goal of "Drive your Shape" game from Mathematical aspect was to make 6-9 year-old children practice on defining and classifying 2D and 3D geographical shapes. For Physical Education, "basic movement knowledge and skills" like movement awareness and making partially specific movements were determined as main goals.

Following sub topics of geometric shapes and learning goals of Mathematics from Board of Education and Discipline were considered during game design and development process;

- **a.** Know square, rectangle, triangle, circle, rectangle, square and triangle prisms.
- **b.** Geometric shapes such as define cube, prism, cylinder, cone and sphere among complicated shapes

Following sub topics of "basic movement knowledge and skills" and learning goals of Physical Education from Board of Education and Discipline were considered during game design and development process;

- **a.** Development body and space awareness during bodily movement

b. Perform rhythmic movements himself / with a parent / in a group / with an object / or without an object harmonically

c. Be aware of entertainment part of physical activities

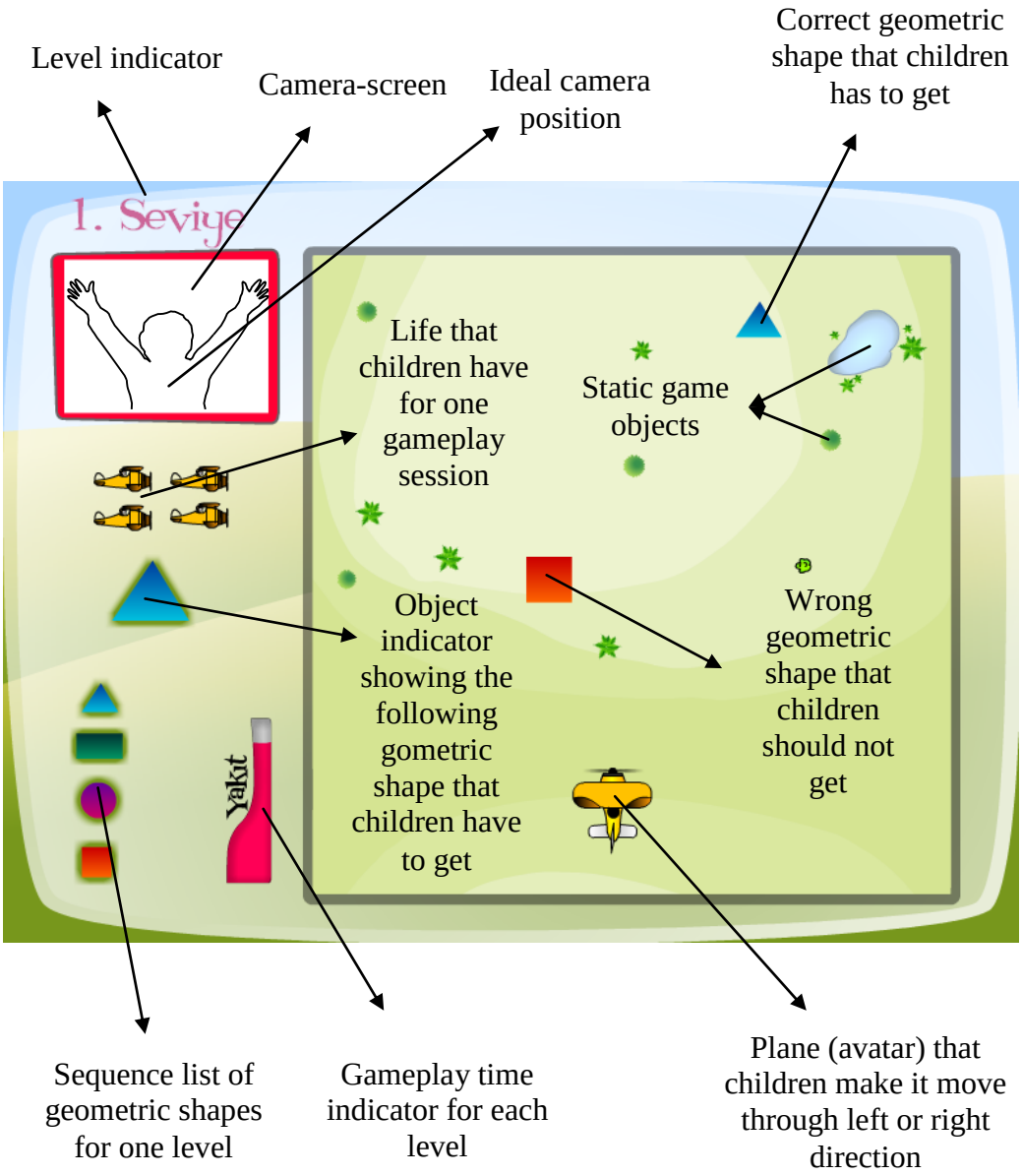
d. Have self-confidence while performing physical activities

Mission: Children collect expected geometric shapes among different objects and shapes. They try to drive a plane by using their bodily movements through the shape which is shown at the left side of the screen respectively to help children. Children use their arms to make the plane move through left or right direction. The aim is to collect geometric shapes as quick as possible.

Scenario: In terms of children's game performance concerning gameplay activities and their interactions with game, making partial bodily movements that are using left or right arms to move plane through left or right direction are main requirements of game. The role of children is to collect expected geometric shape among given different shapes and other game objects in a given time.

Feedback: Children get immediate feedback against their actions in game. When they try to collect unexpected or wrong geometric shape, a vocal feedback is presented to worn children. Besides, as a formative evaluation of game, by using animations and sound effects, children also realize when they don't try to collect wrong shape. At the end of the game, children see their overall performance of game. Total numbers of collected shapes and their names are presented in a written feedback table as summative evaluation.

Figure 4. 2: Screenshot of Paper-Based Prototype



A paper-based prototype was designed and developed in order to get teachers' feedbacks for the game. In the game, a sequence of geometric shapes was given to teachers and they were expected to collect correct shapes in a given order. Screenshots from the game and adequate explanations about how to play game, educational content and player-game interaction were explained to the teachers.

Besides, proper and correct camera use in terms of camera angle, camera position and players' distance from the camera were introduced to make them clear about the game.

There were three levels and each level has different geometric shapes with approximately 1.5 minute-gameplay session. Therefore, teachers' opinions, points of views, and suggestions were reported to design and develop more effective and efficient game. In order to increase educational potential of the game, teachers were also informed about educational content and they were expected to give sufficient feedback and clear information for the next design and development steps.

4.2.3 Third Game (SAVE THE NUMBERS)

Target: Educational goal of "Save the Numbers" game from Mathematical aspect was to make 6-9 year-old children practice on addition and subtraction on one and two digit numbers. For physical education, "basic movement knowledge and skills" like movement awareness and making specific movements with partial bodily movements from one point to another by focusing moving objects on screen were determined as main goals.

Following sub topics of addition and subtraction of natural numbers and learning goals of Mathematics from Board of Education and Discipline were considered during game design and development process;

- **a.** Know result of addition process of two different natural numbers and compare and analyze the results
- **b.** Solve and analyze calculation problems in terms of addition on natural numbers
- **c.** Subtract two different natural numbers in mind as quickly as possible
- **d.** Solve and analyze calculation problems in terms of both addition and subtraction on natural numbers

Following sub topics of “basic movement knowledge and skills” and learning goals of Physical Education from Board of Education and Discipline were considered during game design and development process;

a. Development body and space awareness during bodily movement
b. Be aware of body and space awareness, move on a place, make balance and control objects
c. Perform rhythmic movements himself / with a parent / in a group / with an object / or without an object harmonically
d. Be aware of entertainment part of physical activities
e. Have self-confidence while performing physical activities

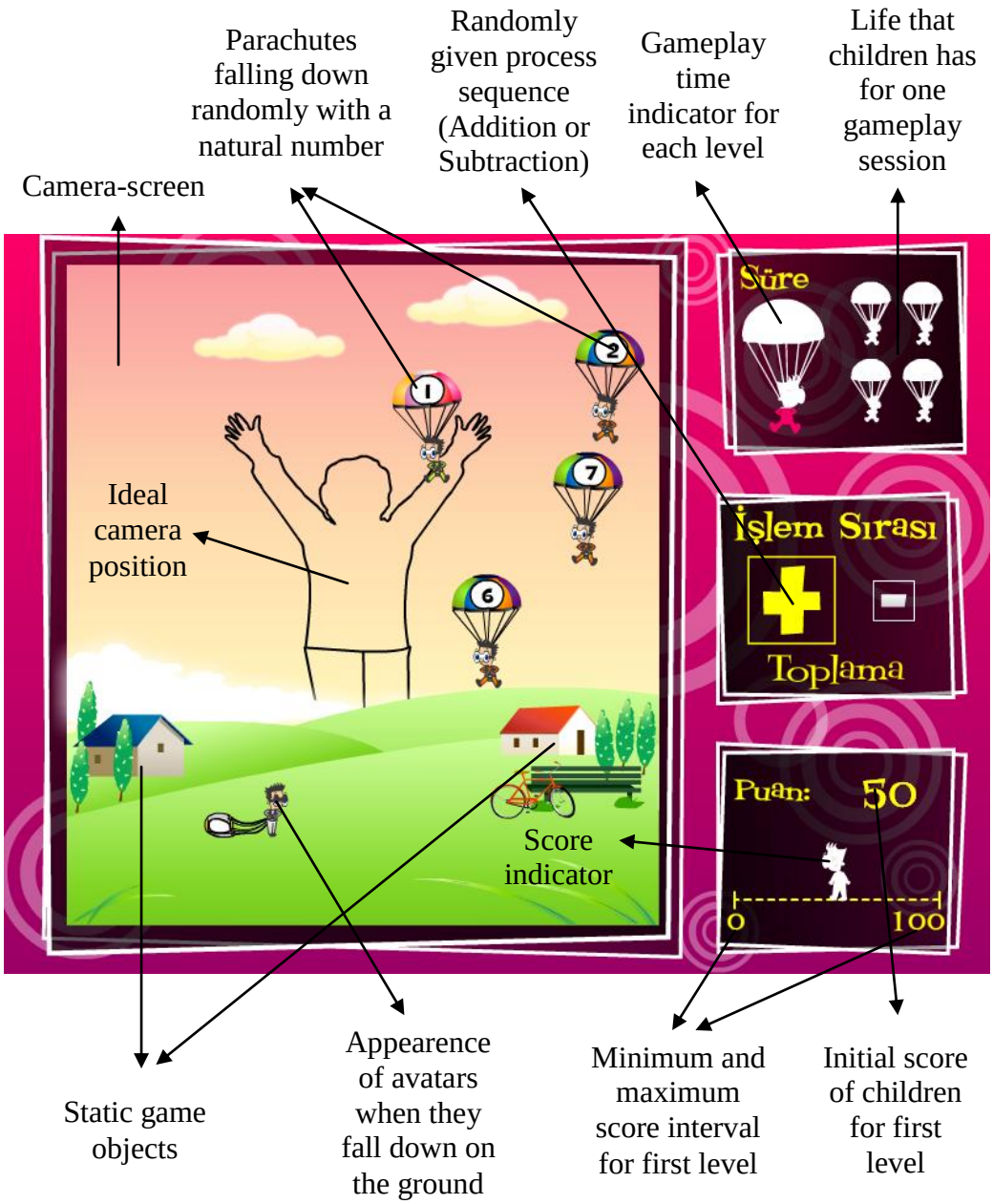
Mission: One or two digit numbers fall down randomly on parachutes. Children are expected to collect numbers according to process type that might be either addition or subtraction. Children get a starting score at the beginning of game and the purpose of players is to control score between numbers given in the game. Time limitation is a challenge that children need to be careful.

Scenario: Concerning gameplay activities and children’s interaction patterns, making partial bodily movements and entire bodily movements that are using left or right arms, stepping behind or forward or using entire body to collect natural numbers are main requirements for children to both control and play the game. The role of children is to collect given natural numbers according to process type and try to maintain gameplay.

Feedback: There is different feedback mechanism in game because of its game concepts and rules. Children are free to collect any natural numbers in gameplay screen. They are allowed to make any performance during gameplay. However, they have to control their initial score that are given at the beginning of the game.

Children have to make a decision about whether they should collect a given number or not. Therefore, feedback is presented by showing score in the game.

Figure 4. 3: Screenshot of Computer-Based Prototype



In order to get feedback from teachers as subject-matter experts, a computer-based prototype was designed and developed. In the prototype, there were parachutes falling down on the ground. Teachers had to collect natural numbers by taking randomly given process sequence into account. They had an initial score for each level and there was a maximum and minimum score interval that was different for each level. They needed to touch parachutes directly to increase or decrease their initial score to keep it between expected score interval.

There were three levels and each had approximately 1.5 minutes to play. All teachers had four lives and when their initial score were out of expected score interval, their lives were decreased. Teachers interacted via both game environment and educational content directly during the gameplay session. For their physically interaction, they were allowed to use their entire bodily movements or partial bodily movements.

4.2.4 Fourth Game (FIND THE NEXT)

Target: Educational goal of the Find the Next game from Mathematical aspect was to make 6-9 year-old children practice on pattern subject. For physical education, "basic movement knowledge and skills" like movement awareness and making specific movements with partial bodily movements such as arm, leg or head movements by focusing on a specific object on screen were determined as main goals.

Following sub topics of pattern and learning goals of Mathematics from Board of Education and Discipline were considered during game design and development process;

- **a.** Realize and find a relationship in a pattern
- **b.** Realize, find and complete a missed piece in a pattern

Following sub topics of “basic movement knowledge and skills” and learning goals of Physical Education from Board of Education and Discipline were considered during game design and development process;

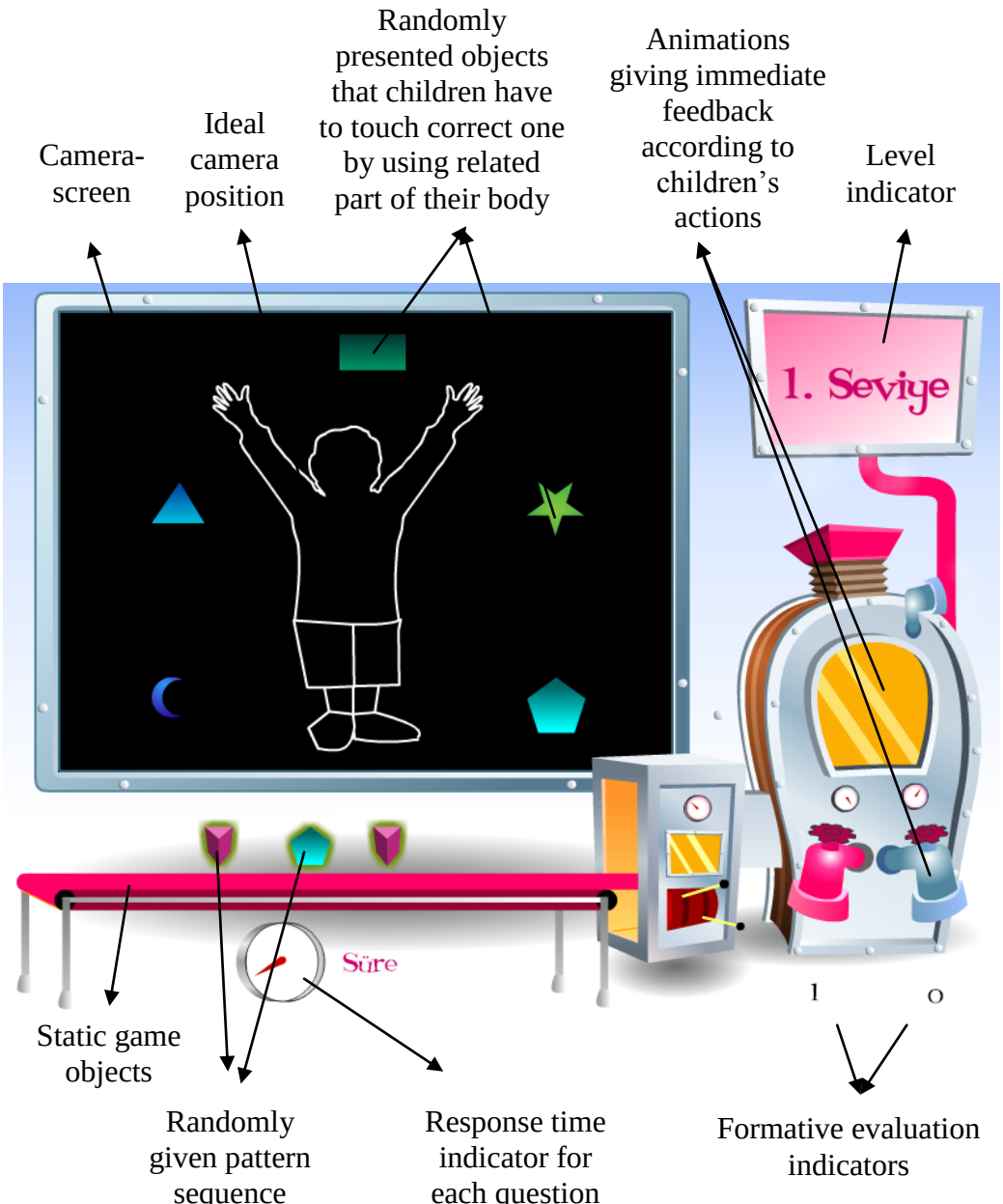
a. Development body and space awareness during bodily movement
b. Be aware of body and space awareness, move on a place, make balance and control objects
c. Perform rhythmic movements himself / with a parent / in a group / with an object / or without an object harmonically
d. Make specific movements of a desired part of body on expected levels
e. Control objects by making speed and force organization on his body
f. Make rhythmic movements on a desired sequence and expected levels
g. Be aware of entertainment part of physical activities
h. Have self-confidence while performing physical activities

Mission: In the game, children are expected to make some practice on pattern subject in Mathematics and partial bodily movements such as arm, leg or head in Physical Education. In the gameplay screen, there are objects where are placed at five different locations. Children are expected to find correct object that is related to a pattern sequence which is given in the game. Pattern sequences and locations of possible answers related to pattern sequences are selected randomly. Children are also expected to touch correct object by using their parts of body. By this way, children will make some practice on Mathematics and Physical Education simultaneously.

Scenario: Major gameplay requirements are making partially bodily movements that are using left and right arms, left and right legs and head to control and play the game. The role of children is to choose correct object in a given pattern sequence and touch it by making expected bodily movements.

Feedback: Immediate feedback as formative evaluation is very important for this game. Children need to get a quick response related to their performance. Therefore, when they make an action such as touching an object to make a selection for a given pattern sequence, they get an immediate feedback supported by sound effects and animations. Besides, at the end of the game, a total score is presented to children to make them realize their overall game performance.

Figure 4. 4: Screenshot of Paper-Based Prototype



Gameplay sessions were organized to get feedbacks from teachers related to designed game prototypes. A paper-based prototype were designed and developed for "Find the Next" game, and teachers were informed about the game during the gameplay session and interviews. In the game, a random pattern sequence was given at the bottom of the screen. Teachers had to make a choice among randomly given objects in the gameplay part by using related partial bodily movements. Totally 10 pattern sequences were directed with 30 second for each question.

In the game, teachers had to make a direct interaction with educational content by touching given objects. Supporting animations, sound effects and visual images, immediate feedbacks were given to teachers basing on their actions and performance in the game. They were informed about rules of game, pattern subjects and feedback issue, and their considerations concerning game components and educational content were noted. Besides, specifically Physical Education teachers were informed about expected bodily movements.

