Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Procedia Social and Behavioral Sciences 9 (2010) 709–716
Procedia
Social and Behavioral Sciences

WCLTA 2010

Math teachers' perspectives on using educational computer games in math education

Muhammet Demirbilek[a] *, Suzan Lema Tamer[b]

[a]Suleyman Demirel University, Faculty of Technical Education, Isparta 32260, Turkey
[b]Suleyman Demirel University, Faculty of Technical Education, Isparta 32260, Turkey

Abstract

By using a grounded theory approach, the purpose of this study is to develop a theoretical framework concerning the use of educational computer games in math education. Interviews (*n*=13) are conducted with math teachers living in Turkey. Data are analyzed according to constant comparative method. A model is formulated that the problems with using computer games in math classes, teaching the philosophy of teachers, requirements to use affect how to use computer games in the classes. They all directly affect the contributions of using computer games in math classes. Using educational computer games in math education can be understood through the background of five interrelated factors.

Keywords: Game-based learning, math education, computer games;

1. Introduction

Nowadays, the advancements in the field of science and technology greatly influence our lifestyles, impact our lives and cause changes in every aspect of them. These developments also affect the ways of teaching and learning. As a result technological innovations reveal a new generation of education tools designed to help students to learn in a non-traditional way. Today having computers in the classrooms is often not enough to embrace tech-savvy students. Therefore, teaching through games and simulations has a potential to engage today's students who are masters of multitasking through information and communication technologies. Furthermore, computer games are found to be one of the interesting and entertaining virtual environments and as an important strategy to support new approaches as a teaching tool for students (Yigit, 2007; Tuysuz, 2009).

1.1. Games in education

Motivational and immersive features of computer games may help and encourage students to sustain their interest and work on a specific subject in both formal and informal educational setting. Games may help educators for whom math is meaningful and may motivate learners to get involved and participate actively in the learning activities in the context.

* Muhammet Demirbilek. Tel.: 0090 246 211 1412; fax: 90 246 - 237 12 83.
E-mail address: mdbilek@sdu.edu.tr.

doi:10.1016/j.sbspro.2010.12.222

Researchers have started to explore the potential of computer games to support learning, and some have found that computer games have positive effects on learning (Egenfeldt-Nielsen, 2005; Gee, 2003; Prensky, 2001; Rosas et al., 2003). In a study about the use of computer games in education, researchers indicate that computer games attract the attention of students (Malone, 1981; Rieber, 1996), computer games encourage active learning and learning by doing (Garris, Ahlers, & Driskell, 2002). There are also experimental findings that educational computer games can be used as an effective learning method (Can, 2003; Mitchell & Savill-Smith, 2004; Tuzun, Yilmaz, Karakus, Inan, & Kizilkaya, 2006). There are also experimental findings that games can be a tool to improve learning and to figure out complicated subjects (Ricci, Salas, & Cannon-Bowers, 1996) and computer games can improve the cooperation among students (Kaptelin & Cole, 2002). Kirriemuir and McFarlane (2004) emphasize that games provide important acquirements such as strategic thinking, planning, communication and decision making. Zavaleta, Costa, Gouvea & Lima (2005) state that computer games improve cognitive, emotional, social and psychomotor skills of the students. It is also emphasized that games have effects on adolescents' emotional development and games are associated with psychoanalytic theories (Kuzu & Ural, 2008). According to the fact that games can be instructional when games are combined with the curriculum. Hence wit the use of computer games educational environment can be entertaining .Furthermore, Garris, Ahlers and Driskell (2002) state that computer games are appropriate for facilitating in education due to training and motivational features of computer games. Recent studies indicate that game based learning environments attract students' attention and increase student motivation (Abrams, 2008; Bakar, 2008; Ke, 2008; Papastergiou, 2009; Tuzun, Yilmaz-Soylu, Karakus, Inal, & Kizilkaya, 2009). Furthermore, Kramer (2000) shows that gamers are motivated as long as they control the game. Losing themselves in the activities and that the player is deeply engaged in the activities are explained with "Flow theory" by Chickszentmihaly in 1990. Chickszentmihaly explains that flow theory is a mental state that appears with the adoption of what he does (Bacon, Faust, Guerena, & McDowell, 2004). Game based learning is a useful method to learn especially when transformation of abstract terms into concrete ones, and when presenting extensive learning activities that they can do on their own pace. Consequently the educational potential of games can be grounded in various learning theories.

