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Designing a collaborative learning game: Its validation with a turn-taking control scheme in a primary science unit

Kubaşık Bir Öğrenme Oyunu Tasarımı: Tasarımın İlköğretim Fen Bilgisi Ünitesinde Sıralı Arayüz Kontrolüyle Geçerlenmesi

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Abstract

This study first attempted to blend the framework of the activity theory for tool and context interaction, some other game design models for pedagogical principles, and collaborative learning issues for promoting shared understanding between learners. The study then outlined a model for designing a collaborative game, accordingly implemented a learning game for elementary science, and examined it with two groups of students under two different play and control schemes: The students played the game collaboratively scored higher in the post-test, and their progress scores were higher than individually playing students. Additionally, in collaborative mode, the students taking control first had similar post-test and progress scores to the ones taking the control second. The result favored players' turn-taking control over a chain of tasks for desired collaborative learning outcomes.

Keywords: turn-taking, collaborative learning, collaborative game, learning game, learning science.

Öz

Bu çalışma, önce öğrenme ortamlarında araç ve bağlam etkileşimi sağlamak için etkinlik kuramını, eğitsel oyunlardaki eğitimbilimsel ilkeler için bazı oyun tasarım modellerini ve öğrenciler arası ortak anlayışların kubaşık geliştirilmesi için kubaşık öğrenme ortamı gereklerini sentezlemiştir. Çalışma daha sonra işbirlikli öğrenme oyunları tasarımı için bir mimari model önermiş, bu mimariye uygun olarak fen bilgisi dersindeki bir ünite için bir öğrenme oyunu geliştirmiş ve oyun mimarisini iki farklı kullanıcı kontrolü modunda ve iki farklı oyun senaryosunda incelemiştir. İşbirlikli oynayarak öğrenenlerin sontest ve erişi puanları, bireysel oynayarak öğrenenlerden anlamlı derecede yüksek bulunmuştur. İşbirlikli oynayarak öğrenenlerin oyun üzerindeki kontrolü ilk alanlarıyla sonra alanlarının sontest ve erişi puanları benzer bulunmuştur. Bulgular, bir öykü bağlamında dizilmiş görevlerin işbirlikli öğrenme modunda eşleşmiş öğrencilerce sıralı kontrol yoluyla yapılmasının, işbirlikli öğrenme çıktılarını desteklediğini göstermiştir.

Anahtar Sözcükler: Sıralı kontrol, işbirlikli öğrenme, işbirlikli oyun, öğrenme oyunları, fen bilgisi öğrenme.

Introduction

With the improvement in computational technologies, there are now games with more complex graphics and richer content, and user roles. Further, the tactics, strategies and skills involved in recent games are more than ever. Digital games are arguably attractive means for learning and teaching, because learners can pay more attention to and engage in activities of games, and learners feel free in the games though they have strict rules. Besides, because games may

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have rich and immersive representational facilities, teachers plan to convey curricular knowledge and skills through games under different usage themes (Egenfeldt-Nielsen, 2005; Moreno-Ger, Burgos, Martinez & Fernandez, 2008). For example, a game could be used independently or collaboratively by students (Squire, 2002) or a teacher may use it as a frame of reference to other classroom activities (Gee, 2003; Prensky, 2001).

A learning game is a system that combines simulation, pedagogy and entertainment to create a truly engaging and behavior-changing form of immersive environment (Kapp & O'Driscoll, 2010). These environments provide learning activities and the chance to collaborate, problem solve and apply critical thinking skills. In addition, with the networks, the environment becomes a multi user virtual environment, allowing multiple perspectives and collaborative decision making and even argumentation. For example, students playing a virtual town management game would voice their own perspective in placing, say, residential areas, and share justification of her decision in the chat panel of the game with other students.

There are many advocates of digital games in learning environments, but conflicting results about effectiveness of learning games are reported. For instance, according to Kirriemuir and McFarlane (2004) learning games, drawing on features of game design, have not been particularly successful. Because the games have been too naive (Salonius-Pasternak, 2005), that tasks are repetitive and weakly designed in a way that activities are limited to isolated skills or content, they do not give forth any active exploration (Arnsenth, 2006; Kirriemuir & McFarlane, 2004; Mitchell & Saville-Smith, 2004; Moreno & Mayer, 2005). However, other research on edutainment demonstrates that certain applications might have positive effects (for a comprehensive review, see Egenfeldt-Nielsen, 2005). For example, Virvou, Katsionis and Manos' study (2005) revealed that all students benefit from learning but groups of students who used to be poor performers benefitted the most from learning games. Moreover, recently, the instructional potential of games as learning objects has been examined in some detail (e.g. Barab, Dodge, Thomas, Jacksen & Tüzün, 2007; Gee, 2003; Karakus, Inal & Cagıltay, 2008; Shaffer, 2006; Sherer, 1998; Squire, 2002; Tüzün, Soylu, Karakuş, İnal & Kızılkaya, 2009; van Reijmersdal, Jansz, Peters & van Noordt, 2010). Gee (2003) points out that it is necessary to consider different educational interventions forming the computer game experience through the surrounding context or the design of computer games that support an educational framing. The question of the context of computer games and how they facilitate learning environments with peer-collaboration, knowledge construction, and a changed student role is yet to be answered. Further, relatively little research has been done looking at construction process of learning games which could be played collaboratively.