4.3. PHASE 3 (Teachers' Feedbacks for Game Prototypes in PHASE 2)

4.3.1 Educational Content

EVEN vs. ODD Game: Interviewed teachers all agreed that educational content in the game was appropriate to 6-9 year old children. Mathematics teachers stated that fall down speed of ball might be used to make the game more difficult in different levels. Physical Education teachers stated that by increasing fall down speed of balls, children's decision time about whether the ball is even or odd will be shorter, and they need to make more rhythmic and rapid bodily movements in following levels. Physical Education teachers mostly stressed that periodical feedback regarding children's posture in camera-screen about whether it is appropriate or not should be given during gameplay. They mostly emphasized appropriate camera use focusing on giving instructions and feedback about camera use in game. A Physical Education teacher stated that *"Instruction part should be given from the beginning of game to the end. Children always need to know accurate position in camera. An appropriate*

body in camera might appear periodically, and if children get lost their position, they might find chance to set their position again." (PE1)

When teachers played Even vs. Odd game, they mostly stressed that the game should be easy to play. Although ball speed is important factor regarding challenge of the game, children need to play the game easily to get expected acquisitions from the game. During the observation about teachers' gameplay, it was seen that they focused on educational part more than other parts of the games. Motivation is another issue that almost all teachers focused on. In order to motivate children effectively in game, more interactive game environment should be organized with a less camera-based control according to the teachers. To strengthen the interaction between children and game environment, children are able to control game via simple and easily understandable camera movements. Two of Mathematics teachers stated that both visual and vocal feedbacks might be enough to give information to children about whether their movements in game are correct or not. At the end of the game, how many correct actions, that are putting related number to correct basket that children performed might be showed to children for a self-summative evaluation.

Almost all teachers focused on directive instructions about partial bodily movements. Physical Education teachers, for instance, stated that to get maximum benefits from the game, children should be informed clearly about how to play game by using textual and visual instructions. Physical Education teachers stressed that effective camera use is crucial. Performing correct actions for Physical Education might affect children's performance on their Mathematics success because they cannot touch correct object properly with a wrong position in camera screen. A Physical Education teacher stated that "*Children might get lost their position while they are playing the game. For Mathematics, children cannot play the game if they couldn't touch objects in camera. Being in a correct position is related to getting expected benefits from the game." (PE1)*

DRIVE YOUR SHAPE Game: Teachers criticized this game prototype much more than other games. They had suspicious on game concept that couldn't present children to make practice in an enjoyable learning environment. Mathematics teachers stated that there should be an interesting and attractive story behind the game to draw children's attention. Only collecting geometric shapes in game environment might not be beneficial. A Mathematics teacher having similar critical points of views stated that "*Aim in the game is to make children practice on educational content which they were already taught in the school. But, only collecting geometric shapes might be boring for children because they have too many chances to find better funny games in Internet." (M2)*

Mathematics teachers generally argued that collecting geometric objects in game without having an aim cannot motivate children. They stressed that there should be a time limitation, and a route in terms of object collecting sequences during gameplay to make the game more playable and enjoyable. In order to overcome this problem, Mathematics teachers suggested that a limited number of geometric shapes might be presented to children to collect in given time. Children will try to collect shapes, in a given order, as quickly as possible. Mathematics teachers also suggested that geometric shapes might be presented from the easiest shape to the most difficult one. A Mathematics teacher stated that *"In the game, some barriers should be embedded to make it more enjoyable. Time limitation for each level might be a good solution. Children should not be allowed to collect any geometric shapes. There should be a collecting sequence in game as a rule and children have to obey this rule to play the game." (M2)*

Mathematics teachers had different opinions about giving names of the geometric shapes. Most of them stated that children should match given shape in the game environment and don't need to get written information during gameplay. It might be better to give a summative evaluation at the end of the game with written information

about names of geometric shapes. Most of the interviewed teachers (except one Mathematics teacher) stated that it is not necessary to give children written information about names of the geometric shapes while they are playing. The best way to present them is to give the names at the end of the game that might also be summary of game.

All Physical Education teachers stated that bodily movements that were determined for Physical Education is appropriate for children. They claimed that children might get expected learning benefits, if they only use their arms properly and correctly in camera-screen. A Physical Education teacher stated that *"In order to move the plane through left and right directions, children need to use either left or right arm. This is a basic movement and skill that we already use in Physical Education lessons. Expected movements are appropriate." (PE2)*

Another aspect that Mathematics teachers stressed that some of children, at this age, might not be able to read written text fast and clearly. Therefore, when they try to read names of geometric shapes, they might get lost their focus on gameplay part and educational content. Physical Education teachers stated that children might be forced to collect more geometric shapes for upper levels. Children need to make more rhythmic movements and basic movements and skills for each level.

SAVE THE NUMBERS Game: According to interviewed teachers, selected subject was mainly appropriate to children's level. A Mathematics teacher stated that "*Making children lots of practices on natural numbers without using paper and pencil might be beneficial. The game seems beneficial 6-9 year-old children because they need to make many practices." (M2)* Mathematics teachers stressed that most of children have negative attitudes toward Mathematics course, and don't like educational subjects in Mathematics. Thus they try to make the course much more enjoyable to teach subjects meaningfully. All Mathematics teachers agreed that

educational software targeting to make children practice on Mathematical subjects might be beneficial for elementary school students.

Mathematics teachers stated one and two digit numbers are enough to play game effectively for children at these ages. Three digit numbers might be difficult to make a calculation of addition and subtraction in mind. Challenge level in game might be determined by using numbers. Physical Education teachers gave more importance to physically interactive games because of their huge potential in subjects of Physical Education. They stated that the most important issue is that they might find chance to make children perform physical activities in scientific ways. During the interviews, Physical Education teachers mainly complained that children at this age don't like making physically movements for educational activities. They only want to play with balls. They all agreed that by using such software or games, they can help children to select a sportive branch according to their interest and talent at early ages.

All teachers agreed on that playing Save the Numbers game is very easy to play. It was observed that teachers all played the game easily. They only encountered difficulties regarding focusing on both navigation part, process part showing subtraction or addition and gameplay part. All teachers stated that a final evaluation for a summative evaluation in game might be beneficial. It is better for children to learn their performance in game according to teachers. This also increases children's motivation and keep them highly motivated during gameplay. A Mathematics teacher stated that "*A conclusion text like "Well Done, You Finished the Game!" might be used to inform children about whether they finish the game. Intervals for each level might be 0-100 for the first level, 20-80 for the second level and 40-60 for the third level."(M2)*

Most teachers believe that children might be motivated highly and might give much more attention to the game because they have chance to be avatar of the game. They stated that these games might have strong educational characteristics and power for

children because children have chance to interact with educational content directly by using their bodily movements.

FIND THE NEXT Game: Interviewed teachers all agreed that educational content in the game are appropriate for 6-9 year-old children. Making children practice on pattern subject might be effective for getting expected educational benefits. A Mathematics teacher stated that "*Activity-based instructions are very helpful. Pattern subject is appropriate for this game because children will find chance to make lots of practice about patterns." (M1)*

Mathematics teachers stated that difficulties might be determined by asking children to find missing part as quick as possible. Giving more limited time for each level might be appropriate to make the game more difficult. Mathematics teachers stressed that pattern subject is important for children to help them develop their intelligence and wisdom. To make children understand educational subject better, positive and negative reinforcements should be given by sound effects and animations according to Mathematics teachers. Children need to be aware of their answers about whether they are correct or incorrect. Therefore, in the game, immediate feedback with sound effects and animations should be given. Like Mathematics teachers, Physical Education teachers agreed that physical movements that children are expected to make is appropriate. Selected educational subject that is both about Mathematics and Physical Education is good choice to Physical Education teachers.

In terms of evaluation of children's performance in game, teachers agreed that immediate feedbacks about children's responses for a pattern sequence might be sufficient. They stated that children need to see results about whether they make a mistake or they choose correct subject for each pattern sequence. Total scores of corrects and mistakes might be given during gameplay. From Physical Education side, evaluation about children's performance is very difficult to understand. Physical Education teachers agreed that giving a clear and easily understandable

instruction about how to play game, how to use camera more effectively and rules of game might be given to overcome this problem.

All Physical Education teachers agreed that feedback related to children's actions in game might be more beneficial for Mathematics than Physical Education. Regarding evaluation of children's performance in the game, Physical Education teachers stated that they can infer when children reach a success in Mathematics; it might be claimed that children performed expected bodily movements correctly.

4.3.2 Visual Design

EVEN vs. ODD Game: All interviewed teachers stated that camera-screen seems that it is not primary part of the game, and this will help children to concentrate on gameplay part more. Most of the teachers stressed that camera screen should be backward of the gameplay part. This will help children to attend gameplay part more. A Mathematics teacher stated that "*It might be difficult for children to control two different parts of a game. Camera screen should be designed as a connected part of gameplay screen allowing children to control both of different part easily. Camera use should not be difficult and very far from gameplay part." (M1)*

In motion-driven games, children have to control both gameplay part and camera-screen. There need to be additional attention requirements than classical games. Besides, teachers mostly stressed avatar use in games controlling game environment with bodily movements. Controlling an avatar by using bodily movements might be enjoyable and interesting for children according to the teachers. This might increase their motivation and draw their attention during gameplay. Background music and sound effects were also mentioned and most of teachers stated that music and sound effects might be very motivational for children.

It is mostly stressed by teachers that navigation part and camera-screen should be designed closely in order to not to distract children's attention. A Mathematics

teacher stated that *"Camera and other parts of the game should be close to each other. In this game, information part is just under the camera. This will be helpful for children to control game easily because they should not only play the game, but also control other parts." (M3)*

All teachers stressed that game environment might be simple with a funny and usable game design. Otherwise, children's motivation might decrease and game might be boring. Color selection and animation is another important issue that teachers stressed. Colorful balls and baskets are needed to like by children according to teachers. Cartoon movies like animations and drawings with sounds might be very appropriate.

DRIVE YOUR SHAPE Game: Basing on visual design sketches and storyboards, almost all teachers stated that visual design of game seems appropriate for children. However, "Drive your Shape" game was the most revised game by teachers regarding game concept. A Mathematics teacher stated that "*Driving a plane via bodily movements might be attractive for children. In addition to geometric shapes, different enemy planes might be funny. A route on a map might be good to imagine that they follow a route on a map." (M1)*

Background music and sound effects should be suitable for not only children's age characteristics but also game concept and educational content according to teachers. They stressed that with an attractive sound selection, children might like to play game more. A Mathematics teacher stated that "*Effective sound effects might have direct impact on children's attitudes toward game. Sound effects, visual objects, and animations play deterministic role on attractiveness of a game." (M1)*

Simple and easily understandable navigation part helps children to control game effectively according to teachers. A Mathematics teacher stated that *"Children have to be careful about time, content, life and bodily movements in camera. All these*

issues should be harmonically designed to present children a usable game environment. They need to control time, geometric shapes and their position in camera simultaneously. The game should allow children to play easily without spending too much effort." (M2)

SAVE THE NUMBERS Game: Teachers agreed that children having these age characteristics mostly like to play 2D Flash games in Internet. Main design characteristics of games in Internet that children like to play should be examined to get information about their likes and dislikes. Teachers agreed that visual design characteristics of the present game should be similar to cartoon-movies. A Mathematics teacher stated that "*6-9 year-old children play games that have less complicated rules and design with cute and attractive characteristics. Design should have attractive so that children can play willingly." (M1)*

Teachers focused on simplicity and usability of game design. Physical Education teachers stated that visual design of game should be simple but attractive. It is not necessary to consider gender differences on visual design according to teachers, because there are little differences between boys and girls at these ages in terms of game design preferences. In motion-controlled interactive game environments, camera-screen is used to not only control the game but also play game by making direct interaction with game objects, and educational content. Therefore, in visual design, large size camera-screen might be better for children according to teachers.

FIND THE NEXT Game: All interviewed teachers stated that the game needs a big camera screen because children should be in a stable position in camera, and their entire body should be seen in the screen. A big camera screen should be placed in game to help children to focus on both visual design and educational part.

One Mathematics teacher stated that focus in design should be on educational part. They stressed that sequence objects and navigation parts should be located closely so

that children can easily control and play the game. A Mathematics teacher stated that *"It would be better to place pattern sequence below the camera-screen. By this way, children can control the game easily because it might be difficult for them to control different parts of game simultaneously." (M3)* For 6-9 year old children, avatar use is very important as teachers stressed, and computer games including avatars have more potential to draw children's attention and increase their motivation.

4.3.3 Camera Use

EVEN vs. ODD Game: Teachers mostly stressed that bodily movements that were expected from children should be very clear and easily understandable to focus on educational subject. A Mathematic teacher stated that *"Children might get lost their focus on game when they have to encounter difficult or complicated movements. They might get lost their self-control and this might decrease their attention or focus. When children are expected to make simple and easy movements, they will focus more on game and educational subject." (M3)*

All interviewed teachers stressed effective and efficient camera use to get expected learning benefits. Physical Education teachers frequently stressed that children might get lost their correct position in the game. They stated that camera use should be very easy, understandable and clearly informed before they started to play. A Physical Education teacher stated that "*It is inevitable that children will get lost their initial position that they should keep during gameplay, because camera screen is apart from gameplay part in the design. Exact position, angle and distance should be clearly declared before the game so that children can keep their ideal position." (PE2)*

When teachers played the game, they had difficulties regarding using camera to control the game. They mostly disappeared in the camera screen when they concentrate on the gameplay part. They realized their wrong position when they couldn't control the game. Because of teachers' low performance in the game, they

mostly focused on using camera screen properly. It was hard for them to manage different parts of games at the same time. They needed a guide to show them their exact camera position while they are playing the game.

All teachers stated that adequate explanations about camera use should be given to children before they start. A Physical Education teacher stated *"These games need effective camera use to play properly. This obstacle can be easily managed by giving clear instructions at the beginning of game. In addition to written text information, visual explanations will be very helpful for children to understand how to use camera-screen." (PE1)*

When children have trouble to control game by using camera-screen, they might forget educational part of game, or they might get lost their concentration. Children should be provided prerequisites to play game correctly. Otherwise, they will give up playing the game and will never try to play. A Mathematics teacher stated that "*For both Mathematics and Physical Education, we have to inform children about rules, how to play, and educational benefits. Otherwise, it is very easy to give up the game and try to play another one. To make them feel confident, children should take adequate instructions before they start to play." (M3)*

Teachers all agreed that children's motivation might absolutely decrease after they get lost their control in game. Complicated camera-use might distract their concentration on the game. It was figured out during the interviews that instructions about correct and proper camera use should be given to children not only at the beginning of game, but also during gameplay, because children might need to fix their position in camera-screen. A visual image should be appeared on camera-screen to allow children to check their position. All teachers agreed that this will be very helpful for children.

DRIVE YOUR SHAPE Game: Teachers frequently stressed that camera use play very important role in this game because children will use to control the game. Especially Physical Education teachers emphasized that watching a role-model to perform an action is one of the best ways to understand well for 6-9 year old children. All teachers have similar opinions that clear and understandable instructions about children's effective camera use should be given through multiple sources together like animation, text, sound etc. They stated that instructions about camera use should also be given at two different part of game, which are respectively at the beginning of game and during game as a feedback appearing periodically. According to the teachers, children's bodily movements, which are left arm to move plane through left directions and right arm to move plane through right directions, play critical role on keeping gameplay or giving up playing.

Physical Education teachers focused on children's possible mistakes that might be occurred during gameplay. They stated that children are highly expected to make lots of mistakes in terms of effective and correct camera use. In this game, children might get lost their initial position in game and need to be informed about ideal camera position periodically according to teachers. Almost all teachers agreed that game design in motion-driven interactive games doesn't need to have a big or large camera-screen part in game. The most important issue in the game that all teachers stressed was effective camera use to control and play game. All teachers had concerns about children's correct camera use. For instance, teachers stressed that troubles or problems on camera use in game cause giving up playing or keeping to play game with very low attention and motivation.

Mathematics teachers stated that when children don't like playing a game, they might have a tendency to give up playing toward that game. They stated that the key point here is to present children a highly controllable and confident game environment with specified bodily movements in camera-screen. From educational side, main issue to make children concentrate on educational content is to present them easily

controllable game environment. Teachers believe that problems or difficulties on proper camera use impact on children's success on expected learning benefits. A Physical Education teacher stated that "*Children's achievement in game directly depends on effective camera use. When they have troubles in making bodily movements correctly, it is difficult to concentrate on the content for children. This influences children's success on both Physical Education and Mathematics." (PE2)*

SAVE THE NUMBERS Game: All Physical Education and Mathematics teachers stressed that camera shouldn't bring extra difficulties or complexities for children to play game. Physical Education teachers mostly stated importance of camera use from Physical Education side. A Physical Education teacher stated that "*The most important point is proper camera use for Physical Education. Children are supposed to use camera properly to make bodily movements. Clues about exact positions in camera will be helpful for children to make them set their position." (PE2)*

It was very easy for teachers to play the game. It was observed that teachers easily set their exact camera position while they are playing because camera screen and gameplay part were at the same part of the game. The game was very funny and enjoyable for teachers. Physical Education teachers had concerns about wrong or unexpected camera use during gameplay. They stated that children will most likely get lost their correct position in camera screen under the excitement of gameplay. They will absolutely need to know ideal camera positions in terms of distance from camera and physical movements that they need to make. Physical Education teachers stated that in this game, it is better for children to use their all body instead of part of body so that they can make bodily movements for Physical Education effectively. A Physical Education teacher stated that "*It might be beneficial for children to use their all body to be aware of body and space usage by walking backward and forward or moving through left or right directions in the game." (PE1)*

Like Physical Education teachers, Mathematics teachers agreed that instructions about effective camera use should be presented to children. Teachers believed that in order to make a game more educational and increase its power in terms of educational benefits and purposes, clear instructions about how to play and aims of game should be presented in an effective way.

FIND THE NEXT Game: Teachers all agreed that effective camera use should be provided for children to give them playable game environment. They stated that camera size is appropriate. Camera might be placed at the center of the game because children will play the game in this screen and need to use their entire body.

Almost all teachers stressed that it is very important to inform children because this might affect their performance in the game. When a physical bodily movement is required, camera gains importance to play properly. Like mouse and keyboard control in games, children need to know correct camera use and physically movements in physically interactive games. Physical Education teachers stressed that correct camera use is directly related to children's educational success.

Physical Education teachers stated that it might be helpful for children to locate instructions and clear directions about physical bodily movements. They believed that these instructions might increase their performance and academic success in the game. A Physical Education teacher stated that *"Children are expected to make certain bodily movements for Physical Education. They need to use their arms, legs or head according to location of correct shapes. Ideal camera position, distance from camera and camera angle should be determined and children should be informed about these effective camera use indicators." (PE2)*

Like Physical Education teachers, Mathematics teachers focused on effective camera use because children make selection for correct pattern object by using their some part of body. Correct camera use have impact on children's success and performance

on Mathematics. Mathematics teachers all believed that children's success on Mathematics is directly related to their effective camera use. Children need to touch correct object in game according to given pattern sequence and when they are not able to make correct choice easily in camera screen, they cannot perform the game properly.

4.3.4 Interaction

EVEN vs. ODD Game: Children need to interact with game environment by using camera-screen indirectly in the game. Especially, by using bodily movements, avatar in the gameplay move through left or right directions and making avatar move through such directions might be enjoyable. Children might have different way of experiences on avatar use in the game. Game with an attractive avatar use might be very interesting and enjoyable for children because of its different interaction type, camera use and avatar movements.

Physical Education teachers frequently stressed that the easiest way to overcome control problem is giving clear instruction before and during the game. A Physical Education teacher stated that "*Because camera is used for interaction, it should be controlled that children might perform unexpected movements in the camera. Clear instructions and feedbacks will be very helpful." (PE2)* Most of teachers agreed that camera use should be emphasized that interaction can be only performed by using camera-screen in order to both control game components and keep playing. Especially Physical Education teachers give much more importance to effective camera use and one of them stated that "*Children will use the camera at one part of the game and play at another part. This means that children should divide their attention into two different parts. They need to spend too much effort to play the game. They should use camera via easily bodily movements." (PE1)*

All teachers stressed that children should spend more effort to play the game correctly. They had concern about indirect interaction way that children might get

lost their focus on gameplay part and educational content. They stated that educational part in motion-driven games should be apparently emphasized in game environment so that children can easily focus on educational content.

DRIVE YOUR SHAPE Game: Most teachers stressed that role of camera-screen should be connector or bridge between children and gameplay part. Any problematic situations about camera use might influence all gameplay actions such as concentration on games, getting expected learning benefits, playing games with a high attention and motivation etc.

