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Evaluating Computer Games for the Professional Development of Teachers:
The Case of Atlantis Remixed

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ABSTRACT

This study aimed to analyse the usefulness of educational computer games in teachers' professional development. The study used the game Atlantis Remixed, which is intended to be a technologically rich and individualized learning environment. The study used formative research to demonstrate what works and what does not work for the use of educational computer games in teachers' professional development, and improvements to be made for this purpose in learning environments in Turkey, where schools are equipped with technologically rich learning and teaching environments as part of the FATIH (the Movement to Increase Opportunities and Technology) project. The study included ten participants. Of these, five were teachers who participated in the implementation, and five were instructional technology experts. The study found both positive and negative results with respect to the use of Atlantis Remixed for teachers' professional development and articulates the participants' opinions and suggestions.

KEYWORDS

Computer Games, Computer Uses in Education, Educational Software, Information Technology, Teacher Professional Development

INTRODUCTION

As in many other professional fields, professional development is a part of teachers' careers. Professional development is systematic, sustainable and extensive training performed based on teachers' needs. With professional development, it is intended to increase the instructional effectiveness of courses and students' academic achievement (Reese, 2010). Considering that all investment in teachers is actually made in individuals who will eventually form our society, it is an important part of teachers' profession that they improve their knowledge and skills based on innovations and

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development in education (Odabaşı & Kabakçı, 2007). Teachers' professional development can be supported with face-to-face activities, summer seminars, and conferences, and new resources and means for these activities have been enabled by the popularization of the Internet (Reese, 2010). Researchers have begun to design online professional development programs that are adaptable to teachers' busy schedules since they can be accessed anytime and anywhere (Dede et al., 2009). Another benefit of online training is that they make teachers interact with each other while they are in different physical environments. The digital environments created for this purpose can either be social networks or computer games that include social interaction.

Currently, computer games have a growing number of users. Many studies (such as Barab et al., 2005; Rieber, 1996; Tüzün et al., 2006) of their use for educational purposes concluded that these games have positive effects. One of the greatest benefits of computer games, which offer amusing environments to students, is that they increase students' motivation (Bakar, Tüzün, & Çağıltay, 2008). According to Malone and Lepper (1987) challenge, curiosity, control, and fantasy items can motivate learners during the game play. In addition, Tüzün (2004) found 13 items that make digital games motivational: identity presentation, social relations, playing, learning, achievement, rewards, immersive context, fantasy, uniqueness, creativity, curiosity, control and ownership, and context of support. Students learn better when they are more enthusiastic about their lessons (Prensky, 2001). Educational computer games can be adapted to all levels of education (Pre-school, primary education, secondary education, higher education, undergraduate, etc.) are also available for teachers' professional development. Computer games can train teachers and give them a positive attitude towards computer games. Koh et al. (2012) stressed that teachers, one of the most important elements of the educational process, need to be open-minded about computer games (Kebritchi et al., 2009; Spodark, 2003) and have a positive attitude towards computer games for them to be used effectively in education. Besides, students are also one of the most important elements of the educational process (Rouse, 2005). Kirriemur and McFarlane (2004) stated that computer games can improve students' skills such as strategic thinking, planning, communication, use of numbers, interviewing skills, group decision making, and data processing. For these reasons computer games can be integrated into classes.

FATIH (the Movement to Increase Opportunities and Technology) Project, conducted by Turkish Republic Ministry of National Education, is one of the biggest investments in education in national history. It was initiated in the year 2010 and is still in progress. The project has five components: 1) hardware and software infrastructure, 2) the provision and supervision of educational e-content, 3) the effective use of Information Technology (IT) in curricula, 4) conscious, reliable, manageable, and measurable IT use, and 5) in-service teacher training. In the context of hardware and software infrastructure, the project aims to provide an interactive board for each classroom, a multi-functional printer for each school, and tablets to all students and teachers starting in elementary school. (MEB, 2015).