Designing collaborative digital learning games

Different game design models exist. Kiili (2005) proposes an experiential gaming model "based on the antecedents which are challenge matched to player's skill level, clear goals, unambiguous feedback, sense of control, playability, gamefulness, focused attention, and a frame story used to situate the problems of the game" (p.20). Kiili's model is based on simulation or microworld design, and explicit enough and implementation guidelines for individualized games are given. Nonetheless, how those guidelines are to help designing multi-user games is not addressed.

Moreno-Ger and others (2008) suggest a general game design method that includes adaptation and assessment features. Their model focuses on providing a development paradigm that facilitates the transition from a previously written storyboard to a fully functional game without losing value, but that concept assumes that the process begins with a good script. Writing compelling stories for collaboration is a creative task and its study is not pursued in this model. Recently, Anneta (2010) proposes a six elemented framework for educational game design consisting of identity, immersion, interactivity, increasing complexity, informed teaching and instruction. However those guideline principles are so general that implementing a collaborative digital game within this framework is fuzzy.

These recent models have pitfalls for designing different type of learning games, particularly collaborative ones. Squire (2002) specifically addresses design of collaborative learning in games, and referred to the activity theory (Engeström, 1987). Squire points that how the game is contextualized; the kinds of collaborative learning activities embedded in gameplay, and the quality and nature of debriefing are pivotal elements of the gaming experience. Sociocultural psychologists proposed Activity Theory as a framework for understanding how both tools and cultural context mediate continuous human activity (Engeström, 1987; Kaptelinin & Nardi, 2009). In a generic system of the activity theory, the inter-related components are subjects, community, objects, tools, division of labor and roles. The meaningful context in a possible learning game is the dialectical relations between subjects (learners/players) and that which they act upon game objects as they are mediated by tools, language, and sociocultural contexts (Engeström, 1987; Lazarou, 2011). Application, e.g. games, objects are that "at which the activity is directed and which is molded or transformed into outcomes with the help of physical and symbolic, external and internal tools" (Engeström, 1993, p. 67). As such, objects can be physical objects, abstracted concepts, or even theoretical schemes. Tools are the concepts, physical or virtual tools, operators, artefacts or resources that mediate a player's interactions with an object. The community of a game refers to peers with whom the subject shares transformation of the object: Communities mediate subjects' activity through game rules, scripts, roles, division of labor, and shared norms and expectations.

There is a lack of operationalisation problem in the activity theory (Kaptelinin, 1996), and it is not clear how collaborative learning activities are designed and tailored to the students, nature of labor division, and the guidelines to be followed for positive outcomes in activity systems. The next section will deal with these issues.

Collaborative learning and shared control in learning games

A significant number of research demonstrates that collaborative learning groups, both face-to-face and online, can promote shared understanding, deep processing, higher-order learning and retention of learned material compared to non-collaborative learning settings (Anderson, Howe, Soden, Halliday & Low, 2006; Gokhale, 1995; Johnson & Johnson, 1994; Kirschner, Beers, Boshuizen & Gijselaers, 2008; Sins, Savelsbergh, Joolingen & Hout-Volter,2011; Slavin, 1992; Webb, 1989). There is continuing evidence that how control is distributed is a noteworthy factor in collaboration (Eales, Hall & Bannon, 2002; Issroff & Soldato, 1996; Keller, 1987; Malone & Lepper, 1987). For example, Issroff and Soldato (1996) discuss six features of collaborative learning settings for motivation and control: social affinity between partners, feedback, students' cognitive ability, time on task, nature of task and distribution of control. According to Jones and Issroff (2005) a collaborative learning environment can be managed to ensure a balance of control amongst students. That may be accomplished in several ways: The instruction given to students may be specific; the software can manipulate the control. For them, there are two different aspects of control in computer supported collaborative learning (CSCL): Control of the tool and control of one's own learning. They both influence each other. The one controlling the tool may not actually control the interaction in collaborative settings.