1.2. Usage of educational games in math education

Researches about computer games in education show that computer games can be used in subjects such as science, math, medicine, engineering, language learning, problem solving and developing strategic thinking (Bayırtepe & Tüzün, 2007; Mitchell & Savill-Smith, 2004).

Math, construction of the human mind, is a pure science branch. Although their widespread usage fields, math and mathematical thinking are considered as "difficult" all over the world and teaching them is usually a hard work. Its hardness comes both from its structure and from prejudice and fears about it (Umay, 1996). Anxiety towards math contains fear and avoidance. If fear and avoidance increase, then, this causes the belief that he/she cannot achieve the situation that he/she fears. In teaching math, technology and computer games are very important for changing abstract mathematical terms into concrete ones and removing or at least decreasing the anxiety against math (Baykul, 1999; Yıldız & Uyanık, 2004).

Abrams (2008) mentions that computer games are strong motivation tools for math lessons. When the development of math is examined in terms of game technology, there are some related areas between computer games and math; for example, genetic algorithms, intelligence games and artificial intelligence paradigms. It is thought that if educational computer games are placed to curriculums appropriately, it would help reaching the aims of the teaching (Yigit, 2007). Similarly, Ke (2008) finds that games are more motivating than pencil and paper activities in learning math; on the other hand however, no difference is noted in learning outcomes.

In a study, it is found that computer game utilizations in math teaching foster the success level of and creative ability of students in education and help to peer teaching and interaction that in turn creates a positive effect (Ozusaglam, 2007). In his experimental study in Texas, Neimeyer (2006) researches the effects of educational computer games on student success in mathematics. It is shown that the control group students are more successful. The results of another study show no significant difference for the effects of computer games on the success of students in math (Abrams, 2008).

In his experimental study in the USA, Kebritchi (2008) examines the effects of math games on the success in math and on the motivation of high school students. As a result of the study, it is seen that the students in the experiment group increase their grades in math. In terms of motivation, there is no significant difference in both groups. According to the findings of the interviews with teachers, individual differences have an important role at initial stage; however, the effects diminish gradually when students gain the required skills to play the game. Math game used in the study is thought as an effective learning and teaching tool to develop their math success and using games in math education is suggested by the teachers who attend to the research. It is indicated that efforts and support of teachers, previous math knowledge, and computer skills and English language knowledge of students are important for an effective game utilization.

1.3. The aim of the study

Digital games, an interactive technology within the multimedia learning environment, can effectively and interestingly foster learning processes, particularly among young learners. In spite of the enormous potential of digital game based learning, it is still difficult to integrate games into the curriculum of formal education. This is caused by the difficulty in identifying their relevance to the curriculum and potential benefits (Han & Zhang, 2008). Obviously there is no study about what the effective and necessary factors are. These factors affect computer game utilizations in lessons. So, the aim of the paper is to gather the information about using computer games by math teachers in K-12 schools and to reveal the grounded theory with the gained information.

The purpose of the paper is also to investigate the perspectives of math teachers on utilizing educational computer games in math education. In addition it is tried to find answers of the following questions:

- How are computer games used by math teachers (K-12)?
- Why are or are not math teachers interested in utilizing computer games?
- What are the reasons of utilizing or not utilizing computer games in their teaching?
- Which obstacles do they face?

2. Methodology

In the paper, the qualitative research design is applied in order to analyze the utilization condition of educational computer games by math teachers at K-12 schools during courses, and to put forth a model regarding the issue.

Within qualitative research methodology, the purpose is to obtain “in-depth information” by collecting long, much detailed and open-ended data; thus, there are fewer people and situations subject to the research, compared to the quantitative research methodology. The working group at the research consists of thirteen math teachers at K-12 schools in the province of Isparta. During sample selections, the voluntariness and eligibility of teachers are taken into account. 8 of 13 teachers are female, while the remaining 5 consists of men.