The provision and supervision of educational e-content involves both preparing educational e-content with variety of activities that focus on the effective use of IT in lessons and designing educational games that simultaneously teach and entertain. For the effective use of Information Technology (IT) in curricula, the project created a portal called the Education and Information Network (EIN) to enhance instructional environments and presented it for the use of teachers and students. The EIN has an organic structure and is continually being renovated. It also includes a variety of types of e-content. Conscious, reliable, manageable, and measurable IT use planned for schools to be provided with fiber Internet connections. System control rooms were created to provide a safe connection with a steel ceiling system that includes all the wires in the schools. Installation was completed in some of the schools selected for the project. Moreover, the project trained instructors to explain safe Internet use to students and teachers and prepared a booklet on this subject.

Teachers are expected to teach twenty-first century skills to students. Teachers' roles have been changing with the increase in e-learning activities. For in-service teacher training, the FATIH project explains the materials used in education and the principles that guide their use. The courses provided to teachers in FATIH project training concentrate on the adequacy of the materials to be selected at various stages of lessons and emphasize how and for what purpose games should be used. The main requirement for the success of this project, which aims to enhance technology in schools and increase the use of technology in education, is that teachers adapt to this process and use technology in a more effective and productive way in the teaching and learning process. As a result of this adaptation and the skills they earn, teachers will be able to create more beneficial educational environments for students, and teach them the knowledge and skills included in the higher learning acquisitions. Teachers' professional development is supposed to increase in direct proportion with the integration of technology in schools. This results from the fact that one of the greatest barriers to the effective integration of technology in schools is teachers' lack of training on the use of technology in education (Balanskat et al., 2006; Beggs, 2000; Schoepp, 2005).

Quest2Teach (Q2T) is a project that researches the contribution of three dimensional educational games to teachers' professional development. It is conducted by four partnered US institutions. Q2T includes a number of games. This project aims to unite theory and practice and enable pre-service teachers to practice teaching in a unique and individualized way using a three-dimensional game. In Q2T, pre-service teachers can create an avatar and a personal identity. They create this identity by playing three-dimensional role games with unique story lines with the guidance of the lecturer at the teacher training institute. Q2T helps teachers have safe experiences in a three-dimensional environment. Teachers are able to see the results of their decisions and learn fluency and flexibility. Teachers try to be active throughout the training to improve their avatars in the social network. Q2T network also offers active teachers an environment where they can share posts and get into interaction with other teachers who enter the system from their own country or foreign countries.

The fact that teachers do not use educational computer games efficiently in their lessons can prevent them from conducting their lessons effectively and entertaining. Prejudiced teachers in educational computer games may refuse to use educational games in their lessons. This can make lessons tedious and ordinary. If teachers use three-dimensional educational games in their lessons they will be able to practice their lessons independently of time and space. By using three dimensional educational games in their lessons, they will be able to have an idea about the usefulness of educational games. In addition, teachers will be able to provide students with fun while teaching the course content to the students through the three-dimensional educational games. Unfortunately, there are few studies of the use of technologically rich learning environments such as computer games for teachers' professional development. For this reason, this study aimed to analyze the usefulness of educational computer games in teachers' professional development.

LITERATURE REVIEW

Thomas (2004) defined technologically rich educational innovations as instructional innovations that require teachers and students to interact intensely with computers using networks or the Internet. Thus, multi-user virtual learning environments and learning environments based on educational games are technologically rich educational innovations. Altan and Tüzün (2011) indicate that schools must have an IT classroom adequate for their student populations for technologically rich individual learning environments to be used. Hyun (2005) analyzed kindergarten students' collaborative participation and learning behaviors in a technologically rich classroom and found that students had more fluent conversations during their collaborative work in these environments and also showed deeper learning behaviors. In another study, Poitras, Lajoie, and Hong (2011) examined the influence of metacognitive instruments as a technologically rich learning environment. They found that students had a better recollection of the knowledge that they had learned using these instruments. Thanks to

these instruments, students recognized certain unexplained phenomena in a narrative and were able explain how these phenomena occurred.

Additionally, it was asserted that technologically rich learning environments helped students have more meaningful learning. Zandvliet and Straker (2001) also conducted a study of the extent to which technologically rich environments helped students learn, and found that these environments had a positive effect on students when they included adequate guidance. Salter et al. (2013) indicate that all lessons delivered in these environments can be made suitable for cooperative and student-centered learning. The researchers have stated that technologically rich classrooms are good for both students and teachers. Ketelhut and Schifter (2011) mentioned the importance of teachers' professional training in game-based learning environments. They stressed that multiple factors, including teachers' competence with this software, should be considered for professional development training to be successful.