Some researchers (e.g., Lepper, Woolverton, Mumme & Gurtner, 1993 and Infante, Hidalgo, Nussbaum & Alarcon, 2009) argue that the physical control of tools in learning environments such as input devices are seen imminent. Learners should perceive themselves as being in control of their learning process; thus responsibility and choice are linked to outcome of the task in control of related strategies. Further, according to meta analysis studies, the effect of student choice and control over learning is high on motivation outcomes, estimated effect size of student control on learning is around 0,30 and, in turn, effect size of motivation on learning is around 0.48 (Hattie, 2009). Similarly, importance of control in computer games were often emphasized (Goh, Ang & Tan, 2008; Hamlen, 2010, Neal, 1990). In terms of user-control, Neal (1990) identifies three critical factors to a successful computer game: Sense of control, the opportunity for strategy and the discovery of information. Goh, Ang and Tan (2008) also argue that game-users should feel they are in control even when they are working hard to learn a complex computer game; when the worst happens, they can always turn off the system. Nevertheless, it may not be possible in collaborative gaming, when one is not controlling the game, they cannot shut it off. For this reason the individual should know that she will take the control once it is her turn. Hence script for turn-taking becomes an alternative (Inkpen, McGrenere, Booth & Klawe, 1997).

Software interfaces used in classrooms are generally designed for a single user (Kerawalla, Pearce, Yuill, Luckin & Harris, 2008). In paired use, children often manage this by being cooperative, for example, while one thinks the other types or clicks around on the screen. In such scenario, turn-taking is applied. Kerawalla et al argue that it is likely for one child to avoid relinquishing the control device to their partner or to override the work done on their partner's previous turn. This sort of domination of the task is a common feature of shared computer use in classrooms (Kirschner et al, 2008). Considering this, some studies explored the collaborative potential of using multiple mouse. The results show a discrepancy. For example, Scott, Mandryk and Inkpen (2003) observed that multiple mouse did not improve interaction between children, they lost track of previous stage/turn of the task at hand, and had to use the system by turn-taking. Abbnett, Stanton, Neale & O'Malley (2001) investigated the impact of multiple input devices for supporting collaborative studies. They found that the quality of students' product were higher, nevertheless, size of group, knowledge of partners, experience, ownership of tasks and needs are effective factors. Furthermore developing a community of partners who feel safe and trust each other is found crucial (Kirschner et al, 2008).

In a different environment, in an authoring tool for children, Benford et al (2000) investigated children's use of multiple mouse, and reported that children effectively collaborated on task sharing, nonetheless reciprocal discussion was minimal compared to children not sharing a mouse. The study shows that the tasks/sub-tasks were shared and students focused on only their own parts. Later, Constantino, Suthers and Escamilla (2003) recommended dividing the workspace and allocating personal spaces to each user. Though such a screen layout may separate the thinking, and hence may reduce the effects of shared artifacts and reflecting objects, this is tested by Kerawalla et al (2008). They developed an interface paradigm giving each user a separate control of shared spaces (SCSS). The main feature of this paradigm is the provision of separate control over the same version of the task for each child within their own private screen space that is visible to both participants. Each user may at any time control their own task elements, the display of each child's task state on the screen is explicit and partners may use this as a source of discussion. Each user clicks on an agreement button to proceed in the task regime. The authors tested SCSS interface with children working in pairs to categorize words. The pairs used the computer program either in a single user interface or in the SCSS paradigm. Though students used both interfaces collaboratively, in SCSS interface some children attempted to dominate their partner's manipulation of task elements. Similarly in the two mouse for single interface groups, some students dominated the partner. These two type of interfaces can allow one child to dominate the other, thus enabling them to rush through the activity even if their partner expresses a wish for more time to think about the task issue. In SCSS, since there are separate work spaces for each user, students may focus on own space and avoid discussion and collaboration with a partner. Further, they found that one child blindly copied their partner in the SCSS paradigm. The copying child was usually bored and frustrated because their partner was not helping them and was racing ahead, whilst the partner was usually frustrated by the copier's slow progress and reluctant to explain and help (p.203). The authors highlighted these interpersonal problems and poor collaboration that the SCSS paradigm could not address. These two drawbacks direct designers to focus on devise of task patterns which could be completed together with a partner. The study finally reveals that task design and scenario letting each student manipulate sets of task elements on the screen should be taken into consideration in collaborative learning settings where the roles that each participant will play must be made explicit.