2.1. Data collection

In the paper, it is tried to determine the meanings arising from the experiences of participants by using qualitative research methodology (Lincoln & Guba, 1985; Strauss & Corbin, 1998). In this context, semi-structured interviews are benefited for data collection. According to Yildirim and Simsek (2005), it is possible to determine experiences, attitudes, opinions, intentions, comments, mental perceptions and reactions by virtue of interviews. Therefore semi-structured interview forms are elaborated. The questions within these forms are partially differed from each other in order to determine whether teachers utilize computer games during courses or not. In order to maintain internal validity of interview forms, these revised forms are submitted to three experts. The forms are finalized in line with the recommendations of the experts. Each interview with participants is recorded with a recorder only if permission is given by the participant. Each interview takes 10 to 20 minutes, and is carried out in single session. Due to research ethics, the names of participants are not revealed.

2.2. Data analysis

For data analysis, "grounded theory" method is applied. The reason for using grounded theory research model is to generate a theory via systematically collected data and analyzed throughout research process. One of the main features of this approach is to conduct data collection and analysis simultaneously. Glaser and Strauss (1967) call this process "constant comparative analysis". During the process, the data are analyzed immediately once they are collected; and the concepts, facts and processes are included within the following data collection phases. In this context, the records of interviews with math teachers are transformed into texts for the analysis. The collected raw data are transferred to Microsoft Word, and transformed into text. During the formation of transcripts, particular attention is paid for writing exact responses given by participants during the interviews. Besides, after the writing process, each transcript is compared with the equivalent audio record in order to make sure that those two records are the same. The written texts are read meticulously using line-by-line reading technique, and are subject to continuous comparison method. During the "open coding" process that is the first step of the data collection process, the interview texts (transcripts) are analyzed phrase-by-phrase and conceptual names are given. The interview texts are repeatedly reviewed for many times, and the codification operation is then carried out. According to Strauss and Corbin (1998), the researcher deals with the categories and the forming their specifications within open coding.

Besides, the researcher tries to determine how these categories vary with the size. In the second step, "Axial coding" is applied and association of the categories among themselves is tried. At this stage, the categories are gradually developed and connected to subcategories. The purpose of axial coding is to establish connection between categories, and to continue to develop categories according to their specifications and size. Therefore, the notes written during axial coding should reflect this objective. In "Selective coding", which represents the final step of the analysis, the integration of the categories is tired and a broader and more general scheme are tried to be constructed. At this stage, the concepts are integrated around a fundamental category; and the categories that necessitate further development and editing are filled. The memos and schemes during this phase reflect the depth and complexity of the theoretical view. The first step of integration is to decide on the main category. The main category represents the main theme of the research, and includes all analysis products that are summarized by "few words which seem to be explaining what the research is about" (Strauss & Corbin, 1998).

In order to ensure coder reliability regarding data analysis, first of all the interview records are coded separately by the researchers, before the consensuses and dissidences between both analyses are determined by calculating the convention percentage recommended by Miles and Huberman (1994). For this purpose, the reliability formula, "*Reliability = Consensus / (Consensus + Dissidence)*", recommended by Miles and Huberman (1994) is applied. Consequently, the reliability of research is calculated as 80%. A reliability result above 70% is accepted as satisfactory for the research (Miles & Huberman, 1994). Accordingly, the research can be accepted as reliable.

3. Findings

Among 13 math teachers who attend to the research, 8 are female and 5 are male. Moreover, one of the participants has never had the chance to use computer games and the chance to examine, 10 of them have had the chance to use computer games for educational reasons and have had the chance to examine but have never used. 2 of them both have background information and have used computer games in their lessons.

3.1. Problems resulting from computer games utilization in math classes

Some of the teachers mention some "problems in classroom management" caused by in class computer game utilization and they state that "the control of the class may be lost". Many teachers tell that among the problems caused by computer game utilization in lessons, there are "deviation from the goal of the lesson" and "losing the priority of math and thinking the lesson as only the time for playing game". Additionally, teachers tell that there are some problems caused by "the problem about essential technical infrastructure for using computer games (problems caused by computers or power cuts) can disrupt the lesson".