Q2T, which was developed as design-based research, is a theory-based application (Arici, Barab, Sewell, & McIlroy, 2014). Q2T has been used by hundreds of pre-service teachers in multiple semesters, and it was also used with the purpose of improving the system. Each of these studies provided observable learning and participation acquisitions. At the end of the implementation, the teachers who used Q2T said that they started to become the leading actors in learning roles, and they had learned skills rather than merely learning new information. Interestingly enough, the students' self-definitions went from student to teacher. The pre-service teachers considered their participation in this environment a success. They reported that they had great confidence in their ability to teach, which they achieved by practicing in the virtual environment. They were not afraid to make mistakes and try new things. They also said that Q2T helped them become fluent in language education and relevant theories, and beyond just learning these things, they learned how to implement them actively.

With the use of AR in education, students' learning acquisitions increase (Barab et al., 2005), and they have higher motivation and are less dependent on their teachers (Tüzün et al., 2006). AR has been proven to be beneficial in educational contexts, and it can also contribute to teachers' professional development. Since AR has a flexible and adaptable structure, it can be used in many different countries (Tüzün, 2006).

METHODOLOGY

A formative research study seeks to determine the main factors that are required to design or enhance instructional practices (Reigeluth, 1999). Formative research can be used to improve current instructional design theories. This study is an example of formative research and it was accomplished to determine what works and what does not work, and what improvements could be made in AR's teacher professional development module. The study used the naturalistic case method, which is a sub-technique of formative research (Reigeluth, 1999). The researcher follows the principles of the natural cases method when 1) the study's case has not been designed based on a specific theory, yet the case has the same content and purposes as the theory, 2) the aspects of the case that are consistent with the theory are analyzed, and practical shortcomings and valuable elements not presented by the theory are identified, and 3) each case is evaluated formatively with the purpose of determining how to improve each consistent element and whether the exclusion of any element would be beneficial or harmful. In the natural cases sub-technique, designers observe a case that is formed by someone else. The natural cases sub-technique is examined in two sub-categories regarding whether the observation results are formed during the implementation or afterwards. This study used the post-facto naturalistic cases sub-technique since the observation results were formed at the end of the implementation. The operational steps of the post-facto naturalistic cases sub-technique are: 1) handling a case in the design as it emerges, 2) collecting and analyzing the case's formative data and 3) suggesting a temporary model. The case in this study is the usefulness of AR's teacher professional development module to contribute to the professional development of teachers. Instructional technology experts' and teachers' experiences while they played the game and their opinions about it were the formative data of the case.

Participants

The participants of the study included five teachers and five instructional technology experts. Table 1 presents their demographical characteristics.

The instructional technology experts had attended a course on designing educational computer games and their ages ranged between 28 and 39. The other five participants were teachers between 27 and 35 years of age. The teachers' fields of study were mathematics, information technology, Turkish, educational sciences and English. The teachers spent differing amounts of time playing games, while the frequency with which they did so ranged from never to every day. They played mobile games and sports, strategy, fighting, logic, FRP, RPG and FPS games. The participants did not have any prior Atlantis Remixed experience.

Atlantis Remixed

Atlantis Remixed (AR) is a computer game that was intended to be used in learning. It is a teaching and learning project that makes use of the three-dimensional virtual environment and is attractive to students for a number of educational tasks. AR users perform educational tasks while navigating in a virtual environment with the avatars they create for themselves (Gerstein, 2009). The game includes various communication channels such as a chat room and asynchronous messaging so that users can accomplish their tasks by communicating and helping each other in the game environment (Tüzün, 2006). Although AR was initially intended to teach certain subjects to primary school students, it can also be used to teach a variety of subjects to participants of all ages.