Interviewed teachers all agreed that children might get maximum benefits from this game with a properly constructed interaction. Clearly informed children might play the game willingly and properly than children who don't have enough information about interaction and how to play. Mathematics teachers had concerns about interaction way of motion-driven interactive games. They stated that children should reach educational content easily after they start a correct relationship with camera-screen. A Mathematics teacher stated that "*With this type of interaction, educational content might be difficult to reach. Children need to focus on camera and making only bodily movements. They might forget content and get lost concentration on educational part." (M1)*

Teachers especially stressed that complicated bodily movements might cause getting lost self-confidence and self-control. They agreed that when children encounter any difficulties about controlling game, they give up the game immediately. Mathematics teachers stated that the more easily understandable camera movement children need to perform, the more learning benefits they acquired from the game. Teachers also believed that complicated or difficult camera movements will reduce children's motivation and distract their attention. When the game requires complex camera movements for children, playable rates of game will decrease drastically.

According to teachers, loosing self-control in a game causes negative attitudes toward the game with a low level of attention, motivation and self-confidence. A Mathematics teacher stated that "*Children need to play game without having any difficulties so that they can easily concentrate on educational content and try to learn something from the game. Otherwise, the game will be torture for them." (M3)*

SAVE THE NUMBERS Game: Physical interactive games bring a new face of interaction between player and game interface. During the interviews, all Physical Education and Mathematics teachers frequently focused on this innovative game experiences. Teachers stressed that physically interactive games make children dynamic and immersive.

Mathematics teachers stated that when they offer educational software related to Mathematics, children frequently prefer to change games or activities in circumstances in which they encounter some difficulties or troubles. Teachers stated that when either children don't understand how to play or they don't like characteristics of game, they attempt to change it speedily. Physical Education teachers all believed that children interact with game easily because not only concept of game is clear, but also interaction types that children need to make are designed easily. They stated that children might like this type of games too much because present game makes them dynamic and highly motivated during gameplay.

Mathematics teacher specifically stressed complexity of game that game should be simple and don't include complex characteristics that bring barriers for children. A Mathematics teacher stated that "*Game should be designed with simple rules and bodily movements. By this way, children will not get lost their control and focus. Complex games become frightening for especially 6-9 year-old children when they don't understand how to play." (M2)*

Mathematics teacher agreed that easy and correct interaction between children and educational content make them reach educational content efficiently and get expected educational benefits. With motion-controlled interactive game environments, children play games as main character or avatar. During the interviews, almost all teachers stressed this issue and they all agreed that this type of interaction might give a good experience for 6-9 year-old children.

FIND THE NEXT Game: Teachers frequently stated that children's interaction with game environment and embedded educational content should be identified and designed clearly. A Physical Education teacher stated that "*Children should be allowed to interact with game easily without encountering any difficulties. Especially, for 6-9 year old children, clearly provided interaction makes children play the game willingly without getting bored." (PE1)*

Almost all teachers focused on possible problems that children might encounter because of innovative interaction characteristics of motion-controlled interactive games. Children might have problems or troubles about playing games because they don't have any experiences on playing such games before. Considering importance of correct bodily movements, Physical Education teachers stated that because these games might be the first to play for most, how to play and how to make interaction questions should be answered clearly.

Although children at these ages like to learn how to play by making mistakes, all teachers stressed that boredom level of children at 6-9 ages are being very low to maintain making an activity. Children's motivation and attention might be easily decrease by lots of external and internal factors such as lack of entertainment parts of games, difficult control to play or game environment that is hard to make an interaction. To present children both enjoyable and educational game environment and allow them to get an educational benefit, these external and internal factors should be taken into consideration seriously according to the teachers.

4.3.5 Development of Games - Version 1

EVEN vs. ODD Game: Computer-based prototype was modified basing on both Mathematics and Physical Education teachers' feedbacks. Modified game is given in the Figure 4.5. New integrated features and modified parts of the game were identified below;

- Periodically given feedback about children's characteristics,
- Appropriate instructions about camera use,
- Understandable and clear information about camera use,
- Instructions about correct camera use during gameplay,
- Background music and sound effects,
- Visual and vocal feedback about children's performance,
- Summative evaluation about children's correct actions,
- Textual and visual instructions about how to play,
- Closely located camera-screen to gameplay part,
- Closely located camera-screen to navigation part,
- Colorful balls, baskets, cartoon movies like animations and drawings.

Figure 4.5: Screenshots of Even vs. Odd game

DRIVE YOUR SHAPE Game: After getting revise of paper-based prototype of the game from teachers, computer-based prototype was developed basing on both Mathematics and Physical Education teachers' feedbacks. Modified game is given in the Figure 4.6. New integrated features and modified parts of the game were identified below;

- Only collecting ball without a target was useless and aimless,
- A story need behind the game,
- Time limitation, a route of object collection sequences,
- Different enemy planes, barriers in the gameplay screen and a route on a map,
- Limited number of geometric shapes to collect in given time,
- Geometric shapes that should be collected from easiest shape to the most difficult,
- Summative evaluation at the end of the game with written information about the names of geometric shapes,
- Increased number of shapes throughout following levels,
- Background music and sound effects regarding plane crash, shape collecting etc.,
- Easily understandable navigation part to control game effectively,

- Effective camera use explanation via combination of animation, text and sound effects,
- Small camera screen that is close to the gameplay and navigation parts,
- Well-defined instructions about how to play the game before the game is started.

Figure 4.6: Screenshots of Drive Your Shape game

SAVE THE NUMBERS Game: Computer-based prototype was modified basing on both Mathematics and Physical Education teachers' feedbacks. Modified game is given in the Figure 4.7. New integrated features and modified parts of the game were identified below;

- Only one and two digit numbers (Three digit numbers were not preferred),
- Summative evaluation as a final evaluation according to children's performance,

- Conclusion text like “Well Done, You Finished the Game!”,
- Intervals between 0-100 for the first level, 20-80 for the second level and 40-60 for the third level,
- Visual design characteristics similar to cartoon movies,
- Comic sound effects and background music,
- Large camera size in the gameplay part,
- Clues about exact camera position in camera screen during gameplay,
- Full bodily interaction between children and game objects,
- Encourage of body movement and space usage by walking backward and forward or moving through left or right directions in the game,
- Clear instructions about how to play the game.

Figure 4.7: Screenshots of Save the Numbers game

FIND THE NEXT Game: After getting revise of paper-based prototype of the game from teachers, computer-based prototype was developed basing on both Mathematics and Physical Education teachers' feedbacks. Modified game is given in the Figure 4.8. New integrated features and modified parts of the game were identified below;

- 20 questions for each level,
- Time decrease (more limited time) for each question throughout levels as challenge of the game,
- Positive and negative reinforcements via sound effects and animations about children's performance,
- Immediate feedbacks regarding children's correct and wrong answers,
- Total scores of corrects and mistakes of children,
- Big camera size requirements to play the game effectively,
- Entire body appearance requirements during gameplay,
- Importance of avatar use to increase children's motivation and attention,
- Camera screen located at the center of the game to focus children on gameplay,
- Adequate information about ideal camera position, distance from camera and camera angle.

Figure 4.8: Screenshots of Find the Next game

4.4. PHASE 4 (Designing Second Version of Games - Children's Feedbacks)

4.4.1 Educational Content

EVEN vs. ODD Game: It was figured out that almost all children had no experiences on playing physically interactive games. Only two children played Nintendo Wii games before. Children stated that present game might be beneficial to make practices about even and odd numbers. In the game, children need to make correct bodily movements to finish with a high score. 7 of them stated that they make similar bodily activities and movements in Physical Education course. A boy stated that "*I spent many hours to play games in Internet. My fingers are being in pain because of pressing keyboard. But in this game, I do not only play the game, but also make bodily movements without using my fingers." (CM3)*

Figure 4.9: A Gameplay Session

All children stated that gameplay life is appropriate. Concerning level concept and duration of each level, most children (n=8) agree that it would be better if the game has several levels but three levels are appropriate. One of the girls stated that "*Having four chances to finish the game is appropriate for me. I would prefer several levels in this game. But this time, we can be tired to make many movements. Thus, three levels seem appropriate with faster ball speed." (CF1)*

During the gameplay session, it was observed that sometimes children had difficulties to focus on educational part while they were trying to set their position in camera screen. Concerning educational content, when they saw a number that were falling down, first, they tried to find whether it was even or odd. Afterwards, children tried to put the number into the correct basket.

All boys and one girl stated that the game is a little easy for them. However, they believed that making bodily movements was making the game harder. Especially boys confessed that they wouldn't play this game if the game wouldn't include physically interactive gameplay characteristics. One of the boys stated that "*Bodily*

movements make the game very attractive. Honestly, I don't want to play this game when I control it via keyboard and mouse. Making movements make me play the game, because it is entertaining." (CM5)

DRIVE YOUR SHAPE Game: Children all agreed that Mathematics is one of the most appropriate courses that can be embedded within a game environment. They stated that most of the educational games they played are related to Mathematics. When children were asked about educational content and its appropriateness, they all stated that collecting geometric shapes in an order and seeing their names were beneficial. Children stated that the present game is beneficial about making practices on geometric shapes. They stressed that the game might help to remember names of geometric shapes easily. Some of the children stated that they had trouble with especially 3D geometric shapes. Children can find chance to reinforce their knowledge about geometric shapes.

Figure 4.10: A Gameplay Session

Concerning educational content about Physical Education, children stated that making hand and arm movements are easily manageable. They make similar

practices in Physical Education course. They all stated that integrated educational contents are very appropriate for this game. A boy stated that "*Geometric shapes and movements are appropriately fitted. I surprised that I could control the game via movements. Making physical movements to play the game, I could make practices on geometric shapes and I could be active." (CM3)*

Children liked to see geometric shapes in the game. When they saw a geometric shape at the left part of the game, they stated the name of the shape. For instance, when they saw a rectangle, they talked loudly that "Now, I need to find a rectangle!". Similarly, in the gameplay part, there were different geometric shapes that children were not supposed to collect. When they saw a geometric shape in the gameplay part, they talked like "Go out Square!" or "I don't want to collect you Circle!".

In physically interactive games, players need to use their bodily movements during gameplay. They need to be active in these games. When children were asked about duration and gameplay issues, they mostly focused on bodily movement requirements. A girl stated that "*Gameplay life is enough to pass through the levels. Three levels are also appropriate. I had to spend effort to finish the game. I needed to make movement to control the plane. If the game lasted longer, I could be tired and might start to get bored." (CF1)*

Children all stated that control is appropriate for them to collect the geometric shapes. They use their arms to make the plane move through right or left direction. To play the game properly, children need to make appropriate bodily movements and use their arms properly. However, especially girls suffered during gameplay while they were supposed to use their arms harmonically to make the plane move through right or left directions. All children agreed that game didn't have difficulties about geometric shapes and bodily movements. A boy stated that "*Game was not difficult. I used my arms to drive the plane. I can play more than three levels but girls might not*

play. They might be tired. But game should be more difficult in level 2 or 3 with more enemies or less fuel etc." (CM2)

SAVE THE NUMBERS Game: Children stressed that there are lots of Mathematics games related to calculations and most of them are boring. Presentations of educational content in Save the Numbers game were liked by all children. A boy stated that *"I played some educational games before and I got bored when I was playing. In this game, there were numbers falling down. I needed to calculate the results in my mind and gave my decision. I could touch the numbers. It was very fantastic." (CM2)*

In terms of Physical education, children were free to make bodily movements in the game. They need to make practice on space awareness and making free bodily movements. A boy stated that "*Making free movements in the game was enjoyable. I liked to make free bodily movements. I could use all parts of my body. I could step forward, step behind or walk through left or right direction." (CM3)*

Figure 4.11: A Gameplay Session

Almost all children stressed that duration of the game might be longer than the current one. Because they enjoyed the game very much, they asked to have a long gameplay time. A boy stated that "*I liked this game most but each level might be longer. It was too funny. I didn't ask to finish quickly. I just wanted to play long gameplay time for each level." (CM1)*

Some children had difficulties to calculate numbers in mind. It was observed that there were difference between boys and girls in terms of giving reactions when they encountered difficulties in calculating one digit numbers. For instance, when a boy had difficulties regarding adding one digit numbers to two digit numbers or subtracting one digit numbers from two digit numbers, he gave up calculating in mind and just touched the numbers. Afterwards, he watched the results of his action in score part. However, when a girl had difficulties regarding adding one digit numbers to two digit numbers or subtracting one digit numbers from to digit numbers, she tried to calculate without touching any numbers in the gameplay screen.

Concerning difficulties of the game and challenge issues, children stated that playing the game was easy. All children agreed that speed of the parachutes falling down might increase more in the following levels. A girl stated that "*Passing throughout the levels, I thought that speed of falling down parachutes was increasing slowly. For instance, in the final level, parachutes speed should be very fast." (CF5)*

FIND THE NEXT Game: Children were asked about appropriateness of educational content. All children stated that they make similar activities and practices. When children encountered the game, they easily adapted and learn to how to play. Children stated that playing this game might be very beneficial in terms of understanding pattern subjects properly. The game brings strict rules for Physical Education. Children need to be stable in the gameplay screen, and move their correct parts of body to touch correct objects. Children were expected to make precise

movements to play the game. A boy stated "*Being stable in the game to make practice was a bit hard. I was expected to touch correct shapes with my hands, feet or head." (CM2)*

Children all agreed that 20 questions are appropriate for each level. A girl stated that "*Before the game, I needed to fix myself in the camera. It was very easy to play. But, given time for each pattern question was too long. Time should be shorter for following levels. 20 questions were appropriate for each level." (CF1)*

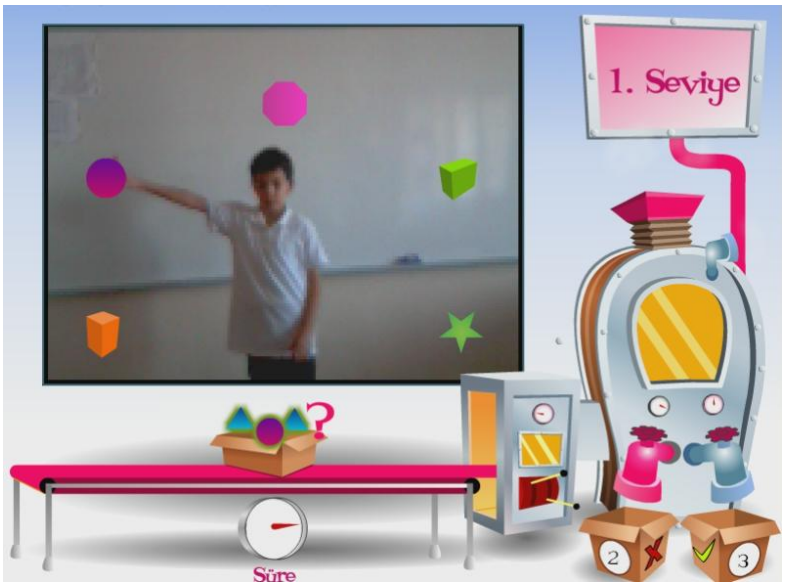


Figure 4.12: A Gameplay Session

Different geometric shapes are shuffled around the children for each question and children were expected to touch correct shape with their part of body. Girls concerned that they might touch wrong shapes accidentally while they are trying to touch correct shape. A girl stated that "*The one thing that I was disturbed was my space. I needed to have more area to fix myself because I might touch other shapes by mistake. If I could have more area in the screen, I wouldn't make any mistake accidentally." (CF3)*

When children played the game, they first had difficulties in finding the answers in given pattern. They needed to guide during gameplay. Unlike boys, girl had difficulties to touch correct answer by using their head. It was observed that they didn't like using their head to play the game. After they jumped to try the object that was above their head, they tried to preen themselves. Therefore, they sometimes missed the following questions in the game.

4.4.2 Visual Design

EVEN vs. ODD Game: One of the mostly liked characteristics of developed games was their visual design features. All of the children stressed that they liked visual objects in the Even vs. Odd game. Specifically, they liked avatar and navigation parts. A girl stated that "*I liked the character. Baskets and balls seem very nice. I didn't encounter any problems related to controlling the game." (CF2)*

Most of the children (n=7) agreed that size of gameplay part is enough for them to play the game and control the objects. Some of the children (3 girls) stated that camera screen could be a little bigger. Children having bigger camera screen stressed that they ask to see themselves in the camera clearly while playing. Another girl stated that "*I would prefer bigger camera. I liked to see myself in the camera in the game. I needed a bigger camera screen to understand whether I was making correct bodily movements. I could easily check myself with a big camera." (CF1)*

In the game, when the avatar walked through left or right direction basing on children's movement in the camera, it was observed that some boys walked through like or right direction in the classroom like the avatar. Because of this reason, they needed to set their position in the camera. They thought that when they walk through right or left, avatar in the game will walk through the same direction.

All children stated that walking animations of avatar that moves through left and right directions is very funny. They all agreed that there is no part in the game that

disturbs them while they were playing. Children were informed by visual and textual information about how to play the game. Because physically interactive games have different gameplay rules, children need to be informed in detail. Especially, concerning Physical Education, children need to be informed about expected bodily movements. One of the girls stated that "*I understood how to play the game before I started. It was a good idea to show with animations by using human-like character. I made similar movements that the character showed." (CM4)*

DRIVE YOUR SHAPE Game: Although plane is the main character and there is no war-based theme or shooting issues in the present game, both boys and girls stated that they liked to control the plane. Children liked visual theme of the game. They stated that size of gameplay area and place of navigations are easily controllable. They didn't suffer to play in the game because they saw easily expected shape and game duration for each level. A girl stated that "*Gameplay, camera and information parts were close to each other. This helped me to control the game easily. Seeing next objects was important because I was expected to drive the plane through those shapes." (CF4)*

While children are driving the plane by making correct and expected partial bodily movements, they need to check the game duration, life, and shape order. Like Even vs. Odd game, camera screen is used only to control the objects or characters. It is not necessary to place big or large camera screen in the game. Children asked to see themselves in camera easily and in detail. Some of the children commented that big camera screen is always enjoyable for them. All girls stressed that being in camera was very funny but camera screen should be made bigger.

All children stated that background music and sound effects were cute. Animations of plane when it is being destroyed or bombed were drew children attention too much. They liked visual and vocal reinforcement in the game. A girl stated that "*Animations of plane when it is bombed was good but might be more. When the*

plane crashed, when I collected wrong or right geometric shape and when I got fuel, I heard a sound. It was funny." (CF5)

Children needed to use their right or left hands to control the game. In the gameplay session, it was observed that especially girls had difficulties in using their hands because they were tired physically. They started the game with a high performance physically, but during the gameplay, their performances were decreased gradually. However, boys liked the game more than girls and their performances were stable in the game. They didn't show any exhaustion in the game. Therefore, duration of games that requires bodily efforts in physically interactive educational games should be taken into account considering children's age and physical characteristics.

SAVE THE NUMBERS Game: All motion-driven and motion-controlled physically interactive educational games have cartoon like drawings to attract children's attention. All children stressed that visual design were liked. 6-9 year-old children like watching cartoon-movies on TV and most of them are becoming a fan of one of famous cartoon-characters. Basing on interview results, it might be concluded that similar drawings to cartoon themes drew children's attention. Gameplay, game rules and concept of the game were the most favorable among the children. Most of the children frequently stressed that they enjoyed playing Save the Numbers game. All children stressed that they never got bored because the game was very enjoyable.

Children had a big camera screen to see themselves clearly while they were playing. This type of characteristics was also liked by children. A boy stated that "*I could see myself easily because there was big camera in the game. I didn't need to control camera and gameplay part at the same time." (CM4)* Almost all children stated that these types of games are much more easily controllable than motion-driven games because they don't need to control camera screen separately from the gameplay part. A girl stated that "*I liked playing this game much more than other games. It was very*

easy to play. I didn't need to control myself in camera. Sometimes, this might be difficult. I could lose my appearance but in this game, it was very easy to fix myself." (CF3)

It was observed during the gameplay of children that they liked watching walking characters or animations. In the game, when a parachute reached the ground, avatar started to walk through either right side or left side. When children saw more than one avatar walking through left or right side, they liked watching these walking avatars. Therefore, they sometimes missed new falling down parachutes in the game. Children stated that they liked animations, sound effects and background music. They liked characters and their movements in the game. Falling down with a parachute and walking through left or right directions were enjoyable. Children stated that how to play part in the game was very beneficial and helpful for them, especially for making correct movements for Physical Education course. They found chance to watch a character while that character was playing the game. They tried to make similar bodily movements while they were playing the game.