3.2. Teaching philosophy of the teachers

In the category that teachers are examined as teaching philosophy that includes the opinions of the teachers on computer game utilization and the clues about what they think about computer games. Some of the teachers indicate that "computer games should not be fun-oriented", instead games should be "topic-based rather"; students should be "aware of studying when they are playing games"; games should be perceived as a "tool". Some of the teachers indicate that because of the nature of math "using games in math teaching is not appropriate", "board and chalk are indispensable factors in math teaching". Some of the teachers who attend to the research indicate that "computer game utilization in math lesson in the secondary school would not provide any benefit" or they believe that "its educational potential is very low". On the contrary, there are some teachers who say that "utilizing computers would affect education positively if the deficiencies of hardware requirements are solved".

3.3. Requirements to use

Teachers indicate that before using computer games in the classes, appropriate class conditions should be provided. Many of the teachers state that "adequacy of hardware" should be provided. To use computer games, suitable environments should be provided. While some teachers tell that "each student should have a computer" and some tell that "a computer and a projection device is enough". Many teachers indicate that there is insufficiency in software. When most of these teachers complain that the current software is not in line with the syllabus, some complain that current software is in English and there is no Turkish software. They indicate that well-qualified software which helps them to teach the topic deeply and is cheap enough should be provided. Teachers mention that "using computer games in the lessons should be encouraged", "there should be computer game utilization in the curriculum", "appropriate games and their instructions should be added to the curriculum". Some of the teachers indicate that "because of the anxiety of not being able to complete all the curriculum topics, and because they have a lot of topics to teach, they don't use computer games. If the intensity of the curriculum is decreased, they can use the computer games in their lessons". Some of the teachers tell that only when curriculum and testing system are changed, can they use the computer games in their lessons.

Teachers indicate that there is lack of information about the technology so "before using educational computer games in the lessons, teachers should take education". "Small classroom size" is another factor which should be provided to use computer games in lessons. Teachers usually state that "the success level of the class should be high" to use the computer games. Another requirement about using computer games in the class is that "students should have enough computer proficiency", say teachers. Teachers indicate that "students should have enough knowledge about the topic" otherwise "they will not be able to play the game". The fact that "students are interested in computer games" is effective in using computer games in lessons. However, teachers tell that "students are already interested in these games" and "by using this interest in a positive way, the success of the education process would increase".

3.4. How to use

In this category, there are findings about how and why to utilize computer games in math lessons. There are some opinions of the participants about utilizing computer games with "evaluation purpose" and "remediation stage" as well as "reinforcements and elimination of deficiencies". Most of the teachers express that computer games could be employed when students' attention level is low to the lesson. Furthermore, it is also stressed by teachers that digital games could be a tool for "after school activities".

3.5. The contributions

12 of the participants have fundamental knowledge about computer games utilization in the lesson. Most of the teachers tell about the advantages of utilizing computer games in the lessons, although they do not utilize computer

games in their lessons because of different reasons. Hence, the codes obtained by teachers are included in the contributions category. When the opinions of the teachers are examined, it is seen that teachers stress that computer games "include visual items", visual items may "help topic to be more concrete". Learning becomes more effective when it is combined with three dimensional rather than only with the visualization on the board and with the submission of the topic". Teachers, inspired by their life experiences, indicate that students understood the lesson better with the help of computer games; they "grasp the logic of the subject better". They add that it "eases the comprehension of the lesson" and "they find answers to the questions like the origin of the concepts and events". Most of the teachers tell that utilizing computer games in the lessons "motivates" students and "takes the attention of the students" and "makes them interested in the lessons and make lessons more entertaining". Teachers tell that "computer games decrease the negative attitude and behaviors towards math". They also add "overcoming the fear of math" and "breaking the prejudice of math."