Table 1. The experts' and teachers' demographical characteristics

Gender	Age	Education Level	Occupation	Field of Study	Length of Service (Years)	Frequency of Playing Games	Types of the Games Played
Male	39	Ph.D.	Expert	Instructional Technology	15	1 hour a day	Mobile, Sports, RPG
Male	33	Master's Degree	Expert	Instructional Technology	11	1 hour a day	Strategy, Simulation, Car racing
Male	30	Ph.D.	Expert	Instructional Technology	4	1 hour a day	Sports, Fighting, RPG
Female	28	Ph.D.	Expert	Instructional Technology	4	1 hour a day	Strategy, Logic, Entertainment
Male	28	Master's Degree	Expert	Instructional Technology	5	2 hours a day	Sports, Car racing
Male	30	Undergraduate	Teacher	Mathematics	6	Never	-
Female	29	Undergraduate	Teacher	Information Technology	1	Rarely	Mobile
Male	27	Ph.D.	Teacher	Turkish	4	1 hour a day	FRP, RPG, FPS games
Female	27	Master's Degree	Teacher	Educational Sciences	3	1 hour a day	Logic, Strategy
Female	35	Master's Degree	Teacher	English	10	1 hour a day	Mobile

The Implementation

Users need to have a user name and a password to play AR. First, the participants individually applied for an account through www.AtlantisRemixed.org. After their applications were approved by the system moderator, the users registered. Then, the installation files were downloaded from the game's web site and installed on their computers. The experts played AR's teacher professional development module individually for five or six hours a week for four weeks, or 20 to 24 hours per person. The teachers played AR for an average of two hours per person. Before the implementation, the authors briefly informed the teachers about the game and helped them play it, and each teacher played a different episode of the game. After they played, the authors administered a survey to the teachers. The teachers participated in the implementation in different locations. They were selected based on the prerequisite of being an instructor and having English reading comprehension skill.

The teachers attempted to accomplish one of the teacher professional development tasks that could only be played in the pre-service teacher role, while the experts completed that process and also tried to complete the 'OTAK Missions' played in the experienced teacher role. The experts also completed the 'Teacher Institute' episode and accessed the 'Teacher Toolkit' tool. This tool offered them the opportunity to experience different aspects of classroom management. In the episode entitled, 'Ander City,' the teachers are given a mathematical task. The scenario of this task requires determining the brand of the bicycles to be purchased for the city. The Mayor and the journalist are the non-playable characters (NPCs) in the game. The teacher is, as a player, required to find out which bicycle brand is the best and vote for it. First, the player goes to the test track and conducts ten tests of the dwell time of the bicycle. Then the player calculates the mean of the tests and reports the result. Next, the player talks to some people from the shops nearby, to locals, and to the Mayor. After receiving their opinions, the player goes to the town hall to vote for a bicycle brand. The teachers explain their selection in their own words. This episode of AR makes the teachers do research using calculations, tests, and interviews, and has them implement the game's pedagogical philosophy to arrive at a conclusion. Figure 1 shows the Teacher Toolkit, and Figure 2 shows visuals from the teacher professional development modules.

The Teacher Toolkit includes five sections. The first section is 'My Desk.' It includes the summaries about the educational activities of the class, which enables teachers to organize the profiles of their classes. In addition, there is a shardflower in this section where teachers can write their personal experiences, add useful notes and see their class's progress using the journal tool. The second section, 'My Questers,' lists current students and can be used to add new students. This section includes students' personal information and the records of the educational activities they have done. Here, teachers can also see their students' rights, scores, the frequency of their logins into the game and extensive statistics for their classes. In the third section, 'My Curriculum,' teachers can select any of more than 500 tasks that are classified by topic and assign them to their students. This section also enables them to review the purposes of the tasks, the virtual world where they are located, and their sub-tasks. Here, teachers can also see the active tasks in their classes, students' feedback about these tasks, to what extent the tasks and sub-tasks assigned to the class are completed, which students have completed these tasks and which have not. In the fourth section, 'Activities & Tools,' teachers can define objects to be purchased as well as their prices, and they can review the purchasing history of these objects. Moreover, teachers can see their students' responses to the survey, the completion rate of the survey, administer assessment examinations to their classes, and review the results afterwards. In this section, teachers can also see the rewards and scores earned by their students and send them bonus points. The fifth section, 'My Records,' includes information about the completed and uncompleted tasks. Here, teachers can review the feedback of the students whether the students' performance had been scored or not. When teachers click on 'Guide' in the 'Teacher Toolkit,' they access extensive information about each task and how to use the tools in the toolkit. The 'Help' button shows the functions of the buttons.