FIND THE NEXT Game: It was figured out that motion-controlled games were much more easily playable and favorable among the all physically interactive games. A boy stated that "*Questions asked orderly were very close to the game part. This was helpful to control the game because it was being easy to match the objects and find the last shape among the given pattern order." (CM1)*

Pattern sequences were presented in a box in the game. Children were expected to solve twenty different puzzles in a given time for each level. However, most of the children stressed that pattern objects might be given in different boxes to understand the relationship among the pieces. A girl stated that "*Everything seemed good; except that pattern objects were given in one box. They were very close to each other. They might be given in different boxes." (CF5)* Among all developed games, the present game requires the most precise bodily movements. Thus, instructions given at the

beginning of the game becomes very important for children. In the how to play part, children are informed with animations and textual explanations like other games.

Concerning interaction patterns of children, Find the Next game was the hardest game among four regarding making interaction without performing any mistakes. Most of the children touched objects in the camera mistakenly. In the game, they needed to stand stable and only use correct part of their body. It was observed that this was hard for some of children. Especially boys had more mistakes when they tried to touch an object in the game than girls.

Animation of pattern sequences that is moving from right to the left direction was liked by children. All children stated that factory concept was very fantastic and enjoyable. Animations and sound effects were appropriate according to the children. A girl stated that "*I liked animations very much. Especially factory theme was very cute. All animations were appropriate. Sound effects when I made a movement were nice. There were different sound effects when I gave correct answer or when I couldn't find the correct shape." (CF4)*

4.4.3 Camera Use

EVEN vs. ODD Game: During the interviews, especially girls mostly complained about motion-driven physically interactive games that it might be difficult for them to see or watch easily themselves while they were playing. A girl stated that "*I liked the game. I ask to see myself clearly in a big camera. If I could find chance to see myself in a bigger camera, it might be more enjoyable." (CF2)*

Girls focused on camera-size more than boys. It might be concluded that it is more enjoyable to see them while they are playing rather than boys. Controlling the game environment by using specific bodily movements was difficult for some children. They stated that sometimes they got lost their focus because they try to concentrate on only game play part.

All children stated that a model appearing periodically to show correct position would be helpful. They stated that this would be very beneficial for them to focus on both camera screen and gameplay part. A boy stated *"I used to play games that are controlled via keyboard or mouse. They are very easy. But, there is different control in the game. One difficult thing for me was that I sometimes forgot my correct position in the camera." (CM2)*

Especially girls mostly stressed that the present game requires high concentration and focus not to lose exact camera position. If they got lost their position, the game cannot detect their movements. Camera can only detect when children are in it. According to most girls, the child appearing periodically would help them to find correct position.

Reactions of children to camera use in the game showed differences between boys and girls. Girls always try to use camera as a mirror. They preened themselves when they first saw the camera. Therefore, they always asked bigger camera screen in the game. Concerning the camera screen, girls' main criticism was the size of the camera. However, boys just used the camera to play the game. Their main criticism regarding the camera was the placement. They asked that camera screen and navigation parts might be close to each other.

Because motion-driven games require more concentration to control the game environment, children need to focus on both camera screen and gameplay part simultaneously to be able to play it. They focused that there should be easily understandable and achievable physical movements in the game. A girl stated that *"I tried not to lose my place in the camera to make the character move through left or right direction. This was easy for me because movements were very easy. If there were very difficult movements, it would be difficult to concentrate on the game." (CF1)*

DRIVE YOUR SHAPE Game: Children were expected to use camera screen to control the game without losing their place. It was figured out that the most complained issues about motion-driven games were their camera size. Concerning difficulties whether children encounter while using camera screen, all of them stated that location of camera was appropriate for them. Girls asked bigger camera screen much more than boys. Boys stressed gameplay issues and game rules than camera screen during the interviews. A boy stated that *"It was funny to drive a plane and collect geometric shapes using my body. Plane was moving through right direction when I shook my right hand and it was moving through left direction when I shook my left hand." (CM1)*

Camera use in Drive your Shape game was similar to Even vs. Odd game. Children were supposed to use the camera to control the game. Similarly, girls asked bigger camera screen. Because they saw themselves smaller in the camera, some of them tried to close to camera to see themselves clearly. However, main focus of the boys were using camera screen effectively to play the game properly. They asked how they could use camera effectively to control the plane well during the gameplay.

Playing motion-driven games was much easier for boys than girls. Focusing on both gameplay part and camera screen and making expected bodily movements was not easy for girls as boys. A girl stated that "*These games are very new for me. It was difficult to play. I focused on gameplay and plane, thus I got lost my place in the camera. I suddenly realized that there is nobody in the camera screen." (CF5)* It seemed that a role model aiming to help children by showing correct place and position in camera screen was necessary. All children stated that this will be very helpful. They stressed that an ideal camera position was necessary to play the game properly.

SAVE THE NUMBERS Game: In the present game, children, as player, were avatar of the game. They didn't need to control any different characters or objects in the game. All children gave very positive feedback about this issue during the interviews. Almost all children, except one boy, stated that being a main character in a game was an amazing experience that they hadn't lived before. A girl stated that "*I was in the game like a game character. This was amazing. I used myself as main character of the game. I had never played a game like this. There was nothing that made the game difficult or boring." (CF2)*

It was observed during the gameplay sessions that, bigger camera screen was always welcome. Motion-controlled games like Save the Numbers game were children's favorite games because of their bigger camera size. Children liked to play the game in a camera. They stated when they play the game that; they felt them as they were living in the game. These types of games make children more immersive in the game.

All children stated that camera size in the game was appropriate. They didn't encounter any difficulties while they were playing. The camera screen was used as gameplay part in Save the Numbers game. Children mostly stressed that they didn't need to get help about correct gameplay position in camera screen. A boy, for instance, stated that "*I could fix myself easily in the game. This is very important because I didn't need to get extra energy to fix my body to the correct position." (CM2)* All children stated that they didn't spend extra energy to fix them to the camera screen. Most children stated that presenting periodically feedback aiming to show them correct camera position wasn't vital for this game. However, if they see periodically such feedback, they can play the game better.

FIND THE NEXT Game: There is a big camera screen in which children play the game and control the game objects directly. In the game, children need to be stable in the camera screen. Their ideal camera position is very important to play the game

properly. A girl stated that "*I needed to be stable in the camera. If I made any wrong movement, it was very easy to touch wrong objects. One of the advantages of this game was that I could fix my body by looking at the camera." (CM3)*

Concerning camera size, all children stated that camera size in the game was appropriate to play. Some children complained that objects around the children in the camera were close to their ideal position. It might be easy to touch wrong objects while they are trying to touch correct objects. A girl stated that "*I touched some objects accidentally. After I found the answer of the pattern, I tried to reach correct shape with my hand. But I touched another objects accidentally because all objects were very close to each other. I did this mistake many times. It would be better if objects in the camera were placed separately." (CF1)*

Placements of objects were main criticisms of children concerning camera use. It was observed that close objects in the camera make children stressed during gameplay. They focused on touching correct object without making any mistakes more than educational content. Especially girls were more stressed in the game than boys. When they touched an object mistakenly, it was observed that their motivations were decreased drastically.

During gameplay sessions, girls suffered to find ideal camera position than boys. When they got lost their beginning camera position, it was very difficult for some of them to fix their body again. This made them make many mistakes. Some girls stressed similar difficulties that they encountered. For instance, a girl stated that "*If I get lost correct position, it is very easy to touch other objects accidentally. I needed to see a guide helping me to find correct position. I missed three questions by touching different objects accidentally while I was trying to find correct place." (CF4)*

4.4.4 Interaction

EVEN vs. ODD Game: All of the children stated that it is very interesting and exciting to controlling an avatar and making it walk through left or right directions. They stressed that this kind of experience was fantastic because almost all of them had never played a game like the Even vs. Odd game concept. Gameplay and rules of the Even vs. Odd game is easily understandable for children. They weren't expected to make any difficult or challenging bodily movements in the game. They just need to make specific bodily movements to move their avatar through left or right directions. Therefore, most children, especially boys, stated that playing the game was easy.

Concerning playing the present game via keyboard or mouse, all children stated that playing this game by using keyboard or mouse would be simpler. Almost all children stressed that making bodily movements in the game was much more enjoyable than classical games that requires using keyboard or mouse to control. A girl stated *"If I would play this game by using keyboard or mouse, I think this would be easier. I would just need to press left or right key to move character. I would get bored when I played this game because it might be boring to just press two keys." (CF1)*

Indirect interaction by using camera screen to control the game was the first experiences of almost all children. It was observed that they were all very exciting to play the game. It was fantastic for them to control the game with a camera. It as also observed that controlling an avatar with bodily movements was also highly motivated for all children.

All girls stressed that controlling an avatar might be more interesting and preferable than controlling an object. All boys stated that there is no difference for them in terms of controlling an avatar or an object. During the interviews, they mostly focused on gameplay issues and enjoyable characteristics of the game. A boy stated that "*It doesn't matter to control either a human-like character or different object. I*

think a game would be enjoyable with a car or with a creature. There are many games in Internet having a character and many of them are boring." (CM2)

It is hard to set a game environment allowing children to play a multiple game in physically interactive games basing on a web-cam technology. Some of children (n=6), especially girls, stated that for this game, it would be very enjoyable with two web-cams. However, boys didn't give importance to play the game with one of their friends as much as girls. A girl stated that "*It would be funny, if I could play this game with my friends. We could control the character together. Maybe, I could make it through left direction and my friend could make through right direction." (CF5)*

DRIVE YOUR SHAPE Game: There is an indirect interaction between children and game environment in the present game. There is a camera-screen building connection between children and game. Children need to use camera screen to build this connection. During the interviews, children mostly focused on indirect interaction. They liked to make game characters or objects move through left or right direction. Especially boys liked playing the game more than girls.

Unlike boys, the game couldn't draw girls' attention as other games. Almost all girls stated that they don't like playing plane games or war games. However, educational content was more favorable among girls than boys. Most girls stated that because they like dealing with geometry, they liked to play the game. A girl stated that "*It was cute but I would prefer to control a human-like character. It would be more exciting and funny for me. I like geometry, thus I enjoyed playing the game." (CF1)*

Especially girls stated that from time to time, it was difficult to concentrate on both camera screen and plane. When they got lost their position in camera screen, they got lost effective interaction in the game. Girls had difficulties when they lost their place in camera screen. All children stated that playing single player is appropriate in Drive your Shape game. They preferred playing the game alone. A boy stated that "*I*

preferred playing this game own my own because I have no idea about how I can play this game with my friend. There would be two gameplay screens, two cameras and two planes. By this way, we can compete by driving our games." (CM5)

Children were supposed to drive the plane like a pilot in the game. Normally, especially boys had played similar games in Internet. However, using bodily movements to drive the plane was very innovative for them. It was observed that girls who stated not to like playing plane games liked to drive the plane.

All children stated that playing the game might be easier when they play via mouse or keyboard. Because of interaction differences between children and game environment, most girls considered that the game might be played easily via mouse or keyboard. A girl stated that *"It would be easy to play the game, if I could find chance to play via mouse or keyboard. Pressing keys or using mouse would be easier than trying to move arms through correct directions." (CF2)*

SAVE THE NUMBERS Game: Children need to use camera screen to build a direct interaction in the game. They just need to touch game objects. In the present game, children are avatar or main character. A girl stated that "*I felt that I was real character of game because I could touch parachutes directly by using my hands. This game was very easy to understand how to play." (CF1)* Children mostly focused on - enjoyable characteristics of game because they were able to build a direct relationship. All children stated that being a major character of a game and building a direct relationship were very entertaining.

Concerning playing the game with one of their friends, all of the girls stated that Save the Numbers game might be more enjoyable with a multi-player game concept. A girl stated that "*I would prefer playing this game with my friends. The camera is big enough to play with 2 people. We can collect parachutes together and help each other related to calculating two digit numbers." (CM4)*

Save the Numbers game as the most favorable game among four developed games for all children. With a big camera screen and direct interaction with gameplay part, children all liked very much this game. It was observed that this type of gameplay was highly motivated for all children. They liked very much to touch objects by using their bodily movements in the game.

Girls focused on collaboration in the game while boys focused on gameplay issues. All girls stated that making calculation with their friend might be more enjoyable. All boys focused on playing the game alone. They stated that Save the Numbers game is more enjoyable when they played alone. The present game has immersive gameplay characteristics basing on their direct interaction features. Especially boys immersed within the game environment while they were playing the game. Basing on interview results, it was figured out that the game has power to draw children's attention and motivation.

FIND THE NEXT Game: Children had difficulties while playing Find the Next game because the game requires very specific physically bodily movements and exact camera position. When children got lost their position in the camera, they built wrong interaction with game environment. Therefore, children were expected to obey game rules and made correct bodily movements while they were playing. Concerning interview results, almost all children stressed that playing Find the Next game was a bit difficult. A girl, for instance, stated that "*I made many mistakes in the game because I couldn't set myself into correct position. I touched wrong objects accidentally. Thus, sometimes I got bored." (CF2)*

Interaction between game and children were the most problematic game was Find the Next game. Because it was easy to touch objects mistakenly in the game, children didn't like this type of interaction very much. It was observed that children didn't

like a game having one action with one result. Children liked to touch objects in camera screen with a high tolerance.

Building a wrong interaction made children get bored during gameplay. Especially girls mostly complained that the game requires very specific camera screen position and exact position that children need to be stable. Boys played the game easier than girls. Concerning playing the game by using keyboard or mouse, all children stressed that playing the game by using keyboard or mouse would be much easier than the present game. A boy, for instance, stated that "*This game would be very easy to play if I could use the mouse. I could click on correct object when I found the answer of pattern." (CM5)*

Concerning playing the game with a friend, all children stated that Find the Next game might be better as a single player game. It might be difficult to play this game with a friend. Basing on concept and gameplay issues, children stressed that the game cannot be played as multi player.

4.4.5 Modification of Games - Version 2

EVEN vs. ODD Game: A second version of game was developed basing on children's feedbacks. Developed game was given in the Figure 4.13. New integrated features and modified parts of the game were identified below;

- Periodically appeared character that will show children ideal camera position in the camera screen,
- Three gameplay levels,
- Appropriate game concept and gameplay movements,
- Appropriate gameplay life numbers,
- More animation such as ball bouncing, avatar walking etc,

- A model showing children how to play at the beginning of the game,
- Faster ball speed throughout the following levels,

Figure 4.13: Screenshots of Even vs. Odd game

DRIVE YOUR SHAPE Game: A second version of game was developed basing on children's feedbacks. Developed game was given in the Figure 4.14. New integrated features and modified parts of the game were identified below;

- Periodically appeared character that will show children ideal camera position in the camera screen,
- Appropriate required bodily movements (right and left hands to control the plane),
- Appropriate game concept and geometric shapes,
- Three gameplay levels,

- Four lives to finish the game,
- A model showing children how to play at the beginning of the game,
- More animations about plane, enemies, fuel and shapes,
- Bigger camera screen to manage the game easily,
- More enemies in the following levels,
- Less fuels in the following levels,

Figure 4.14: Screenshots of Drive Your Shape game

SAVE THE NUMBERS Game: A second version of game was developed basing on children's feedbacks. Developed game was given in the Figure 4.15. New integrated features and modified parts of the game were identified below;

- Periodically appeared character that will show children ideal camera position in the camera screen,
- Appropriate and easily controllable camera screen,
- Enjoyable game concept,
- Three gameplay levels,
- Four lives to finish the game,
- A model showing children how to play at the beginning of the game,
- Appropriate bodily movements that children might use entire part of body,
- Appropriate and enjoyable educational content embedded within the game,
- Faster speed of parachutes falling down in the following levels,
- Appropriate and cute parachutes and walking animations,

Figure 4.15: Screenshots of Save the Numbers game

FIND THE NEXT Game: A second version of game was developed basing on children's feedbacks. Developed game was given in the Figure 4.16. New integrated features and modified parts of the game were identified below;

- Periodically appeared character that will show children ideal camera position in the camera screen,
- Easily controllable camera screen,
- Enjoyable factory game concept with three gameplay levels,
- A model showing children how to play at the beginning of the game,
- Appropriate question numbers (20) for each level,
- Shorter given time to answer each question in following levels,
- More distance among shapes not to touch any of them accidentally/mistakenly,
- Pattern objects given below in different boxes (each of them in different box),
- Appropriate and cute animations,

Figure 4.16: Screenshots of Find the Next game

4.5. PHASE 5 (Evaluation of Game Prototypes - Pilot Implementation)

In the pilot implementation phase, children played all developed physically interactive games before the interviews. Each gameplay session was approximately 20 minutes. After the gameplay sessions, children were interviews regarding developed physically interactive games. In addition, children's demographics were collected in order to understand effectiveness and efficiency of developed games about educational content, visual design, camera use and interaction in detail.

During the gameplay sessions, observation notes were gathered with regard to children's gameplay characteristics and reactions to played games. All interview sessions were performed in computer class in the school. Computer teacher organized children's participation and children were called respectively to play the games and conduct interviews.

4.5.1 Learners' Demographic Characteristics

30 children with 17 boys and 13 girls participated to the Pilot Implementation Study by using semi-structured interview technique. In the first part of the interview, children were asked about gameplay characteristics and habits. 19 of the children were 2nd graders and rests of them (11 children) were 3rd graders. During the interviews, it was realized that almost all of the children (n=26) stated they have

computer at home. Majority of the children (n=21) use computer approximately between 0 and 2 hours per day. Concerning children's gameplay characteristics, almost all of them (n=27) stated that they play computer games either at home or at school. Only 4 boys stated that they played webcam games before. Rests of them had no experiences in playing games with a webcam.

It is the fact that playing computer games are one of the most favorable leisure time activities for children. Similarly, during the interviews, all children stressed that they prefer playing games in free times. Game preferences of children showed differences among boys and girls. Boys preferred playing "Racing Games", "Driving Games" or "Flight Games". Also playing cartoon movies games were their other favorable game activities. Especially, Sonic, Spiderman, Ben10, Bakugan or Caillou characters which are being used as main avatar in games were boys' most favorite games. Unlike boys, girls stated that they prefer playing dress up games and mind games.

Children were asked about reasons of their gameplay, and boys and girls gave different answers during the interviews. While most of the boys (n=11) play games for just fun and as a leisure time activity (n=4), girls (n=7) prefer playing as leisure time activity and making mental practices (n=4). Almost all children (n=24) stated that they prefer playing single player games. Concerning playing physically interactive educational games and their potential regarding using them in educational settings, majority of children (n=28) stated that they didn't play physically interactive games before. Only two boys reported that they played Nintendo Wii before. Most children (n=19) reported that this game genre might be played in educational settings. Children reported that especially in Mathematics and Science, physically interactive games might be beneficial and useful.

4.5.2 Educational Content

Children played 4 designed and developed physically interactive educational games and answered interviewed questions after the gameplay session. Children were asked

about educational content in physically interactive educational games during the interviews. Basing on interview results, it was figured out that almost all children reported that physically interactive games have big potentials in terms of using them in educational settings.

Whereas 13 out of 17 boys reported that physically interactive games might help them to make many practices on educational subjects, 9 out of 13 girls reported that physically interactive games might help to make many practices on educational subjects. Difficulty level of educational content was asked to children and 15 boys and 11 girls reported that educational content was appropriate to their educational background. Almost all children reported that information about how to play games was enough to understand and play games. 14 boys and 9 girls reported that how to play part was easily understandable. Whereas 15 out of 17 children reported that educational subjects might be reinforced by using physically interactive games, 9 out of 13 girls reported that physically interactive games might be used to reinforce educational subjects.

It was observed during gameplay sessions that children liked making educational practices in developed physically interactive educational games. They had positive attitudes toward physically interactive games. Almost all of them did not ask to stop playing the games. Especially calculations and geometric shapes were very popular among children. Especially girls liked making calculations in games much more than boys.