Furthermore some of the teachers tell that educational computer games are effective for making students "gain some information and skills". They tell about that computer games "develop creativity", "enrich the knowledge of vocabulary", "improve the skill of commenting", and "develop the skill of processing".

It is indicated that computer games "contribute to individual learning", allow "learning by discovering and learning by trial-and-error". Computer games "enlarge the scope of the topic" and "lessen the process of learning". It is told that utilizing computer games in the lessons "increases the span of keeping in mind" and "becomes more instructive". Some teachers tell that utilizing computer games in the lessons "increases the participation of the students" and even passive students become "active" in these lessons, therefore the lessons with computer games perceived as "student centered education" by math teachers. They indicate that the reason of this as the abstract character of math and its hardness to "transfer into real life". Furthermore, math teachers express that students may perceive math as a nice topic when computer games are utilized as a tool for math learning activities.

3.6. Limitations of the study

There are several limitations associated with this study that should be noted: (1) this study is encompasses a short period, namely four months, (2) qualitative research design method is used for analyzing perspective so generalization cannot be done, (3) qualitative research that seeks in-depth information relies on multiple sources of data so the study is supported by other data sources, (4) random sampling method is used for the selection of the participants and this is based on willingness and availability, however the validity and the reliability of the study are limited with the sincerity of participants during the interviews, (5) digital game based learning is a new subject in Turkey so game software in Turkish is limited and these game software are not appropriate for each grade and subject. Therefore the interviews could not be customized in a certain topic or grade.

4. Discussion and conclusion

According to the results of data analysis and observations during the interviews there five issues should be addressed on using computer games in Math education. Firstly, Math teachers express their concern about the classroom management during the play. There are discrepancies with teachers' beliefs. While teachers think that there are limited educational potential of Math games, they also believe that computer games may have positive effects on Math learning. On the other hand, the lack of hardware infrastructure in the classroom, difficulties finding educational computer games in native language (Turkish), unavailable game software for particular subjects, teachers' anxiety to cover curriculum in a certain time and lack of computer proficiency both teachers and students. Furthermore, participants stress that computer games could improve students' creativity, allow students to participate lessons actively, develop Math vocabulary, and comprehend the Math concepts easily, increases the span of keeping subject in mind.

The results of this study suggest that the professional development training regarding to introduce educational computer games is crucial to change Math teachers' attitudes toward computer games. Math education standards need to be reorganized integrating computer games into curriculum by Ministry of National Education in Turkey. In addition, creating game repository in nationwide could allow math teachers to reach educational games to employ them in their classroom.

Problems using computer games in the classroom, Math teachers' teaching philosophy, the hardware and software requirements to utilize computer games in the Math classes affect how to facilitate computer games in the classroom. All these factors also affect the outcomes of integrating computer games in Math education.

References

Abrams, L. (2008). *The Effect of computer mathematics games on elementary and middle school students' mathematics motivation and achievement*. Unpublished Doctoral dissertation, Capella University.

Bacon, S., Faust, R., Guerena, M., & McDowell, D. (2004). *Motivational Issues*. Retrieved November 9, 2009, from http://www.guhsd.net/mcdowell//edtec670/simmigration/index.html

Bayirtepe, E., & Tuzun, H. (2007). Oyun-tabanlı öğrenme ortamlarının öğrencilerin bilgisayar dersindeki başarıları ve özyeterlik algıları üzerine etkileri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 33, 41-54.

Baykul, Y., (1999). İlköğretimde Matematik Öğretimi, *İlköğretimde Etkili Öğretme ve Öğrenme Öğretmen El Kitabı*. Ankara: MEB Yayınları.

Can, G. (2003). *Perceptions of prospective computer teachers toward the use of computer games with educational features in education*. Unpublished Master's Thesis, METU, Ankara.

Egenfeldt-Nielsen, S. (2005). *Beyond edutainment: Exploring the educational potential of computer games*. Unpublished doctoral dissertation. IT University of Copenhagen, Copenhagen, Denmark.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming*, 33(4), 441–467.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.

Glaser, B., & Strauss, A. L. (1967). *The Discovery of Grounded Theory*.