Figure 1. The teacher toolkit

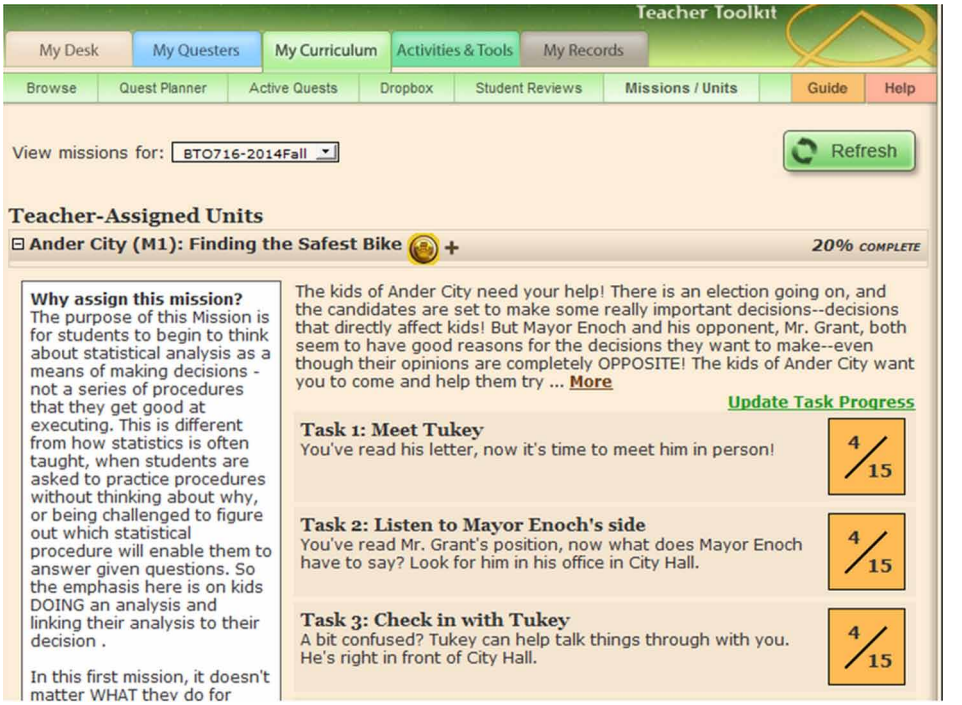
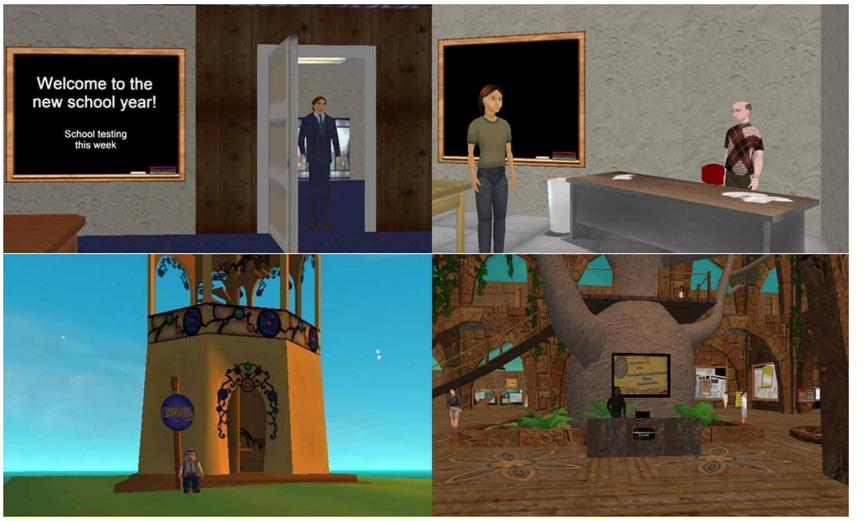


Figure 2. Images of AR's teacher professional development modules



Data Collection Tools and Data Analysis

The authors received five teachers' and five experts' opinions about their experiences with the teacher professional development module using a questionnaire with open-ended questions. After the questionnaire was created, it was reviewed and evaluated by three faculty members other than the authors. The authors also administered a demographical data questionnaire. The qualitative data in

the questionnaire were analyzed using content analysis by focusing on related participant experience such as the characteristics of the AR game, the user experience within the AR game, the educational characteristics of the AR game, and usefulness of the AR game in terms of teacher professional development. The raw data have been reported in detail on behalf of transferability. In order to provide reliability, the raw data and analyses were reviewed by experts. The raw data were analyzed by three researchers. The social environment and processes were described for verifiability. For consistency, researchers did not add their own comments to the raw data.