Strijbos and de Laat (2010) argue that roles can promote cohesion and individual responsibility, guide individual behavior and regulate interaction. They can consolidate interdepence since participation of peers are required for the task (Brush, 1998), and stimulate group members' awareness of other member's contribution (de Laat, 2006). There are two perspectives on roles in CSCL literature (Strijbos & de Laat , 2010; p. 499): Scripted and emergent roles. Scripted roles are assigned by a teacher/designer to structure the collaborative learning process. Each student is assigned a role, often contains a single task. Emergent roles are that spontaneously transpire or negotiated by group members without interference by a teacher. In collaborative activities the task and individual orientations towards the task affect how students build their collaboration and develop a personal participative manner during learning (Pilkington & Walker, 2003). In small group CSCL settings, roles are frequently scripted, as Hakkarainen, Lipponen, Jarvela & Niemivirta (1999) stress that group members' orientation during collaborative activities is crucial, members should not be after a continuous leadership role. They should be oriented towards working effectively with others on the tasks. Hence the scenario of collaborative learning game activities should be developed to delegate tasks where each learner will make optimal mental effort, take autonomous control of the elements of the task and discuss, negotiate and share with others.

A hybrid set of guidelines for designing collaborative learning games

The features discussed above advocate and complete properties of the activity system and the other three set of game design guidelines (Kiili, 2005; Moreno –Ger et al 2008; Anneta, 2010) as well as a number of distinct design elements of games, such as embedded epistemic artefacts (Shaffer, 2006), situated learning in an authentic context and engaged players in a community of practice (Halverson, Shaffer, Squire & Steinkuehler, 2006), rules (Jenkins, Klopher, Squire & Tan, 2003), goals and objectives (Swartout & van Lent, 2003) , rewards (Denis & Jouvelot, 2005), multisensory cues (Gee, 2003), and conflict (and/or competition, challenge, argumentation, opposition) (Ke, 2008; Prensky, 2001). Once the components of the activity theory and of other game design guidelines above are put together, and reflected onto the design guidelines for interactive and collaborative learning environments (Akpınar & Hartley 1996; Ilomaki et al, 2003; Villalta et al, 2011), a hybrid set of guidelines may be obtained for designing a collaborative learning game. We may portray its architecture as in Figure 1.

Within triad of this model of a learning game, learning content and game players, there is an interface language which shares a mediating position to assist players in order to merge their informal language and prior knowledge, and language of the game as well as the learning content conveyed in the game. Language of the game is shaped by its context, rules and interaction between objects and operators of the task regime defined. In turn, the language of the game and its underlying conceptual model of the learning domain to be explored in the game context will outline rules of the game. In a microworld of the game, players carry out activities tailored according to goals of instruction, players and nature of the game (context, story, roles). These will then determine engaging and attention gathering features of the game. Since the overall purpose is to concretize, and hence, to ease learning, and to avoid students to develop misconceptions, learning activities must get players to discuss each task case, argue over different perspectives and conflicts, and co-explore the knowledge conveyed or reflected in actions.

The task design should result in a task regime, a meaningful set of activities, immersing players in tools of the game, and maximizing the player-tool interaction along with interaction between players. If possible, through a control panel used by a teacher, the tasks may be adapted to known user needs. In the preparation of a task regime, increasing complexity of the game, hence content knowledge and skills, will be balanced and organized in the flow of the game scenario. In each task, each player's role to play and how task elements are controlled collaboratively will be scripted. Division of interface control between the group/pair members will be balanced in workload of the activities in a way that each group member puts similar amount of cognitive effort in passing from one level to the next. Further, the flow of the scenario will be orchestrated and scripted that group members have the sense of screen control in an autonomous manner.

This implies that, in a collaborative learning game, turn-taking is inevitable, but characteristics of the tasks must not allow anyone of the group members to dominate the interaction taking place in the environment either by controlling manipulation devices or by always deciding what action to take.