4.5.3 Visual Design

Children were asked about visual design in physically interactive educational games during the interviews. Basing on interview results, it was figured out that almost all children reported that they liked visual designs, animations, sound effects and gameplay durations of developed games. Whereas 14 out of 17 boys reported that color preferences and visual designs that are used in games were appropriate for

them, 10 out of 13 girls reported that color preferences and visual designs were appropriate. Concerning gameplay durations of games, 13 boys and 9 girls reported that durations in games were appropriate. All children agreed on animations among levels were understandable. They all reported that animations and sound effects showing level animations were easily understandable to them.

16 boys and 11 girls reported that navigations of developed games were easily understandable and controllable. Because of developed physically interactive games' main characteristics in which children need to get scores to be successful in games, children need to understand how they need to get scores. It was figured out that all boys and most of girls (n=11) agreed that how to get score in games was easily understandable.

In order to present much more enjoyable educational games, sound effects and background music were embedded within developed physically interactive games. Children were asked about sound characteristics of games. 15 out of 17 boys and 10 out of 13 girls reported that sound effects and background music in games were appropriate and not disturbing. All 30 children reported that animation in games were enjoyable.

Basing on children's demographic characteristics and points of views on games, it might be concluded that avatar-based games are much favorable among children at these ages. Similarly, all children except one girl reported that characters used in games were enjoyable. Children were asked about size of gameplay screen, it was figured out that boys showed more positive than girls. Whereas 12 out of 17 boys reported that size of gameplay screens were enough to play, 6 out of 13 girls reported that size of gameplay screen were enough.

Children liked motion-controlled games more than motion-driven games. They liked controlling human-like characters in games than objects. It was observed that

colorful visual design had power to attract children's attention. When they first saw the games, they tried to understand game concept and theme. Animations, sound effects and background music were also very important to motivate children and increase their attention. They liked listening background music or hearing sound effects basing on their performance in games.

4.5.4 Camera Use

Camera is the most necessary and vital component in physically interactive games. Camera is used in these games either to play game making interaction with game objects directly or to control game objects making indirect interaction. During interviews children were asked about camera use in games. Basing on results, it was figured out that girls reported that they encountered more difficulties in camera use than boys.

While 6 out of 13 girls reported that controlling position in camera screen while they were playing game was difficult, only 4 out of 17 boys reported that controlling position in camera screen was difficult. Similarly, 6 out of 13 girls reported that they spent effort to fix their position in camera screen. Only 5 boys reported that they spent effort to fix their position.

Concerning difficulties in camera use, 7 girls and 3 boys reported that controlling camera and playing game simultaneously was difficult. 14 out of 17 boys and 9 out of 13 girls reported that camera size where they saw themselves were appropriate to play the game properly. Children were asked about effective camera use during the interviews. It was figured out that all of the children reported that a role model character showing their correct camera position helped them to play games easily.

Because motion-controlled games have bigger camera screen than motion-driven games, children liked these game very much. It was observed that the more camera screen that a game had, the higher motivation that children had. They did not give up

playing motion controlled games. However, it was very easy for them to distract their position in camera screen. Therefore, periodically given feedback showing exact camera position in camera screen helped children to set their position properly. Girls were more careful about adjusting their body in camera screen.

4.5.5 Interaction

Physically interactive games have different type of interactions. Understanding children's points of views and learning their considerations about interaction were important to figure out design principles. During the interviews, children were asked about interaction patterns in physically interactive educational games. Basing on interview results, it was figured out that almost all children liked playing developed physically interactive educational games.

Most children agreed that playing physically interactive games was not difficult gameplay activity. 3 out of 17 boys and 4 out of 13 girls reported that controlling game objects by using physically bodily movements was difficult. Children didn't need to use mouse or keyboard while they were playing the games. They just needed to use their bodily movements to both control and play games. They were asked about differences of gameplay characteristics. It was figured out that children preferred using bodily movements. All children reported that playing games via mouse or keyboard would be easier. However, most of them reported that playing these games via mouse or keyboard wouldn't be more enjoyable. Only 2 girls reported that playing developed physically interactive educational games via mouse or keyboard would be more enjoyable.

All boys reported that controlling characters in games was enjoyable. 10 out of 13 girls reported that controlling characters was enjoyable. In the games, children need to control either human-like characters or game objects like plane etc. While 6 out of 17 boys were reported that controlling objects like plane etc would be more

enjoyable than human-like characters, only 2 out of 13 girls reported that other objects would be more enjoyable.

Concerning playing games as either single player or multi player, most girls (n=9) preferred playing developed physically interactive educational games with their friends, however, nearly half of boys (n=8) reported that they prefer playing developed games with their friends. Developed games presented two different way of interaction to children that they can interact with game objects either directly or indirectly. Children can make direct interaction by touching game objects in camera screen, or make indirect interaction by using camera to control gameplay part. All children reported that touching game objects directly was more enjoyable than indirect interaction.

Direct interaction was liked by all children than indirect interaction. Experiences in touching game objects in camera screen were very exciting for children. It was observed that especially when touching objects all children excited too much. Especially girls had difficulties more than boys in terms of using camera screen to control the games. It was difficult for them to manage camera screen, navigation part and gameplay part.

4.6 PHASE 6 (Evaluation of Game Prototypes - Final Implementation)

In the final implementation phase, children played all developed physically interactive games before the interviews. Each gameplay session was approximately 20 minutes (see Figure 4.17). After the gameplay sessions, children were interviews regarding developed physically interactive games. In addition, children's demographics were collected in order to understand effectiveness and efficiency of developed games about educational content, visual design, camera use and interaction in detail.

During the gameplay sessions, observation notes were gathered with regard to children's gameplay characteristics and reactions to played games. All interview sessions were performed in computer class in the school. Computer teacher organized children's participation and children were called respectively to play the games and conduct interviews.

4.6.1 Learners' Demographic Characteristics

50 children with 27 boys and 23 girls participated to the Final Implementation Study by using semi-structured interview technique. In the first part of the interview, children were asked about their gameplay characteristics. 33 of the children were 2nd graders and rests of them (17 children) were 3rd graders. It was figured out during the interviews that majority of children (n=41) had computer at home. Concerning children's computer use and gameplay habits, most of the children (n=36) reported that they use computer less than 2 hours per day. Only 4 children stated that they couldn't use computer at home but could use at school. Rests of the children (n=46) stated that they use computer and play computer games either at home or at school. Only 4 boys and 1 girl stated that they played webcam games before. Rests of the children had no experiences in playing games with a webcam.

Almost all children reported that they prefer playing computer games as a leisure time activity. Concerning game preferences and game characteristics that children prefer, it was figured out that there were drastic differences between boys and girls in terms of their expectations and points of views. Boys preferred playing games that are action or adventure like games. They also preferred playing games including cartoon-movie stars like Ben10, Bakugan, Caillou etc. However, girls preferred playing baby or fashion model dress up games and mental development games.

17 boys reported that they prefer playing computer games for just fun. 8 boys reported that they play games as a leisure time activity. Girls gave different answers

in terms of reasons of their gameplay habits. 11 girls reported that they prefer playing computer games as leisure time activity and making mental practices with 8 girls.

Figure 4.17: A Gameplay Session

It was figured out that 6-9 age children prefer playing online casual games. Flash-based casual games are mostly single player games in internet. When children were asked about their gameplay preferences, majority of children (n=44) reported that they prefer playing single player casual games. All boys and girls reported that they didn't play physically interactive games before. Majority of children (n=43) reported that physically interactive games might be played in educational settings beneficially. They reported that Mathematics is the most appropriate subjects that might be embedded within physically interactive games.

4.6.2 Educational Content

As Final Implementation Study, 50 children played 2 motion-driven and 2 motion-controlled physically interactive educational games and answered interviewed questions after the gameplay session. In the first part of the interview, educational

content in developed physically interactive educational games were asked to children. Basing on interview results, it was figured out that almost all children reported that physically interactive games have big potentials about using in educational settings.

Girls gave more positive answers in terms of potentials of physically interactive educational games than boys. 24 out of 27 boys reported that physically interactive games might help to make practices on educational subjects. 21 out of 23 girls reported that physically interactive games might help to make many practices on educational subjects. Concerning difficulty level of educational content in developed games, 25 boys and 22 girls reported that educational content was appropriate to their educational background.

All girls and almost all boys (n=25) reported that information about how to play games was enough to understand easily. They reported that how to play part in games was easily understandable to play and control both camera screen and gameplay part. 24 out of 27 boys and 21 out of 23 girls reported that physically interactive educational games might be used to reinforce educational subjects.

It was observed during the gameplay sessions that girls gave more importance to educational parts of games than boys. Boys especially tried to touch or collect many objects in games rather than getting high score. Some children had difficulties in calculating two digit numbers in mind. Therefore, they had lower motivation during gameplay.

4.6.3 Visual Design

Concerning visual design issues in developed physically interactive educational games, children were asked about their preferences and points of views. According to results of interviews, it was figured out that all children reported positive notion in terms of animations, sound effects and other game characteristics. Concerning

gameplay durations, majority of boys (n=22) and girls (n=18) agreed on gameplay durations that were appropriate. Color preferences and visual design theme were liked by 25 out of 27 boys and 19 out of 23 girls. All children agreed that animations between levels were easily understandable. In order to make enjoyable games, developed games had funny and cute animations and sound effects. Children were asked about these game components and according to all children, animations and sound effects showing level animations were easily understandable.

All 27 boys and most of girls (n=21) reported that lives showing gameplay rights for each gameplay session were easily understandable and controllable. Most of boys (n=26) and girls (n=20) reported that how to get score in games was easily understandable. 25 out of 27 boys and 21 out of 23 girls reported that sound effects and background music in games were appropriate and cute. Like sound characteristics, children reported to like animations in games. It was reported that all 50 children reported that animations in games were enjoyable and funny.

All children reported that human-like characters used in games were enjoyable. Children were asked about size of gameplay screen and boys showed more positive points of views than girls. 21 out of 27 boys reported that size of gameplay screen were enough to play properly, only 7 out of 23 girls agreed on this.

Children all liked visual design of games. Especially cartoon like drawings and characters in games were liked too much by children. During the gameplay sessions, it was observed that game parts such as navigation, camera screen, gameplay part etc should be located close to each other. It was difficult for some children to control all parts of games. Also, animations regarding how to play the games were liked by children. They liked to see a role model helping them about how they should play the game properly.

4.6.4 Camera Use

Physically interactive games are being played by using camera screen to control the gameplay screen. Camera is very important and used in physically interactive games either to make interaction with game objects directly or control game objects making indirect interaction. Basing on results of interviews in terms of effective camera use in developed games, some boys and girls reported that they encountered more difficulties in camera use.

Concerning camera use, 3 out of 23 girls and 4 out of 27 boys reported that controlling correct position in camera screen while playing game was difficult. 3 out of 23 girls and 6 out of 27 boys reported that they spent too much effort to fix their position. While 7 girls reported that controlling camera and playing game simultaneously was difficult, 4 boys reported that controlling camera simultaneously. Camera size in physically interactive games was deterministic for not only game concept but also educational content selection. Almost all children reported that camera size was appropriate to play games properly. 24 out of 27 boys and 16 out of 23 girls reported that camera size where they saw themselves were appropriate to play the game properly. Almost all children except 2 girls reported that a model character showing children's correct camera position helped them to play games easily.

It was observed that children liked playing physically interactive games in camera screen. They liked being main character / avatar of games and making direct interaction in games. Reactions of girls and boys about camera use had different. When girls saw camera-screen in the game first, they tried to tidy up their hairs. Therefore, they liked bigger camera screen much more than boys. Almost all children preferred playing games with bigger camera screen and using camera to play the game.

4.6.5 Interaction

Interaction in physically interactive games is different than classical games. Making interaction via camera screen was innovative and unique experiences for children in the study. Thus, their considerations and points of views about interaction in these games were very important. Concerning interaction patterns in developed physically interactive educational games, it was figured out that all children liked playing games making this type of interaction.

Almost all children reported that playing physically interactive games was not difficult to play. Concerning difficulties in gameplay, only 2 boys and 3 girls reported that controlling game objects by using physically bodily movements was difficult. Children were asked about different interaction patterns of physically interactive games. Results of interviews revealed that developed games would be easier when they are played via mouse or keyboard. All 50 children reported that playing games with mouse or keyboard control would be easier. It was figured out that all children preferred using bodily movements. Although games via mouse or keyboard control would be easier, almost all children reported that playing these games via mouse or keyboard wouldn't be more enjoyable. 2 boys and 4 girls reported that playing developed physically interactive educational games via mouse or keyboard would be more enjoyable.

Concerning controlling game directly or indirectly, all boys reported that controlling human-like characters directly in games was more enjoyable. Only 3 girls reported that controlling game objects indirectly might be more enjoyable than directly interactive game environments. While 8 out of 27 boys were reported that controlling objects like plane etc would be more enjoyable than human-like characters, only 4 out of 23 girls reported that other objects would be more enjoyable.

Girls showed more positive tendency in terms of playing games with their friends than boys. 14 out of 23 girls reported that they prefer playing games with their

friends. Only 6 boys reported that they prefer playing games with their friends. Concerning interaction patterns of games, all children reported that touching game objects directly was much more enjoyable than making indirect interaction.

It was observed during the gameplay sessions that especially some girls had difficulties to make indirect interaction in games. In the games that camera screen was used to control, they couldn't focus both camera screen and gameplay part simultaneously. Girls having difficulties in playing the games properly had lower motivation than girls having ability to play the games properly.

4.7 Summary

During the design phase of the study, reviews of teachers and children were taken into considerations. First, Physical Education and Mathematics teachers reviewed two paper-based and two computer-based game prototypes. They played computer-based physically interactive games and gave their comments and recommendations. Afterwards, second version of games that are all computer-based games were developed. Children played developed games and reviewed at the end of the each gameplay session. A summary of teachers' and children's reviews were given below.

Table 4.1: Summary of teachers' and children's reviews (Even vs. Odd)

EVEN vs. ODD Game	
Teachers' Reviews	**Children's Reviews**
• Periodically given feedback during gameplay, • Appropriate, understandable and clear information about camera use, • Background music and sound effects, • Visual and vocal feedback about children's performance, • Summative evaluation about children's correct actions, • Textual and visual instructions about how to play,	• Periodically appeared character that will show children ideal camera position in the camera screen, • Three gameplay levels, • Appropriate game concept and gameplay movements, • Appropriate gameplay life numbers, • More animation such as ball bouncing, avatar walking etc, • A model showing children how to play at the beginning of the game,

• Closely located camera-screen to gameplay part, • Closely located camera-screen to navigation part, • Colorful balls, baskets, cartoon movies like animations and drawings.	• Faster ball speed throughout the following levels.

Table 4.2: Summary of teachers' and children's reviews (Drive Your Shape)

DRIVE YOUR SHAPE Game	
Teachers' Reviews	**Children's Reviews**
• Only collecting ball without a target was useless and aimless, • A story is needed behind the game, • Time limitation, a route of object collection sequences, • Different enemy planes, barriers in the gameplay screen and a route on a map, • Limited number of geometric shapes to collect in given time, • Geometric shapes that should be collected from easiest shape to the most difficult, • Summative evaluation at the end of the game with written information about the names of geometric shapes, • Increased number of shapes throughout following levels, • Background music and sound effects regarding plane crash, shape collecting etc., • Easily understandable navigation part to control game effectively, • Effective camera use explanation via combination of animation, text and sound effects, • Small camera screen that is close to the gameplay and navigation parts, • Well-defined instructions about how to play the game before the game is started.	• Periodically appeared character that will show children ideal camera position in the camera screen, • Appropriate required bodily movements (right and left hands to control the plane), • Appropriate game concept and geometric shapes, • Three gameplay levels, • Four lives to finish the game, • A model showing children how to play at the beginning of the game, • More animations about plane, enemies, fuel and shapes, • Bigger camera screen to manage the game easily, • More enemies in the following levels, • Less fuels in the following levels.

Table 4.3: Summary of teachers' and children's reviews (Save the Numbers)

SAVE THE NUMBERS Game	
Teachers' Reviews	**Children's Reviews**
• Only one and two digit numbers (Three digit numbers were not preferred), • Summative evaluation as a final evaluation according to children's performance, • Conclusion text like "Well Done, You Finished the Game!", • Intervals between 0-100 for the first level, 20-80 for the second level and 40-60 for the third level, • Visual design characteristics similar to cartoon movies, • Comic sound effects and background music, • Large camera size in the gameplay part, • Clues about exact camera position in camera screen during gameplay, • Full bodily interaction between children and game objects, • Encourage of al body movement and space usage by walking backward and forward or moving through left or right directions in the game, • Clear instructions about how to play the game.	• Periodically appeared character that will show children ideal camera position in the camera screen, • Appropriate and easily controllable camera screen, • Enjoyable game concept, • Three gameplay levels, • Four lives to finish the game, • A model showing children how to play at the beginning of the game, • Appropriate bodily movements that children might use entire part of body, • Appropriate and enjoyable educational content embedded within the game, • Faster speed of parachutes falling down in the following levels, • Appropriate and cute parachutes and walking animations.

Table 4.4: Summary of teachers' and children's reviews (Find the Next)

FIND THE NEXT Game	
Teachers' Reviews	**Children's Reviews**
• 20 questions for each level, • Time decrease (more limited time) for each question throughout levels as challenge of the game, • Positive and negative reinforcements via sound effects and animations about children's performance, • Immediate feedbacks regarding	• Periodically appeared character that will show children ideal camera position in the camera screen, • Easily controllable camera screen, • Enjoyable factory game concept with three gameplay levels, • A model showing children how to play at the beginning of the game,

children's correct and wrong answers, • Total scores of corrects and mistakes of children, • Big camera size requirements to play the game effectively, • Entire body appearance requirements during gameplay, • Importance of avatar use to increase children's motivation and attention, • Camera screen located at the center of the game to focus children on gameplay, • Adequate information about ideal camera position, distance from camera and camera angle.	• Appropriate question numbers (20) for each level, • Shorter given time to answer each question in following levels, • More distance among shapes not to touch any of them accidentally/mistakenly, • Pattern objects given below in different boxes (each of them in different box), • Appropriate and cute animations.

4.7.1 Summary of the Results

Summary of Results chapter was given below.

Table 4.5: Gameplay Characteristics

Gameplay Characteristics
• Children preferred playing games that they didn't like playing normally when they were designed as physically interactive game genre. • Direct interaction was more motivated than indirect interaction. • It didn't matter controlling either human-like character or objects in physically interactive games. • Effective and efficient interaction was directly related to correct posture in camera screen. Therefore, correct posture should be maintained during gameplay. • It was observed that all children liked to talk loudly while they were playing. • When children saw more than one avatar walking through left or right side, they liked watching these walking avatars. • Close objects in the camera made children stressed during gameplay. • One wrong action shouldn't cause one negative results in the game. Children needed to have a tolerance regarding their mistakes in the game.

Table 4.6: Gameplay Requirements

Gameplay Requirements
• Physically interactive games should have short term gameplay sessions because

they require bodily efforts to play. • The bigger camera screen physically interactive games had, the more motivation children had during gameplay. • Animated instructions about how to play was necessary to help children make bodily movements properly. • Standing stable in the camera screen was hard for some of children, especially boys. • Children's success in Mathematics was deterministic in their success in Physical Education.

Table 4.7: Physically Interactive Educational Game Characteristics Requirements

Physically Interactive Educational Game Characteristics
• Motion-controlled games had more advantageous in terms of concentration and enjoyment than motion-driven games. • Especially for motion-driven games, easily manageable bodily movements should be preferred in camera screen. • Motion-controlled games were much more liked than motion-driven games. • Children could focus easily on gameplay part in motion-controlled games. • Children could find chance to check their correct camera position easier in motion-driven games than in motion-driven games. • Playing motion-driven games was more difficult than playing classical games in which children needed to use mouse or keyboard. • Playing motion-controlled games was easier than playing classical games in which children need to use mouse or keyboard. • Motion-controlled games gave more immersive gameplay environment than motion-driven games.