FINDINGS

The Experts' Opinions

The experts evaluated the educational game and reported that the visuals were good, and that the graphics had a very life-like design. They saw the character modeling and lighting details as adequate, although not enough environmental details were included in the game. The experts also said that the appearance of the objects and the movements of the characters were not very realistic, but the graphics could be qualified as successful given the state of the technology when the game was designed.

An evaluation of the playability of the game indicated that it was difficult to play the game by using only the keys on the keyboard, yet the use of the mouse made it easier to play and when the game was played using different keys, this change was not reflected on the game. The mechanics of the game was easy and clear, which made it predictable for the players who were familiar with computer games. It was determined that the viewpoints were not sufficient in interiors, and that character modeling had no visual or audio effect on the game. It occasionally froze and required English reading skills to play, which limited its playability.

When the experts evaluated the game in educational terms, they determined that the game was exciting and functioned as an effective learning method since it assigned tasks to participants like in project-based learning. The participants proceeded in the game by doing research to achieve the tasks assigned to them, and they needed to find things out by themselves. The game was successful educationally thanks to its relevant explanations, and it made users more enthusiastic about by requiring tasks to be performed by following specific steps. This aroused players' curiosity about what would happen next as they completed the tasks.

The experts thought that the difficulty level of the English in the game was not too high for players who had a good command of English if they read carefully. Although the tasks were easy to understand, the lack of language support caused players to lose time trying to understand the tasks, and the game is not suitable for non-English speakers. The experts also said that the instructions for some of the tasks were not clear. Other points reported by the experts include that the tasks were explained in lengthy instructions that distract the players and need to be shortened, and the clues for performing the tasks were insufficient. Feedback about success or failure to complete the tasks was also inadequate, and in some cases the players were unable to obtain a result and pass to the next level although they accomplished the tasks with much effort. The experts also said that if the authors desired to have large groups of people play the game, it should definitely be translated into Turkish.

The game's contributions to the teachers' professional development was evaluated by experts. Their evaluation revealed that the game made teachers gain experience about how to guide students to self-learning and to obtain information on their own. It taught them how to guide students' development and gave them ideas about how to use educational games in their lessons.

The guidance of certain characters oriented the players to the tasks, and this could shape their professional lives by means of puzzle-like activities. In addition, they said the game was beneficial for teachers since it introduced them to alternative learning environments, helped them adapt to innovative learning approaches, and greatly contributed to integrating these innovative approaches into education.

The experts also reported that the game gave teachers the opportunity to experience learning in game-based rich learning environments and to learn by playing in task-based learning environments. The game taught teachers how to use and manage the class management software and content administration system, both of which function similar to Learning Management Systems (LMSs) and the knowledge and skills needed to monitor students' development using online surveys and examinations.

The experts said that they occasionally had problems with the Internet connection while playing the teacher professional development module, and that the game froze sometimes. They found it very difficult to set the angle of the camera. Moreover, the excessive length of some of the texts made them less enthusiastic about playing the game, and some of the maps were not clear and easy to read. However, they were able to continue playing the game when they found out that interruptions in the game were due to technical problems that were later eliminated.

The experts said that it was necessary to eliminate the interruptions, shorten the instructions and resolve the problems with camera angle. They also said that it was a problem that it was possible to write in the chat window even if it was closed and that this should be fixed. In addition, they said that some redundant NPCs should be excluded from the game, the number of the directions should be increased and the visual effects should be enhanced.

The experts said there should be more guiding characters in some parts of the game and that an audio guide should be added to the game to increase players' feeling of social presence. They said more effective animations could give feedback to players after they accomplish their tasks. Adding a variety of language options would make the game available to many more people. Finally, they suggested that a technical support team be present to handle problems instantly.