Han, Z., & Zhang, Z. (2008). Integration of game elements with role play in collaborative learning – a case study of quasi-GBL in Chinese higher education. *Edutainment,* 427-435.

Kaptelin, V., & Cole, M. (2002). Individual and collective activities in educational computer game playing. In: T. Kosmann, R. Hall, & N. Miyake (Eds), *CSCL 2: Carrying forward the conversation* (pp. 303-316). Mahwah, NJ: Erlbaum.

Ke, F. (2008). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development, 56*(5/6), 539-556.

Kebritchi, M., (2008). *Effects of a computer game on mathematics achievement and class motivation: An experimental study*. Unpublished doctoral dissertation,, Universty of Central Florida, Orlando, Florida.

Kirriemuir, J., & McFarlane, A. (2004). *Literature review in games and learning (Futurelab Series, Report 8)*. Bristol, UK: Futurelab.

Kramer, W. (2000). *What makes a game good?* Retrieved November 20, 2009, from http://www.thegamesjournal.com/articles/WhatMakesaGame.shtml

Kuzu, A., & Ural, N. (2008). *Game choices and factors effecting on game choices of game players*. Retrieved November 20, 2009, from http://www.ietc2008.anadolu.edu.tr/online.php

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*, Beverly Hills, CA: Sage Publication

Malone, T. W. (1981). What makes computer games fun? *Byte*, 6, 258–277.

Mitchell, A., & Savill-Smith, C. (2004). The use of computer and video games for learning - A review of literature. *London: the Learning and Skills Development Agency*. Retrieved November 21, 2009, from http://www.mlearning.org/archive/docs/The%20use%20of%20computer%20and%20video%20games%20for%20learning.pdf

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analyze*. Thousand Oaks, CA: Sage Publications.

Neimeyer, S. (2006). *An examination of the effects of computer-assisted educational games on the student achievement*. Unpublished Master's Thesis, The University of Houston, Clear Lake.

Ozusaglam, E. (2007). Web tabanlı matematik öğretimi ve ders sunum örneği. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 1(21), 33-41.

Prensky, M. (2001). *Digital game-based learning*. New York: McGraw-Hill.

Ricci, K., Salas, E., & Cannon-Bowers, J. A. (1996). Do computer-based games facilitate knowledge acquisition and retention? *Military Psychology*, 8(4), 295–307.

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology, Research, and Development*, 44(1), 43-58.

Rosas, R., Nussbaum, M., Cumsille, P., Marianov, V., Correa, M., Flores, P., et al. (2003). Beyond Nintendo: Design and assessment of educational video games for first and second grade students. *Computers & Education, 40,* 71-94.

Strauss, A. L., & Corbin, J. (1998). *Basics of qualitative research, techniques and procedures' of developing grounded theory* (2nd ed.), London: Sage Publications.

Tuzun, H., Yilmaz, M., Karakus, T., Inal, Y., & Kizilkaya, G. (2006). Bilgisayar oyunlarının öğrencilerin öğrenme ve motivasyonuna olan etkileri. *Akademik Bilişim '06*. Retrieved June 1, 2010, from http://ab.org.tr/ab06/sunum/172.ppt

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 and Education, 52*(1), 68-77.

Umay, A. (1996). Matematik eğitimi ve ölçülmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 12, 145-149.

Yildirim, A., & Simsek, H. (2005). *Sosyal bilimlerde nitel araştırma yöntemleri.* Ankara: Seçkin Yayınları.

Yildiz, I., & Uyanik, N. (2004). Günümüz matematik öğretimi ve yakın çevre etkileri. *Kastamonu Eğitim Fakültesi Dergisi,* 12(2), 437-442.

Yigit, A. (2007). *İlköğretim 2. Sınıf seviyesinde bilgisayar destekli eğitici matematik oyunlarının kalıcılığa etkisi*. Çukurova Üniversitesi Sosyal Bilimler Enstitüsü, Yüksek Lisans Tezi, Adana.

Zavaleta, J., Costa, M., Gouvea, M. T., & Lima, C. (2005). Computer games as a teaching strategy. *Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies* (ICALT'05), 257-259.