Table 4.8: Gender Differences

Gender Differences
• Girls preferred bigger camera-screen than boys. • Concentrating on both camera-screen and gameplay came more difficult to girls than boys. • Girls preferred controlling human-like characters (avatar) much more than boys. • Girls preferred playing physically interactive games with their friends as multiplayer game much more than boys. • Girls gave importance to collaboration in physically interactive games. • Boys preferred playing physically interactive games alone instead of playing with their friends. • Educational content encouraged girls to like playing games. For instance, they didn't like controlling plane, but they liked geometry, thus they liked playing

geometry based educational games by controlling plane. • Girls got bored easily when they needed to make complex bodily movements. • There were differences between boys and girls regarding giving reaction when they encountered difficulties in calculating one digit numbers in mind. • Girls tried to calculate without touching any numbers in gameplay screen, but boys gave up calculating and touched by watching results of their action in score part. • Unlike boys, girl had difficulties in touching correct answer by using their head • Some boys walked through left or right direction in the classroom like the avatar. • Girls started the game with a high performance physically, but during the gameplay, their performances were decreased gradually. But boys didn't. • Reactions of children to camera use in the game showed differences between boys and girls. Girls always tried to use camera as a mirror, but boys used as a mouse or keyboard.

Table 4.9: Teachers' Considerations

Teachers' Considerations
• While teachers tried to make the games easier but more educational, children tried to make more difficult but enjoyable. • Teachers had difficulties in focusing on different parts of games such as gameplay, navigation etc at the same time, but children didn't.

CHAPTER 5

DISCUSSION and CONCLUSIONS

In this study, qualitative data collection techniques was used to determine design principles of physically interactive educational games and research questions were investigated to figure out both teachers' and children's considerations on these principles. Descriptive questionnaire results and researcher's observation notes were aimed to strengthen and support findings. This chapter is going to evaluate the findings that were written and reported in the previous chapter.

In addition to classical game classification, new game genres have been appealing basing on new technological developments in game markets. Computer games have common characteristics that have potential to motivate children and present them enjoyable leisure time activities. Subrahmanyam, Greenfield, Kraut and Gross (2001) stated that "despite advances in interactive technology and the capabilities of current computer games, the fundamental nature of computer games has remained unchanged" (p.13). These main characteristics of games give clues to practitioners or educators regarding integrating and implementing educational games within classrooms. Subrahmanyam, Greenfield, Kraut and Gross (2001) stated that "the nature of the effects of computer game playing that stem from structural features of the medium would likely remain the same - although the strength of the effects on visual intelligence could change with increasing sophistication of the graphics" (p.13).

Physically interactive games have appealed as a new game genre in recent years. They have been emerging in game markets with growing interest. Physically

interactive games have potentials regarding making players perform bodily movements while they are playing games. Players have chance to control and play these games by using only physical movements. Because of specific gameplay characteristics, physically interactive games have potentials that they might be integrated for some disciplines within educational settings. For instance, in Physical Education, Mathematics, Physics etc, physically interactive games might be a good choice to implement and integrate. It was figured out in the previous studies focusing on physically interactive games that players, especially children, liked playing these games. Höysniemi and Hamalainen (2005) stated that "children liked that they could see themselves in the game world and that there were no traditional game controlling devices or small displays" (p.7-8).

Because physically interactive games are one of the lastly emerged game genres, there has been limited number of research studies focusing on design issues of physically interactive games. Boyle, Connolly and Hainey (2011) stated that "developing and evaluating games for specific purposes whether learning or behaviour change is a very complicated enterprise requiring an understanding of the design of games, knowledge of the relevant content or subject area, knowledge of motivation, pedagogy and behavior change, an understanding of how to select a game which will address the required learning or behavioural outcomes and evaluation techniques" (p.73). Although developing computer game is not a difficult process, main difficulty is designing and developing computer games with the most appropriate gameplay and graphic characteristics to defined target group (Hanna, Neapolitan & Risden, 2004). In addition to gameplay and graphic characteristics of games, another difficulty is embedding educational content and pedagogy within game environment beneficially and understandably for selected target audience.

In this study, it was concluded that all teachers had positive point of views about using physically interactive games for educational purposes in classrooms. Especially Physical Education teachers needed to have educational software like

computer games that they can use. Similarly, all children liked to play designed and developed physically interactive educational games. It was concluded that there is lack of enjoyable and educational content and educational games might close this gap effectively. Especially because of innovative and different gameplay characteristics of physically interactive games, all children liked to play physically interactive educational games for educational aims.

In the present study, design principles of physically interactive games to apply them in educational settings were aimed to define. Outcomes that were figured out during design, develop and implementation processes with finalized design principles regarding designed and developed physically interactive games were given below. This chapter will evaluate the findings that include design principles of the study first. Afterwards, a model of physically interactive educational game design and development will be explained basing on the findings and design principles (DP).

5.1 Gameplay Habits and Characteristics

Gender differences of children regarding playing computer games, computer gameplay habits, attitudes towards computer games or computer game genres that children prefer playing were focused in many studies (i.e. Funk & Buchman, 1996; Quasier-Pohl, Geiser & Lehmann, 2006; Chou & Tsai, 2007; Inal & Cagiltay, 2007; Miller & Summers, 2007). It was concluded in the previous studies that there are obviously differences between boys and girls regarding playing computer games (i.e. Hartmann & Klimmt, 2006; Lucas & Sherry, 2007; Miller & Summers, 2007). In the current section, gender differences between boys and girls with various subjects are discussed in detail.

Playing computer games with one of their friends are favorable gameplay activities for most children. Gender stereotype and differences between boys and girls in terms of their game preferences that they prefer playing different types of games were concluded in most studies (Funk, Buchman & Germann, 2000; Quasier-Pohl, Geiser

& Lehmann, 2006). Lucas and Sherry (2004) conducted a study aiming to examine gender differences in computer games and found clear differences. Similarly, Chou and Tsai (2007) purposed to explore gender differences among Taiwan students. They found that boys preferred playing computer games much more than girls. Motivations of boys were higher regarding playing computer games than girls. Similarly, in the present study, there were differences between boys and girls in terms of playing computer games. Boys preferred playing games more than girls. In addition, all children preferred to play computer games including cartoon like drawings or theme. In order to draw attention of children, *game design in physically interactive games should be usable and attractive including game objects that are similar to objects, characters or animations in cartoon movies.* (DP)

Results of the previous studies (i.e. Quasier-Pohl, Geiser & Lehmann, 2006; Inal & Cagiltay, 2007) concluded that there are gender differences regarding playing computer games that boys more like to play computer games than girls. They spent more time playing computer games than girls (Funk & Buchman, 1996; Chou & Tsai, 2007). Boys are interested in computer games more than girls (Miller & Summers, 2007). Playing computer games continue to become popular entertainment activities of boys (Subrahmanyam, Greenfield, Kraut & Gross, 2001). Similarly, in the present study, there were clear differences between boys and girls regarding expectations from the games and gameplay habits. Especially boys were more motivated than girls. *In order to increase both boys' and girls' motivation and encounter their expectation, considerations of both boys and girls should be taken into considerations during design and development of physically interactive games*. (DP)

Children have different gameplay characteristics in different ages, and each child has their own avatars, characters, stories, or theme (Kafai, 2006). Similarly, in the present study, children liked cartoon like drawings and animations according to their

age characteristics. *Colors, animations and sound effects should be selected considering children's age characteristics and embedded educational content.* (DP)

Miller and Summers (2007) investigated and found significant gender differences in video game characters. They concluded that boys prefer playing computer games that they ask to be "heroes or main characters". However, girls prefer playing computer games that they ask to be "supplemental characters" (p.741). Despite the findings of study conducted by Miller and Summers (2007), it was concluded that it doesn't matter controlling either human-like character or an object for boys. However, girls, in the present study, preferred controlling human-like characters much than boys. They were highly motivated when they controlled a human-like character by using their bodily movements. *It is better to design and develop avatar based physically interactive game concept to attract especially girls' attention efficiently.* (DP)

5. 2 Camera Use

Höysniemi and Hamalainen (2005) concluded that children liked playing physically interactive games and they liked using camera screen while playing. Similarly, children in the present study liked using camera screen much and see themselves clearly while they were playing the games. While, some children, especially girls, liked playing physically interactive games in a bigger camera screen, others, especially boys, were using camera screen effectively and efficiently to play the game. *It is important to design camera screen big in size and effectively usable considering educational subject and game concept* (DP). In order to make children use camera screen efficiently, *ideal camera position, camera angle and distance from camera should be instructed clearly not only before the game but also during the gameplay periodically.* (DP)

Concerning reactions of children to camera use in the games, children had different views. Since girls used camera as a mirror cause, they asked bigger camera screen in games. The bigger camera screen physically interactive games have, the more

motivation especially girls have during gameplay. However, boys used the camera to play the game and they criticized the games about the placement of camera screen. *Game components such as camera screen, navigation part and gameplay part should be close to each other in the design.* (DP)

Children might move through out of the camera screen (Hamalainen & Höysniemi, 2002) that might cause problems regarding decreasing their performance in physically interactive games. Similarly, in the present study, some of the children got lost their focus on camera screen and they got lost their position. This had negative effects on their gameplay. When they were out of camera screen, they couldn't control the game and play the game properly. *Effective animations showing exact camera position in camera screen should be given to children during gameplay periodically.* (DP)

5.3 Bodily Movement Preferences and Difficulties

Physically interactive games have different gameplay characteristics than classical games that require mouse or keyboard to control and play games (Höysniemi, 2006). Children are supposed to use either partial or entire bodily movements in physically interactive games (Höysniemi, 2006). Because physically interactive games have additional gameplay part like camera screen, children needed to focus on one more part while they were playing. In the present study, some children, especially girls, suffered focusing on different parts of games simultaneously. *Navigation parts should be designed to allow children, especially girls, control game environment easily without facing any difficulties.* (DP) Besides, *navigations and educational content should be designed and placed close to camera screen to help children, especially girls, control entire game components easily.* (DP)

5.4 Single-Player vs. Multi-Player Game Preferences

It was concluded in the previous studies (i.e. Inal & Cagiltay, 2007; Chou & Tsai, 2007) that there are game preferences differences between boys and girls regarding

characteristics of games that are either single-player or multi-player. Because almost all boys like competition and social interaction in games, it was expected that they like playing multi-player games. Children have tendency regarding forming a group while they are playing computer games (Inal & Cagiltay, 2007). More specifically, boys have more tendencies forming a group than girls (Inal & Cagiltay, 2007).

Similarly, in the present study, some of the children preferred playing physically interactive games with one of their friends. However, unlike the previous findings, girls preferred playing physically interactive games with their friends as multiplayer game much more than boys. They preferred more cooperation in games than competition. Girls might have considered getting help from their friends in the games. However, boys generally didn't prefer playing games with their friends. They preferred playing physically interactive games alone instead of playing with their friends. It was figured out that boys didn't ask to share their gameplay. While girls gave more importance to collaboration in physically interactive games, boys gave importance to gameplay alone. *In designed and developed physically interactive games, children should have gameplay options about whether they could play with their friends cooperatively or not.* (DP)

Quasier-Pohl, Geiser and Lehmann (2006) concluded that while boys prefer playing action games or simulation games, girls prefer mental games, educational games or skill games. Some girls might dislike competition in computer games like sport games, racing games, adventure games etc. (Hartmann & Klimmt, 2006). Similarly, in the present study, especially boys liked competition in physically interactive games than girls. *Different game genres and gameplay characteristics should be combined with or embedded within physically interactive games to present diverse gameplay environment to children.* (DP)

It was figured out in the present study that playing physically interactive games as a multiplayer game is another problem that players might face. Players need to use the

same camera screen while they are playing physically interactive games. Possible problems related to this were stated by Höysniemi and Hamalainen (2005) that "although children were careful not to harm one another, it was possible for accidents to happen, especially during intensive game events when the children were especially busy in playing the game" (p.10). *Multiplayer options of physically interactive games should be designed carefully considering whether children have enough space to play properly.* (DP)

5.5 Reaction Differences between Boys and Girls

Kinzie and Joseph (2008) concluded that "girls may come to appreciate Active and Strategic play if offered appealing opportunities to develop related skills and comfort. Similarly, boys' may find greater satisfactions in Creative activities if provided with well-designed, targeted experiences" (p.658). In the present study, there were differences between boys and girls in terms of their reactions and gameplay performance in physically interactive games. Girls were afraid of making mistakes in calculating numbers in mind during the gameplay; but boys gave up calculating or trying to do their best and touched by watching results of their action in score part. Therefore, in order to keep children's attention on educational part of games, *educational subject should be given hidden that makes children, especially boys, can feel playing games instead of making only drill and practice.* (DP) In addition, girls got bored easily when they need to make complex bodily movements; but boys tried to do their best about complex bodily movements. *Easily performable bodily movements should be considered basing on gender differences that influences on children's gameplay.* (DP)

5.6 Differences in Preferences of Educational Parts in Games

Playing computer games including educational characteristics have potential in terms of giving educational benefits to children (Ogletree & Drake, 2007). Enhancing complex and particular learning strategies (Gros, 2007), presenting meaningful problem-based learning environment (Kiili, 2005a, p.17), high motivation during

making educational drill and practices (Nenonen et al., 2007), and developing specific skills (Subrahmanyam, Greenfield, Kraut & Gross, 2001) are only some of beneficial aspects of educational computer games. Besides, physically interactive games have additional benefits for children because of their innovative gameplay characteristics.

Games have big educational potential in terms of allowing children make lots of practices (Gee, 2003). Children might find chance to learn from their failures in computer games. Similarly, in the present study, children made several educational practices in developed physically interactive educational games and they made mistakes especially in touching specific/expected objects while standing stable in camera screen. Especially, boys had more mistakes when they tried to touch an object in the games than girls. *Game concept in physically interactive games should support large physical gameplay space for children that they can touch expected objects without making any mistakes accidentally.* (DP)

It is mostly stated in the literature that girls and boys have different gameplay characteristics and preferences (Quasier-Pohl, Geiser & Lehmann, 2006; Inal & Cagiltay, 2007; Miller & Summers, 2007). Similarly, in the current study, educational part of games and their innovative gameplay characteristics encouraged girls to playing games willingly. Girls liked playing games that included a plane as main object of the game, but they normally don't like to play. *A wide diversity of game concepts including different game objects should be considered to attract children's attention in design of physically interactive games.* (DP)

5.7 Innovative Features of Physically Interactive Games

Almost all children in the study haven't played something like physically interactive games beforehand. This may made children to play developed games highly motivated. They all were very excited during gameplay sessions. Höysniemi (2006) concluded that children liked playing physically interactive games. Nenonen et al.

(2007) stated that developing innovative interactive gameplay environment between player and computer make computer games interesting and enjoyable. Similarly, in the present study, children liked playing developed physically interactive educational games. Almost all of them didn't ask to stop playing. For example, using bodily movements to drive the plane was very innovative for them.

Due to the innovative characteristics of physically interactive educational games, design principles were figured out. Children don't prefer playing some computer games. However, they may like to play games, which they don't like to play, if they were re-designed and re-developed as physically interactive games because of innovative gameplay characteristics of physically interactive games. *Innovative characteristics of physically interactive games should be highlighted during the design and development process.* (DP)

There are limited numbers of research focusing on physically interactive games in the literature, because physically interactive games have been appealing as a new game genre in game markets or Internet in recent years. One of the studies conducted by Sell, Lillie and Taylor (2008) concluded that "participants with greater playing experience can work at higher intensities, promoting greater energy expenditure." (p.505). Subrahmanyam, Greenfield, Kraut and Gross (2001) concluded that "more skilled video game players had better developed attentional skills than less skilled players" (p.15). Levac et al. (2010) concluded that "children with game play experience may have a greater understanding of how to move on the balance board in order to achieve game success. Children without experience on these games were observed to move their head, trunk and/or upper extremities during game play rather than weight shift through their lower extremities" (p.1035). Similarly, in the present study, easily adaption to playing designed and developed physically interactive games influenced children's gameplay performance. It might be concluded that children have experiences in playing physically interactive games adapted easily to gameplay characteristics of developed games.

Kinzie and Joseph (2008) concluded that children need help about how to play a game. Therefore, a guideline including hints and clues about how children could play the game may be helpful for children. This might make them play the game properly without making lots of mistakes. Kinzie and Joseph (2008) concluded that "of the one-third of students desiring help, most selected hints from a guide rather than being given the answer" (p.659). Concerning physically interactive games, most children might have no idea about how to play these games by using bodily movements. Since, almost all children haven't experienced in playing computer games using bodily movements in the present study, they needed to know how they could play the games. Explanations and instructions giving information about how to play physically interactive games properly gain importance. *Instructions regarding aims of games and necessary physically movements should be given to children by using multiple sources such as sounds, written texts and animations.* (DP) In addition, *it should be considered that children are needed to easily adapt to play physically interactive games via effective and efficient instructions regarding how to play.* (DP)

Timpka et al. (2004) investigated a study focusing on how computer games could be designed for "Interactive Health Education Environments" (p.941). They concluded that "challenge and competition should be considered as central motivational features" (p.944). Levac et al. (2010) conducted a study about children's movement characteristics in physically interactive games. They explored movement characteristics of children who have experienced and not experienced in playing physically interactive games. They also investigated impacts of motivation on children's performance regarding bodily movements. Children liked innovative gameplay characteristics of physically interactive games and using bodily movements (Höysniemi et al., 2004). Similarly, in the present study, almost all children had no experiences in playing computer games like physically interactive games and they all liked playing new features of this new game genre. *Innovative*

characteristics of physically interactive games should be focused on more during design and development processes. (DP)

Papastergiou (2009) reviewed 34 published studies focusing on computer game use for Health Education and Physical Education and concluded that "electronic games do have the power to help young people adopt a healthy lifestyle and become physically active for life" (p.613). Similarly, in the present study, children were active to play the game by using bodily movements. They used either partial or entire bodily movements in order to play the games properly. *Physically interactive games should be developed making children physically more active during gameplay.* (DP)

Two different gameplay interactions between children and game interface were performed in physically interactive games. One is interacting game environment via indirect interaction (motion-driven interactive game) and another is interacting game environment via direct interaction (motion-controlled interactive game). In the present study, it was concluded that direct interaction is more motivated than indirect interaction. As a conclusion of this, motion-controlled interactive games were liked and motivated children more than motion-driven interactive games among developed physically interactive games. Children can also focus easily on gameplay part in motion-controlled interactive games. *Direct interaction should be preferred in some educational content that children are needed to have high attention and motivation.* (DP)

Physically interactive games have new gameplay and interaction characteristics that bring new immersive game environment for children (Höysniemi, 2006). Similarly, in the present study, while children were trying to make bodily movements, they immersed feeling that they were as main character in games. This made some children walk through left or right direction in classroom like the avatars during gameplay. *Children should be given visual interaction regarding exact camera position while they are playing physically interactive games.* (DP)

5.8 Gameplay Requirements of Playing Physically Interactive Games

Main requirements that physically interactive games bring are using bodily movements to control the game environment and play the game. Because players are supposed to use bodily movements while playing physically interactive games, they expend energy to play these games (Sell, Lillie & Taylor, 2008). Therefore, players are needed to have enough time for resting in physically interactive games (Höysniemi et al., 2004). In the present study, children showed different gameplay performance in games. Playing developed games was hard for some of children, especially girls. They were tired of playing developed physically interactive games. *Physically interactive games should have short term gameplay sessions because they require bodily efforts to play*. (DP) Some children getting tired in games played with low motivation. *In physically interactive games, children should be given resting time while they are playing the games.* (DP)

Physically interactive games require bodily movements making players expand energy while playing the games. Studies (i.e. Barkley & Penko, 2009) focusing on energy expenditure concluded that there were gender differences in expending energy in physically interactive games. Similarly in the present study, it was expected that girls and boys had different gameplay performance. Girls started the games with a high physical performance, but during the gameplay, their performances decreased gradually. However, boys' performances were stable during the gameplay. *Duration of gameplay in physically interactive games should be determined considering children's age and physical characteristics.* (DP) Besides, *expected bodily movements from children in physically interactive games should be determined basing on children's age and physical characteristics.* (DP)

Using camera screen brings additional components to physically interactive games when they are compared to classical games. Managing all components in game and controlling all parts simultaneously are important gameplay requirements in

physically interactive games. Subrahmanyam, Greenfield, Kraut and Gross (2001) concluded that "another skill incorporated in playing computer and video games is divided visual attention, the skill of keeping track of a lot of different things at the same time" (p.14). Similarly, in the present study, some children had difficulty in managing all parts of games including camera screen. Effective and efficient gameplay was directly related to correct posture in camera-screen. Correct posture was needed to be maintained during gameplay. *Easily controllable and manageable game environment should be designed and developed in physically interactive games.* (DP)

5.9 Evaluation of Children's Performance in Physically Interactive Games

In the present study, the subjects of Physical Education and Mathematics were integrated within physically interactive game environment. Evaluation of players' performance in physically interactive games is a difficult issue. Kostomaj and Boh (2009) stated that "evaluation is complex, as the coordination of mental and physical skills is required for successful playing" (p.145). Children's success in designed and developed games was related to both children's physical performance and academic success. Similar to Kostomaj and Boh's (2009) conclusion, it was hard to evaluate children's success in Mathematics and Physical Education at the same time. In this study, children's performance in Physical Education was influenced by their Mathematics achievements. Besides, children's success in Mathematics was deterministic in their achievements in Physical Education. When children made mistakes in making physical movements, they couldn't get high score in Mathematics. Similarly, when children couldn't have enough success in Mathematics, an assumption might be considered that children couldn't make correct bodily movements. *Evaluation of children's performance should be considered and evaluated jointly with related subject matters as summative evaluation.* (DP)

Children's performance regarding making proper and expected bodily movements in physically interactive games were also needed to evaluate. Concerning children's

actions in games, it was concluded that they needed to have a tolerance regarding their mistakes. Therefore, *children should be given a right allowing them making mistakes without getting bored or getting lost the game.* (DP) Children liked physically interactive games that allow children to make mistakes during gameplay. They didn't like games that had one action which caused one results in the game. *Physically interactive games should be designed that children are expected to make mistakes and have tolerance that are not directly related to getting lost the games.* (DP)

5.10 Differences between Teachers' and Children's Considerations

Computer games have been attracting teachers' attention gradually in recent years with big potential for integrating and implementing within classrooms (Papastergiou, 2009). It is obvious that "there is no doubt that the role of the teacher is very important with respect to how the game becomes a learning process" (Gros, 2007, p.35). In the present study, Physical Education teachers' and Mathematics teachers' considerations as subject-matter experts were taken into account during design phase of physically interactive educational games. Mumtaz (2001) claimed that "teachers could use computer games in the classroom that promote exploratory learning, problem solving skills, thinking skills, memory, perseverance, imagination, collaboration and team work. In order to do this, the teachers themselves must be confident about using them". Gros (2007) stated that "the basic function of the teacher is to provide elements of analysis and reflection that allow work to be done on the contents of the game" (p.35).