Teachers' Opinions

According to the teachers, the game was eye-straining and was neither realistic nor interesting enough. However, much effort went to locating objects where they would be in real life. They also found it difficult to control the game using the keyboard, that the angle of the camera was poor, and that both reduced its usability. The teachers said it was necessary to enhance game control and players' viewpoints to give players better control of the game and keep them from getting bored or tired.

An analysis of the playability of the game revealed it was highly restrictive that the language of the game was English. Considering that a majority of students and teachers in Turkey have problems with speaking foreign languages, it is very hard for them to achieve the required tasks and experience the playability of the game without translating it into Turkish. The teachers said that the assigned tasks or situations were not very clear, that there were not enough interactions and directions for the course of the story, and that the plot of the game was not exciting enough. The teachers also had positive comments and found the plot and the logic of the game to be favorable. They said that both directly and indirectly assigned tasks were understandable. However, they had problems performing the tasks in order, and most were unable to reach the result. The teachers also said that they got lost in the game. This caused them to feel alienated and unsuccessful. This resulted from the fact that they were not given enough clues to solve the problem and the interactions were very repetitive. They reported that, despite completing the tasks, they could not move on to the next level in some parts of the game, making the tasks a vicious circle.

AR was reported to be beneficial in the sense that it got the teachers' attention and led them to develop a positive attitude towards technology-based innovative teaching and learning methods. It was particularly interesting for teachers that the game used the inquiry-learning method. They said that Turkish language support should be included in the game so that it could be used by many more people, and that the feedback after the completion of each task should be improved. They also said that the current stage of the game should be indicated more clearly, that the instructions should be shorter, and that the camera angles should be improved. They found lengthy texts were boring and time-consuming, which was a disadvantage since it extended the duration of the game.

The conversations in the interactions should be made by talking, the music and audio effects in the background of the game should be enhanced and the characters should have more options of movement. The teachers said that the game could be more interesting with these multimedia aspects.

DISCUSSION AND CONCLUSION

This study used AR for teachers' professional development with both positive and negative results and obtained the participants' opinions and suggestions. Although the appearance of the game was insufficient to teachers, the experts found it adequate. Both the experts and the teachers said that it was difficult to control the game by using the keyboard and the camera angles were not satisfactory. Although the experts liked the plot, the narrative and the logic of the game, the teachers said that the interactions and instructions were not satisfactory. This may be due to the fact that the teachers played the game for less time than the experts.

Both teachers and experts said that the tasks in the game were easy to understand, that the texts in English were very long, and that Turkish language support was insufficient. They also said that occasional problems with the Internet connection interrupted the game, and that these problems should be fixed. The game's technical problems can be eliminated by playing it on computers with high bandwidth connections.

AR contributed to the teachers' professional development by giving them the opportunity to adapt to current technologies, creating awareness about the pedagogical use of technology and educational games, making it possible to organize virtual and social educational environments anytime and anywhere, and teaching them about the supervision and system usage of content creation. The authors believe that adapting to the inquiry learning method in the game will help their professional development.

The study by Tüzün (2006) argued that the users were able to complete the educational tasks by interacting and helping each other. This study also found that the teachers tried to achieve the tasks by helping each other through communication channels such as messaging, instant chat, and interacting within the game. More effective use of these communication channels made it possible to complete the tasks more rapidly and accurately.

The findings of the study indicated that the teacher professional development module taught teachers how to guide their students' development, and gave them ideas about how to use educational games in lessons. The module drew their attention and gave them a positive attitude towards technology-based innovative teaching and learning methods. Koh et al. (2012) stressed that teachers should be open-minded and positive about computer games, which is consistent with the findings of this study. Barab et al. (2005) determined that students' learning acquisitions gradually increase with the instructional use of AR. This study found that there was an increase in knowledge and perception about the benefits of the use of educational games in teachers' professional development.