It is important to get adequate feedback from teachers in order to design and develop educationally beneficial physically interactive games. Gros (2007) stated that "teachers with little experience in the use of videogames are reluctant to use them. They feel insecure and require significant support during the process" (p.35). Similarly, it was hard to get feedback from Physical Education and Mathematics teachers because they hadn't enough experience in computer games and specifically

physically interactive games. However, when teachers played physically interactive game prototypes, they imagined easily and gave valuable feedback regarding the prototypes. *Teachers should be given computer-based game prototypes for each physically interactive game including different gameplay and interaction characteristics.* (DP)

It was concluded that almost all teachers tried to make developed games easier but more educational. Their main focus was designing and developing more educational and simple games for children. This might be the results of their attitudes toward computer games. Gros (2007) stated that "it is difficult for teachers to identify how a particular game is relevant to some component of the curriculum, as well as the appropriateness of the content within the game" (p.35). Similarly, in the present study, all teachers had little experiences in playing computer games. It might be concluded that they gave more importance to drill and practice applications than computer games. On the contrary, children asked more enjoyable and difficult games. They tried to make developed games more difficult and enjoyable. *During design process, teachers' considerations should be focused more on a specific educational subject regarding how it is embedded within game environment than gameplay parts.* (DP) Besides, *children's considerations should be focused more on gameplay parts regarding how the game could be designed more enjoyable and entertaining.* (DP)

5.11 Summary of the Design Principles

Design principles determined in the present study are summarized in Table 5.1. In the table, design principles are categorized as Design Process and Development Process. Design principles that should be taken into consideration during design phase are given under Design Process. They are mainly defining and determining concept of games, educational concepts, themes, objects, characters, etc. Design principles that should be taken into consideration during development phase are

given under Development Process. They are mainly implemented after the design phase. They were used while developing physically interactive educational games.

Table 5.1: Summary of final design principles

Summary of Final Design Principles	
Design Process	**Development Process**
• Focus should be appropriateness of educational content, • Design should be usable and attractive including game objects that are similar to objects, characters or animations in cartoon movies, • Camera screen should be designed big in size and effectively usable considering educational subject and game concept, • Game components such as camera screen, navigation part and gameplay part should be close to each other, • Avatar based physically interactive game concepts should be preferred to design to attract children's attention, • Navigation parts should be designed to allow children to control the game environment easily, • Navigations and educational content should be designed close to camera screen to help children control entire game components easily, • Multiplayer options of games should be designed carefully whether children have enough space to play properly, • Educational subject should be given hidden that children can feel playing games instead of making only drill and practice, • Game concept should support large physical gameplay space for children that they can touch expected objects without making any mistakes accidentally,	• Boys' and girls' considerations should be taken into account separately to encounter their needs and expectations, • Colors, animations and sound effects should be selected considering children's age characteristics, • Ideal camera position, camera angle and distance from camera should be instructed clearly not only before the game but also during the gameplay periodically, • Effective animations showing exact camera position in camera screen should be given during gameplay periodically, • Children should have gameplay options about whether they could play with their friends cooperatively, • Different game genres and gameplay characteristics should be combined with or embedded within the games to present diverse gameplay environment, • Easily performable bodily movements should be considered basing on gender differences, • Instructions about aims of games and necessary physically movements should be given to children by using multiple sources such as sounds, written texts and animations, • It should be considered that children are needed to easily adapt to play the games via effective and efficient instructions regarding how to play, • Games should be developed making

- A wide diversity of game concepts including different game objects should be considered to attract children's attention,
- Innovative characteristics of games should be focused on more,
- Direct interaction should be preferred in some educational content that children are needed to have high attention and motivation,
- Easily controllable and manageable game environment should be designed,
- Games should be designed that children are expected to make mistakes and have tolerance that are not directly related to getting lost the games,
- Teachers should be given computer-based game prototypes for each game including different gameplay and interaction characteristics,
- Teachers' considerations should be focused more on a specific educational subject regarding how it is embedded within game environment than gameplay parts,
- Children's considerations should be focused more on gameplay parts regarding how the game could be designed more enjoyable and entertaining,
- children physically more active during gameplay,
- Children should be given visual interaction regarding exact camera position while they are playing,
- Children should be given resting time while they are playing the games,
- Duration of gameplay should be determined considering children's age and physical characteristics,
- Expected bodily movements from children should be determined basing on children's age and physical characteristics,
- Evaluation of children's performance should be considered and evaluated jointly with related subject matters as summative evaluation,
- Children should be given a right allowing them making mistakes without getting bored or getting lost the game,
- Games should have short term gameplay sessions because they require bodily efforts to play,
- Focus should be on transparency of educational content and easily playable characteristics,

5.12 Conclusion

Physically interactive games have innovative and unique gameplay characteristics and potential regarding beneficial features for children. Designing the most appropriate physically interactive games with highly educational values may have power about presenting children enjoyable and educational playing / learning environments. This study mainly focused on designing principles of physically interactive educational games for children.

It is important to gather needs and expectations of not only children, as target audience, but also teachers, as subject-matter experts. In order to design and develop educationally the most beneficial physically interactive games for children, considerations of teachers and children should be taken into account. The more iteration regarding collecting data from teachers and children during the design and implementation phases researcher performs, the more well-designed and appropriate physically interactive educational games s/he designs and develops. In the present study, during design and development phases, a model below (Figure 5.1) was followed. It is obviously encouraged to conduct more than one interaction while collecting data from teachers and children.

At the end of the study, it might be concluded that physically interactive games bring new outcomes regarding differences in gameplay, game habits and game preferences between girls and boys, educational aspects of games and teachers' and children's expectations from educational games. Design principles of the study were given in this chapter including different points of views.

As suggested above, there are still many areas which need to be studied about design and development of physically interactive games. It is hoped that these findings will help teachers, children, practitioners and researchers who want to study designing issues of physically interactive games.

5.13 Suggestions for Practitioners

Results of the present study may also help practitioners when they attempt to design and develop physically interactive games for educational purposes. Practitioners might use design principles defined in the study according to the categorization in Table 5.1. Under the light of aforementioned design principles, following steps might be taken into considerations by practitioners;

- Preliminary design principles (Design Phase)

    - Define preliminary targets of physically interactive educational game,
- Determine educational subject (Design Phase)
    - Determine educational subject,
    - Determine educational topic,
    - Determine educational acquisitions,
    - Get feedback from field experts,
- Develop game prototype (Design Phase)
    - Define computer-based vs. paper-based prototype (Design Phase)
        - Computer-based prototype should be playable characteristics that should give clue to players about features of developed games,
        - Paper-based prototype should have all screenshots of games explaining characteristics developed games,
    - Define size and place of camera screen,
    - Define size of gameplay part,
    - Define navigation part,
    - Define educational content,
    - Draw carton-like objects,
- Teachers' feedback (Design Phase)
    - Make teachers play,
        - Teachers as subject-matter experts should play the games first. This will give more information about how to play developed game and their characteristics,
    - Show teachers how to play,
    - Inform teachers about the gameplay,
    - Inform teachers about the content,
- Develop low fidelity prototype (Development Phase)
    - Design camera-screen functionality,
    - Design gameplay part functionality,
    - Design navigation part functionality,

    - Design cartoon-like object functionality,
    - Design educational content functionality,
- Children's feedback (Development Phase)
    - Make children play,
        - Show developed games to target audience and make them to play developed game. Afterwards, get adequate feedback from target audience,
    - Inform children about the content,
    - Inform children about the gameplay,
- Develop high fidelity prototype (Development Phase)
    - Build physical gameplay space,
    - Build avatar-based interaction,
    - Build (in)direct interaction,
    - Build how to play via animation,
    - Build ideal camera usage,
- Children's feedback (Pilot Implementation Phase)
    - Make target audience play developed game and learn their considerations,
- Children's feedback (Final Implementation Phase)
    - Make target audience play developed game and learn their considerations,
- Develop final version of game
    - Finalize the game basing on gameplay (tolerance of mistakes, duration),
    - Finalize manageable and controllable gameplay environment (if necessary),
    - Finalize ideal camera usage (if necessary),
- Refined design principles
    - Write last thoughts as final design principles,

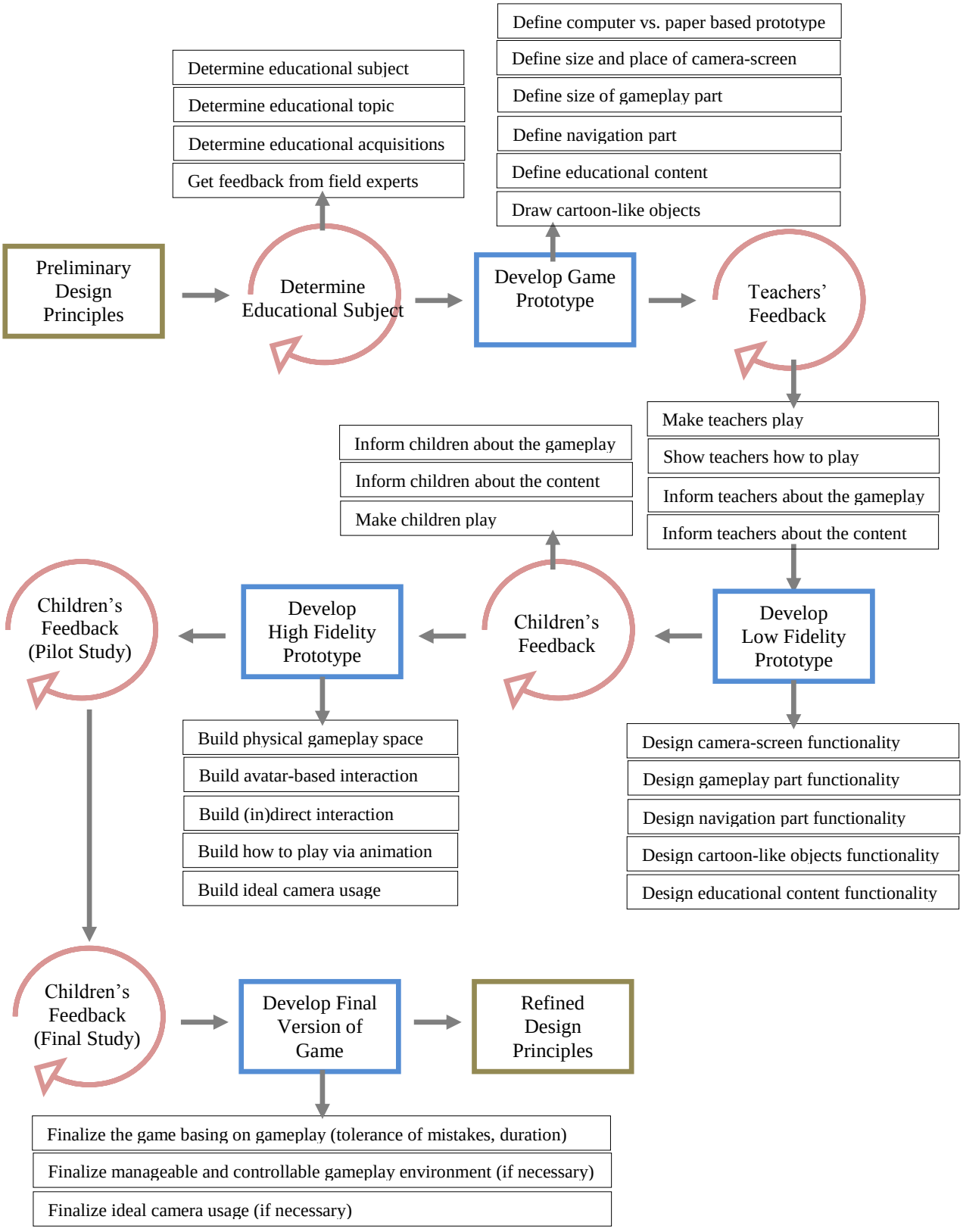


Figure 5.18: Physically Interactive Educational Game Design and Development Guideline

5.14 Suggestions for Future Research

Even though the findings of the study cannot be generalized, some of the implications of this study could be presented. Results of the current study revealed subject matter experts' and target audiences' needs, expectations and suggestions in order to design and develop an educational game. Both Physical Education and Mathematics teachers' considerations regarding physically interactive educational games were taken into account. Besides, children's points of views about and expectations from playing physically interactive educational games were investigated to define design principles of physically interactive educational games properly.

Since there were limitations in the current study and previous research in the area, following suggestions and recommendations might be helpful for the future researchers;

- Based on the results of the present study, differences in needs and expectations from educational games between teachers and children could be investigated.
- Physically interactive games require using camera-screen to control and play the game. Effective and efficient camera use of children could be studied.
- In the present study, more iteration might give more clues about design principles of physically interactive educational games. The researchers might conduct similar research with more iteration with teachers and children.
- Differences between motion-controlled interactive games and motion-driven interactive games could be investigated.
- Defined design principles of the present study could be used to design and develop physically interactive educational games for future research.
- Physically interactive games have unique characteristics and most of children have no experiences in playing these games. Innovation effects of physically interactive games could be examined.

- Gender differences regarding playing physically interactive games between boys and girls could be investigated.
- Getting benefits and power of new technologies such as Microsoft Kinect, physically interactive educational games with new gameplay, educational content and theme might be designed and developed.

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APPENDIX A

ÖĞRETMEN OYUN TASARIM MÜLAKAT SORULARI

A.1 EĞİTSEL İÇERİK

1) Uzmanlık alanınız ile ilgili eğitsel oyun ortamları öğrenciler için faydalı olabilir mi? (*Evet ise nasıl?*)

2) Bu oyun hedef kitlenin ihtiyaç ve beklentileri doğrultusunda eğitsel olarak fayda sağlayabilir mi?

3) Bu oyunun eğitsel olarak daha yararlı olması için bulunabileceğiniz tavsiyeler neler olabilir? Örneğin;

- **a.** Kamera kullanımının eğitsel faydaya etkisi
- **b.** Yazılı, görsel ve işitsel öğelerin eğitsel faydaya etkileri
- **c.** Öğrencilerin dikkat ve motivasyonlarını arttırıcı faktörler

4) Bu oyun kapsamında eğitsel içerik ve içeriğin veriliş yöntemi bu oyun ortamına uygun mu? (*Değil ise başka nasıl verilebilirdi?*)

5) Uzmanlık alanınızı da göz önünde tutarak, öğrencilerin oyun içerisindeki başarılarının / performanslarının değerlendirilmesi nasıl olmalı?

A.2 GÖRSEL TASARIM

1) Oyunu öğrencilerin daha etkin ve etkili kullanmaları için görsel tasarımın sunumu nasıl olmalı?

2) Oyunda kullanılan yazılı, görsel ve işitsel öğeler ile animasyonların öğrencilerin ihtiyaç ve beklentilerini karşılayabileceğini düşünüyor musunuz?

3) Kamera alanının oyun içerisindeki görsel olarak tasarımı ve kullanımı doğru mu? (*Değil ise nasıl olmalı?*)

4) Oyunda karakter (*avatar*) kullanımı olmalı mı?

5) Oyun ekranındaki bilgi bölümü ile oyunun diğer bölümlerinin tasarımı oyun alanında nasıl sunulmalı?

A.3 KAMERA KULLANIMI

1) Oyun kurgusuna bağlı olarak, kamera kullanımı uygun mu?

2) Öğrencilerin etkin ve etkili kamera kullanımlarının sağlanması için önerileriniz nelerdir? Dikkat edilmesi gereken noktaların hangileri olduğunu düşünüyorsunuz?

3) Kamera alanı içerisinde öğrencilerden yapmaları beklenilen hareketler nasıl olmalı?

4) Oyunun kurgusuna bağlı olarak, oyun ekranındaki kamera alanının görsel olarak sunumu nasıl olmalı?

5) Öğrencilere doğru kamera kullanımı ile ilgili ne tür bilgilerin hangi yöntem ile verilmesini uygun buluyorsunuz?

A.4 ETKİLEŞİM

1) Öğrencilerin oyun ortamı ve eğitsel içerik ile olan etkileşimleri nasıl olmalı?

2) Beden Eğitimi ve Matematik konuları ile ilgili alıştırmalar yapmaları için oyunda sunulan etkileşimler uygun mu? (*Değil ise nasıl olmalı?*)

3) Öğrencilerin oyunda kolayca etkileşime geçebilmeleri için bu oyunda kameranın kullanımı uygun mu? (*Değil ise nasıl olmalı?*)

4) Öğrencilerin oyun oynarken yapmaları gereken fiziksel hareketler kendi özelliklerine uygun olacak şekilde eğitsel içerik ile uyumlu mu? (*Değil ise nasıl olmalı?*)

5) Öğrencilerin oyun ortamı ile istenilen biçimde etkileşime girebilmeleri için oyunda nelerin yapılmasını tavsiye edersiniz?

APPENDIX B

ÖĞRENCİ OYUN BİLGİ ANKETİ

1. Cinsiyetin: O Erkek O Kız

2. Yaşın: .....

3. Kaçıncı sınıftasın: .....

4. Bilgisayarın var mı? O Evet O Hayır

5. Günde ortalama kaç saat BİLGİSAYAR kullanıyorsun?

O Hiç Kullanmıyorum O 0-2 Saat O 2-4 Saat O 4 Saatten Fazla

6. Günde ortalama kaç saat OYUN oynuyorsun?

O Hiç Oynamıyorum O 0-2 Saat O 2-4 Saat O 4 Saatten Fazla

7. Şimdiye kadar hiç kamera kullanarak oyun oynadın mı? O Evet O Hayır

8. En çok oynadığın 3 bilgisayar oyunun isimlerini sırasıyla yazabilir misin?

Birinci en çok sevdiğim: …….