Bakar et al. (2008) conveyed that teachers can give feedback after reviewing the students' portfolios using the classroom management tools included in AR, and they can customize the settings in their classrooms based on their needs. The study by Tüzün (2006) found that teachers were responsible for the implementation of AR in their classrooms at the local level, and a learning management system, a system with many functions, was used to meet these responsibilities. As Tüzün (2006) said, it was possible to design a favorable e-learning environment by changing the content according to different regions thanks to the flexible structure of AR, which can be modified for different subjects, units, and educational goals (Schwartz et al., 1999). AR taught teachers how to use and manage the classroom control software and content control system, which were based on LMS, and it taught them how to track students' development using online surveys and examinations. These points are similar to the findings of the relevant literature discussed above.

Altan and Tüzün (2011) indicated that Science and Technology teachers wanted to use AR in their lessons, and the authors thought that this resulted from teachers' attitude towards technology. Teachers

may not desire to use technologically rich learning environments since these environments bring greater workloads and cause teachers to feel ashamed of their incompetence with technology before their students. The authors suggest that, if teachers are given technical support in this field, they will be more interested in AR. Then, teachers will want to use AR in their lessons. When teachers use AR in their lessons, their technological skills will improve and professional development will be enhanced.

Altan (2011) reported that the participants had problems caused by the English texts they had to read in AR's English interface, and that it was technically not possible to translate the game into Turkish completely. Similarly, Lim et al. (2006) found that students had problems due to language barriers. This study's participants reported that insufficient language support in AR caused them to lose time while trying to understand how to perform the tasks. The implication is that future technologically rich gaming environments for teachers' professional development should be customizable in terms of local language of the implementation context.

When games in technologically rich learning environments are text-based, this may cause users to get bored quickly and feel like quitting. Just because a technologically rich environment is game-based does not mean that students will want to use it (Altan, 2011; Devlin-Scherer & Sardone, 2010). The participants of this study also reported that lengthy textual content made it difficult for them to understand the tasks. Moreover, Altan (2011) determined that there were certain disadvantages caused by the shortage of time in this kind of technologically rich learning environment, and learning goals may not be attained due to lack of time.

Gebre, Saroyan, and Bracewell (2014) determined that the groups who were taught by teachers with opinions about effective instruction had higher cognitive and practical participation levels. Many studies (such as Altan & Tüzün, 2011; Hyun, 2005; Poitras et al., 2011; Salter et al., 2013; Thomas, 2004; Zandvliet & Straker, 2011) suggested that technologically rich learning environments significantly contribute to students' effective learning. However, the professional development of teachers who teach in these environments plays a major role in this contribution. Accordingly, teachers have a great responsibility in technology projects such as FATIH, which will popularize technologically rich learning environments.

The teacher professional development module can support teachers and bring them to a higher level in this field since it develops their ability to use technology and integrate it into education. Educational games in teachers' professional development may raise awareness of teachers for the use of technology in education. The "Teachers' Professional Development" module can help teachers to check their students online. In the beginning, teachers thought that this type of applications were very difficult to use or control. However, they recognized that it was a very interesting educational environment as they proceeded and created the necessary structures in the system. In the AR educational game, the teachers can direct the students however they wish, and give them the chance to do research and obtain results by themselves and achieve self-learning using the inquiry learning method. Learners can enter AR whenever and wherever they wish. Teachers can see the tasks achieved by the students, the stages they pass, their participation in activities, and their messages. Teachers' being able to see this type of detailed information is beneficial in the sense that it shows them the kinds of guidance students need to accomplish the tasks. AR has allowed teachers to practice for the adaptation of information technology. It has created awareness in teachers for the use of technology and educational games in education. It allowed teachers to organize virtual social learning environments independently of time and space. With this implementation, teachers experienced the educational games in their lessons. Inquiry learning style in the game may contribute to teachers' professional development. AR may be useful for teachers to develop positive attitudes toward technology-based innovative learning-teaching methods and draw attention. Moreover, the authors believe that teachers' use of this type of learning management system will teach them the superior technological skills required by both the twenty-first century and the FATIH Project.

LIMITATIONS AND FUTURE WORK

This study was conducted with only five teachers and five instructional technology experts. Teachers and instructional technology experts have not spent the same amount of time in the study. Only specific training modules and activities were carried out in the study. Researchers should conduct more studies of educational games and teachers' professional development to achieve a clearer analysis of the effects of educational computer games on teachers' professional development. Future research can be conducted with more people and different content modules. Furthermore, the effect of different educational games on the teachers' professional development can be examined.

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