İkinci en çok sevdiğim:……

Üçüncü en çok sevdiğim:…….

9. Bu oyunların hangi özelliklerini seviyorsun?

……

……

10. Bilgisayar oyunlarını genelde nerde oynarsın?

O Ev O Okul O Internet Kafe O Arkadaş O Diğer....…….

11. Bilgisayar oyunu oynama nedenin nedir?

O Stres atma

O Boş zaman değerlendirme

O Eğlence

O Zekâ geliştirme

O Sosyal bir ortamda bulunma

O Diğer …….

12. Ne tür oyunları tercih edersin?

O Tek kullanıcılı O Çok kullanıcılı

13. Sence bilgisayar oyunları zararlı mı? O Evet O Hayır (Evet ise neden?)

…….....……

……

14. Sence bilgisayar oyunları eğitim amaçlı kullanılabilir mi?

O Evet O Hayır (Evet ise nasıl?)

…….....……

……

APPENDIX C

ÖĞRENCİ OYUN TASARIMI MÜLAKAT SORULARI

C.1 GENEL

1) Daha önce kamera ile her hangi bir bilgisayar oyunu oynadın mı?

- Evet ise nasıl bir oyundu?

2) Bu tür kameralı oyunları oynadığın diğer oyunlar ile karşılaştırdığın zaman, eğlence olarak nasıl bir fark vardı?

- Olumlu yönleri nelerdi?
- Olumsuz yönleri nelerdi?

3) Bu tür kameralı oyunlar eğitimde kullanılabilir mi?

- Evet ise hangi dersler ve konular için daha uygun olabilir?

C.2 EĞİTSEL İÇERİK

4) Oyundaki eğitsel konu sana uygun muydu?

5) Eğitsel içerik oyunda başka türlü nasıl verilebilirdi?

6) Oyunun eğitsel olarak sana faydası olabileceğini düşünüyor musun?

7) Oyunda puan, can ve oyunun seviyesini belirten bilgilerin sana göre uygunluğu nasıldı?

- Oyun oynama süresi yeterli miydi?
- Oyundaki oynama hakkı yeterli miydi?
- Oyundaki zorluk seviyesi sana göre uygun muydu?

C.3 GÖRSEL TASARIM

8) Oyunda yardım, süre, puan, can ve oyunun seviyesini belirten bilgilerin verilme biçimleri nasıldı?

- Oyundaki renk ve ekran tasarımları nasıldı?

- Oyun oynama süresi anlaşılır mıydı?
- Oyunu nasıl oynayacağına dair verilen bilgiler anlaşılır mıydı?

9) Oyunda karakter kullanımı olmalı mıydı?

- Oyun ortamındaki karakter eğlenceli miydi?
- Oyun içerisinde başka ne tür karakterler olmasını isterdin?

10) Oyun oynama alanının büyüklüğü oyunu oynamak için yeterli miydi?

11) Oyundaki ses ve animasyonlar, oyun için uygun muydu?

- Rahatsızlık verici ses ve animasyonlar var mıydı?
- Başka ne tür ses ve animasyonlar olmasını isterdin?

12) Oyundaki oynamanı zorlaştıran veya seni rahatsız eden bir uygulama veya bölüm var mıydı?

- Oyunda olmasa daha iyi olur dediğin bölümler var mıydı?
- Evet ise nelerdi?

C.4 KAMERA KULLANIMI

13) Oyundaki kamera alanının büyüklüğü oyunu oynayabilmek için yeterli miydi?

14) Oyunda hem kamerayı kontrol etmek hem de oyunu oynamaya çalışmak zor geldi mi?

- Evet ise bu konuda ne tür zorluklar yaşadın?

15) Kamera alanı bunlardan farklı olarak başka nasıl olabilirdi?

16) Oyunda kameradaki pozisyonunu kaybetmemeye çalışmak zor oldu mu?

- Kamera alanı içinde yerini bozmamak için çaba gösterdin mi?
- Oyun içerisinde kamera alanında durman gereken yer zaman zaman gösterilse faydalı olur mu?

C.5 ETKİLEŞİM

17) Oyun ortamını fiziksel hareketler ile kontrol etmek zor geldi mi?

- Karşılaştığın zorluklar nelerdi?
- Başka ne tür fiziksel hareketler ile oyunu kontrol etmek isterdin?

18) Sana göre oyun ortamını fiziksel olarak kontrol etmek mi, yoksa fare ve klavye ile kontrol etmek mi daha kolaydı?

19) Oyun ortamında karakter kontrolü mü daha eğlenceli, yoksa onun dışındaki objeleri miydi?

- Uçak, farklı canavarlar vb.

20) Bu tür etkileşimli oyunları arkadaşınla oynamak ister miydin?

- İki kişilik bir oyun gibi
- Böyle bir oyunda oyundaki fiziksel etkileşimin nasıl olmasını isterdin?

APPENDIX D

ÖĞRENCİ OYUN DEĞERLENDİRME MÜLAKAT SORULARI

Aşağıdaki sorulara oynadığın kameralı oyunlar ile ilgili görüşlerin doğrultusunda cevaplar vermelisin.

D.1 EĞİTSEL İÇERİK

Kameralı oyunlar dersler ile ilgili daha fazla pratik yapmama yardımcı olur			
Oyunlardaki eğitsel içerik seviyeme uygundu			
Oyunların nasıl oynanacağına dair verilen bilgiler yeterliydi			
Bu tür oyunlarla eğitsel konular daha iyi öğrenilir			

D.2 GÖRSEL TASARIM

Oyunlardaki renk seçimi ve ekran tasarımları güzeldi			
Oyunların oynama süreleri anlaşılırdı			
Oyunlardaki seviyeler arası geçiş anlaşılırdı			
Oyunlarda kaç hakkın kaldığı anlaşılırdı			
Oyunlarda nasıl puan toplayacağım anlaşılırdı			
Oyunlardaki ses efektleri ve müzikler rahatsızlık vericiydi			
Oyunlardaki animasyonlar rahatsızlık vericiydi			
Oyunlarda kullanılan karakterler eğlenceliydi			
Oyun oynama alanının büyüklüğü yeterliydi			

D.3 KAMERA KULLANIMI

Oyunlarda ekranda kendimi gördüğüm alanının büyüklüğü yeterliydi			
Oyunlarda hem kamerayı kontrol etmek hem de oyunu oynamak zordu			
Oyunları oynarken kameradaki duruşumu kontrol etmek zordu			
Oyunlarda kamera alanındaki yerimi bozmamak için fazla çaba gösterdim			
Oyunların içerisinde kameradaki yerimi gösteren şekiller oyunu oynamama yardımcı oldu			

D.4 ETKİLEŞİM

Oyunları fiziksel hareketlerle kontrol etmek zordu			
Fare ve klavye ile oyunu oynamak daha kolay olurdu			
Fare ve klavye ile oynamak daha eğlenceli olurdu			
Oyunlardaki karakterleri kontrol etmek eğlenceliydi			
Oyunları arkadaşımla iki kişi oynamak daha eğlenceli olurdu			
Oyunlarda insan yerine uçak vb. değişik karakterleri kontrol etmek daha eğlenceli olurdu			
Oyun ekranındaki şekillere direk dokunmak, onları hareket ettirmekten daha eğlenceliydi			

APPENDIX E

TEACHERS' CODE LIST

Educational Content	**M1**	**M2**	**M3**	**PE1**	**PE2**
Appropriate educational content for Mathematics	*	*	*	-	-
Appropriate educational content for Phys. Educ.	-	-	-	*	*
Attractively embedded educational content	*	*	*	*	*
Learner-centered activities	*	*	*	-	-
Game-like learning activities for children	*	*	*	*	*
Motivating children effectively	*	*	*	*	*
Giving immediate feedback	*	*	-	*	*
Activity-based learning	*	*	*	*	*
Lack of educational material	*	*	*	*	*
Educational software characteristics	*	*	*	-	*
Understanding teachers' needs and expectations	*	*	*	*	*
Appropriate instructions for children in software	*	*	*	-	-
Visual, vocal, animation based instructions	*	*	-	*	*
A role play animation for bodily-movements	*	*	-	*	*

Children's age level as deterministic factor	*	*	*	*	*
Clear movements for children's cognitive level	*	-	*	*	*
Educational content should be deterministic factor for challenge	*	*	*	*	*
Periodically given feedbacks about posture in camera screen	*	-	*	*	*
More interaction with less camera-based control	*	-	*	*	*
Summative feedbacks at the end with visual and animated components	*	-	*	*	*
Aim of children to finish game	*	*	*	-	-
Time limitation to interact with educational content	*	*	*	-	-
Limited part of educational content for each level	*	*	*	-	-
More visual educational content than written ones	-	*	*	-	-
Difficulties in determination of evaluation criteria for Phys. Educ.	*	*	*	*	*
Negative attitudes toward Mathematics course	-	*	*	-	-
Negative attitudes toward making physical activities for educational purposes	-	-	-	*	*
Less complicated rules	*	*	*	-	-
Educational power of games	*	*	*	*	*

Visual Design					
Attractive camera-screen with big size	*	*	*	*	*
Location of camera-screen that is backward of gameplay part	*	-	*	*	-
Importance of controlling avatar with bodily movements	-	*	*	*	*
Background music	-	*	*	-	*
Sound effects	-	*	*	-	*
Close navigation part to gameplay part	*	-	*	*	-
Funny and usable game design	*	*	*	*	*
Color selection	-	*	*	-	*
Cartoon-movies like animation	-	*	*	-	*
Simple visual design for children's age level	*	*	*	*	*
Ignorance of gender difference in design	*	*	*	*	*
Self-controlling game environments	*	*	*	*	*
Feeling self-confident in games	*	*	*	*	-
Camera Use					
Effective camera use	*	*	*	*	*
Efficient camera use	*	*	*	*	*
Correct camera use	*	*	*	*	*
Potential to get lost ideal camera position in game	-	-	-	*	*
Lack of gameplay experiences in physically interactive games	*	*	*	*	*

Innovative effect of physically interactive games	*	-	*	*	*
Low motivation with getting lost in camera	*	*	*	*	*
Clear instructions to effective camera use	*	-	*	*	*
Controllable camera-centered game environment	*	*	*	*	*
Relationship between effective camera use and success in games	*	*	*	*	*
Interaction					
Indirect interaction with educational content in motion-driven interactive games	*	*	*	*	*
Direct interaction with educational content in motion-controlled interactive games	*	*	*	*	*
Attractiveness of avatar-driven interaction	*	-	*	*	-
Highly motivated gameplay needs in motion-driven interactive games	-	*	*	*	*
Difficulties in gameplay in motion-driven interactive games	*	*	*	*	-
Difficulties in control in motion-driven interactive games	*	*	*	*	-
Difficulties in educational benefits in motion-driven interactive games	-	*	*	*	*
Innovative interaction characteristics of physically interactive games	*	*	*	*	*

APPENDIX F

CHILDREN'S CODE LIST

Common Points	CM1	CM2	CM3	CM4	CM5	CF1	CF2	CF3	CF4	CF5
Experiences in physically interactive gameplay	*	-	-	*	-	-	-	-	-	-
Appropriateness of Mathematics course in use of educational games	*	*	*	*	*	*	*	*	*	*
Appropriateness of Physical Education course in use of educational games	*	*	*	*	*	*	*	*	*	*
Appropriateness of Mathematics in physically interactive gameplay environment	*	*	*	*	*	*	*	*	*	*
Controlling bodily movements	-	-	*	-	-	*	*	*	-	-
Free bodily movements	*	*	-	*	*	-	-	-	*	*
Cartoon-like drawings	*	*	*	*	*	*	*	*	*	*
Even vs. Odd Game										
Beneficial aspects of game	*	*	*	*	*	*	*	*	*	*
Appropriateness of educational content	*	*	*	*	*	*	*	*	*	*
Similar bodily movements in Phys. Educ. course	-	-	*	*	*	*	-	*	*	*
Gameplay rights	*	*	*	*	*	*	*	*	*	*
Levels	*	*	*	-	-	*	*	*	*	*

Easiness of gameplay	*	*	*	*	*	-	-	*	-	-
Physically interactive game preference	*	*	*	*	*	-	-	-	*	-
Attractiveness of bodily movements	*	*	*	*	*	*	*	-	*	-
Likeness of visual objects	*	*	*	*	*	*	*	*	*	*
Avatar appearance	*	*	*	*	*	*	*	*	*	*
Size of gameplay part	*	*	*	*	*	-	*	*	-	-
Animation	*	*	*	*	*	*	*	*	*	*
Disturbing parts	-	-	-	-	-	-	-	-	-	-
Appropriateness of instructions about how to play	*	*	-	*	*	*	*	*	-	*
Small camera screen	-	-	-	*	*	*	*	*	-	*
Periodically given feedback about how to play	*	*	*	*	*	*	*	*	*	*
High concentration requirements	-	-	-	*	-	*	*	*	*	-
Easily understandable bodily movements	-	*	*	*	*	*	*	-	*	*
Easily achievable bodily movements	-	*	*	*	-	*	*	-	*	*
Excitement in controlling avatar via bodily movements	*	*	*	*	*	*	*	*	*	*
Multiplayer game environment	*	*	-	*	*	*	-	*	*	*
Drive Your Shape Game										
Beneficial aspects of game	*	*	*	*	*	*	*	*	*	*
Appropriateness of educational content	*	*	*	*	*	*	*	*	*	*
Similar bodily movements in Phys. Educ. course	-	-	*	-	*	-	-	*	*	*
Gameplay rights	*	*	*	*	*	*	*	*	*	*
Levels	*	-	*	*	*	*	*	*	-	-
Easiness of gameplay	*	*	*	*	*	*	-	-	-	-
Excitement characteristics of driving plane	*	*	*	*	*	-	-	*	-	-

Likeness of visual objects	*	*	*	*	*	*	*	*	*	*
Small camera screen	-	-	-	-	-	*	*	*	*	*
Likeness of animations	*	*	*	*	*	*	*	*	*	*
Likeness of sound effects	*	*	*	*	*	*	*	*	*	*
Likeness of background music	*	*	*	*	*	*	*	*	*	*
Location of camera-screen	*	*	*	*	*	*	*	*	*	*
Difficulties in focusing both camera and gameplay	-	-	-	-	*	*	*	*	*	*
Periodically given feedback about how to play	*	*	*	*	*	*	*	*	*	*
Complaints about indirect interaction	*	*	*	*	*	*	*	*	*	*
High concentration requirements	-	-	*	*	-	*	-	-	*	-
Multiplayer game environment	-	-	-	-	-	-	-	-	-	-
Save the Numbers Game										
Presentation of educational content	*	*	*	*	*	*	*	*	*	*
Appropriateness of educational content	*	*	*	*	*	*	*	*	*	*
Levels	*	*	*	*	*	*	*	*	*	*
Challenge characteristics	*	*	*	*	*	*	*	*	*	*
Gameplay rights	*	*	*	*	*	*	*	*	*	*
Easiness of gameplay	*	*	*	*	*	*	*	*	*	*
Likeness of gameplay	*	*	*	*	*	*	*	*	*	*
Likeness of game concept	*	*	*	*	*	*	*	*	*	*
Likeness of visual design components	*	*	*	*	*	*	*	*	*	*
Easily controllable game environment	-	*	*	*	*	*	*	*	*	*
Likeness of animations	*	*	*	*	*	*	*	*	*	*
Likeness of sound effects	*	*	*	*	*	*	*	*	*	*
Likeness of background music	*	*	*	*	*	*	*	*	*	*
Periodically given feedback about how to	-	-	-	-	-	-	*	-	*	-

play										
Appropriateness of presentation of how to play	*	*	*	*	*	*	*	*	*	*
Likeness of camera use during game	*	*	*	*	*	*	*	*	*	*
Likeness of camera size	*	*	*	*	*	*	*	*	*	*
Multiplayer game environment	-	-	-	-	*	*	*	*	*	*
Find the Next Game										
Appropriateness of educational content	*	*	*	*	*	*	*	*	*	*
Beneficial aspects of game	*	*	*	*	*	*	*	*	*	*
Appropriate questions for each level	*	*	*	*	*	*	*	*	*	*
Likeness of gameplay	*	*	*	*	-	-	-	-	*	*
Likeness of visual design components	*	*	*	*	*	*	*	*	*	*
Appropriateness of presentation of pattern sequences	-	-	*	-	-	-	-	*	-	-
Likeness of precise camera movements	-	*	*	-	-	-	-	*	-	-
Likeness of animation	*	*	*	*	*	*	*	*	*	*
Likeness of sound effects	*	*	*	*	*	*	*	*	*	*
Likeness of game concept	*	*	*	*	*	*	*	*	*	*
More concentration requirements for ideal camera position	*	*	*	*	*	*	*	*	*	*
Likeness of camera size	*	*	*	*	*	*	*	*	*	*
Periodically given feedback about how to play	*	*	*	*	*	*	*	*	*	*
Easiness of gameplay	*	-	*	-	*	-	-	-	-	*
Multiplayer game environment	-	-	-	-	-	-	-	-	-	-

CURRICULUM VITAE

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BS	Gazi University Computer Education	2003
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2003-2010	METU Department of Computer Education and Instructional Technology	Research Assistant
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FOREIGN LANGUAGES

Advanced English

SELECTED PUBLICATIONS

Book Chapter Publications

1. Antonietti, A., Colombo, B., Iannello, P., & Inal, Y. (2010). Students' metacognitive knowledge about distance education in virtual communities and multimedia environments. In C. F. MacTeer (Ed.) Distance Education. Nova Publishers.

2. Inal, Y., Akyol, Z., & Erden, O. (2008). Technological access points in Turkey: A case study on Internet Cafés and their roles in society. In T. Kidd & I. Chen (Eds.) Social Information Technology: Connecting Society and Cultural Issues. IDEA Group Reference.

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1. Tuzun, H., Yilmaz Soylu, M., Karakus, T., Inal, Y., & Kizilkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education,* 52, 68-77. (SSCI).

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3. Inal, Y. & Kiraz, E. (2008). Bilgisayar oyunları ideoloji içerir mi? Eğitsel ve Ticari Oyunlar Bakış. *Turkish Educational Science Journal,* 6(3), 523-544. (In Turkish)

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5. Inal, Y. & Cagiltay, K. (2007). Flow experiences of children in an interactive social game environment. *British Journal of Educational Technology,* 38(3), 455-464. (SSCI).

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1. Inal, Y., Dikici, A., Güngör, M. K. & Dinçer, K. (2011). Büyük ölçekli kurumsal yazılım geliştirme projelerinde penetrasyonun başarıya etkisi. 5. Ulusal Yazılım Mühendisliği Sempozyumu, Ankara, Turkiye.

2. Inal, Y. & Cagiltay, K. (2011). Making Children Actively Immersive in Educational Games: Physically Interactive Serious Game Design Case. ED-MEDIA 2011, Lisbon.

3. Inal, Y., Karakus, T. & Cagiltay, K. (2008). Designing narratology based educational games with non-players. Edutainment 2008, *Nanjing, China.*

4. Tuzun, H., Yilmaz Soylu, M., Karakus, T., Inal, Y., & Kizilkaya, G. (2008). The effects of computer games on primary school students' achievement and motivation in geography learning. *AERA Conference, New York, USA.*

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6. Inal, Y., Sancar, H. & Cagiltay, K. (2006). Children's Avatar Preferences and Their Personalities. *SITE 2006, Orlando, FL, USA.*

7. Bakar, A., Inal, Y. & Cagiltay, K. (2006). Use of Commercial Games for Educational Purposes: Will Today's Teacher Candidates Use Them in the Future? *ED-MEDIA Conference, Orlando, FL, USA.*

8. Karakus, T., Inal, Y. & Cagiltay, K. (2006). Preservice Computer Teachers' Selections of Game Design Dynamics Based upon Their Game Preferences, Habits and Technical Backgrounds. *ED-MEDIA Conference, Orlando, FL, USA.*

HOBBIES

Instructional Technologies, Theater, Computer Games, Swimming, Movies