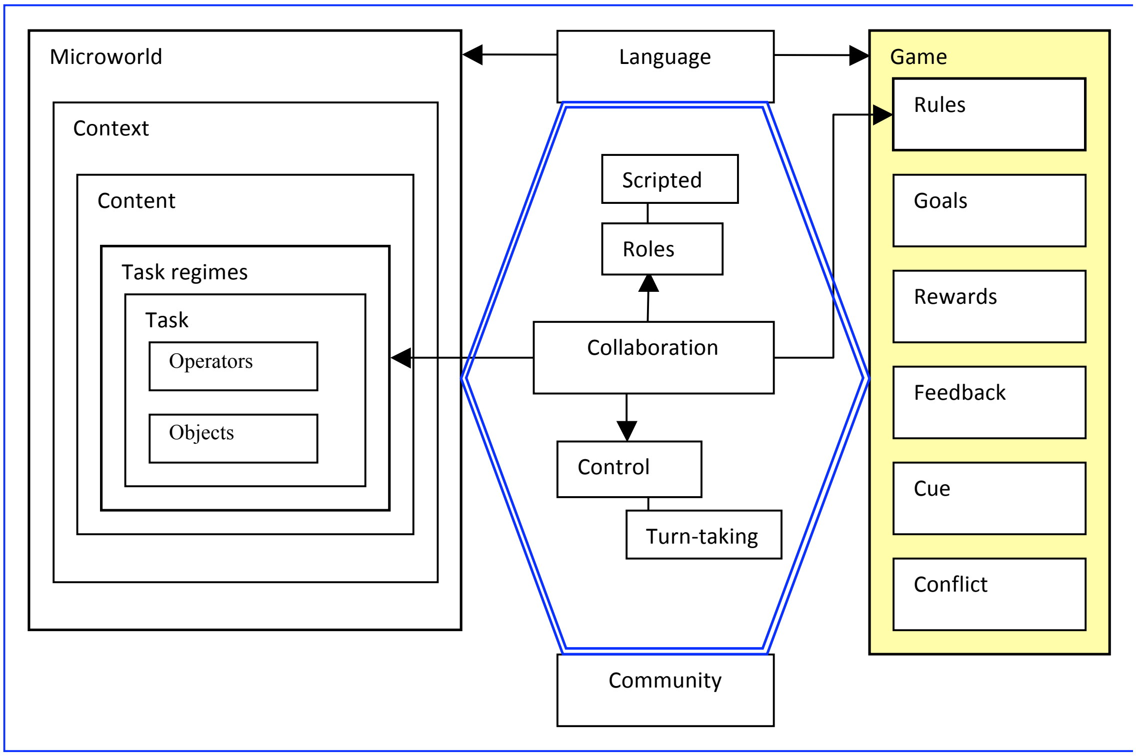

Figure 1: Components and architecture of a collaborative learning game system.

The task accomplishment should credit group members in two ways, one for each member and the second is for the group. To ensure collaboration between group members, number of members must fit to roles assigned in the scenario. Whilst forming the groups/pairs, familiarity of partner to each other, knowledge and experience of partners must be considered in a manner that members get along well. However, in a mentored, for example a teacher, setting, members of a group may be selected considering other features, when there are controversial issues in the scenario and when argumentation between members is likely to contribute to complete the track of the game and to the learning, particularly conceptual change in learning science. The workload of collaborating members should explicitly be considered, and the control given to each player allows each of them to complete a series of tasks in the task regime, sub-task regime. This requires having episodes in the game: Each episode may be so scripted that each player gets engaged in the same sort of episodes his/her partner completed. However, the role of the repeating episode will be different from the one completed earlier. That means the episode repeated will serve for a different purpose of the game scenario. In this way, each player will have a sense of control of the activity as well as manipulation devices in a meaningful period of time. This may be realized through leveling in the games, each level will be, for example, repeated under a slightly different look and version of the same level the partner completed, but thinking and decision making at all activities should be with the partner.

Particular attention must be focused to the players' objectives, which is often meeting challenges of the game. The players' orientation to the learning game should be directed towards the learning objectives of the game by seamlessly merging the players' objectives with the learning objectives. The study of epistemic activities involved in the game must be an integral part of rules of the game.

Purpose

The purpose of this study is in twofold: One is to seek for evidence on validity of the design principles of collaborative learning games outlined above, and second is to examine episodal turn-taking type of control implemented in the game.

Method

To validate the design model of collaborative learning game, a game (ElektronKosuyor) is developed and implemented within a primary school science content, namely "structure of matter and its properties" studied at the seventh grade (aged 12-13) in Turkish curriculum. To test the turn-taking type of control over a series of tasks in the game, scenario of the game was written accordingly. Then, to test whether the individual or collaborative study of the game is more contributive to learning outcomes, the game was piloted with two groups of students. In choosing the sample, it was ensured that the students did not yet study learning content of the game at that grade. The sample was selected from a metropolitan state school in cooperation with classroom teachers who permitted access to their classrooms. Therefore, a convenience sampling was favored due to accessibility. Allocation of the two classrooms to individual (n=20) and collaborative (n=22) study modes were carried out randomly.

Materials and Procedure

The game with simulation characteristics was authored in Adobe Flash CS4 and coded with ActionScript 3.0. The tasks of the game required students to study a given problem within the simulated story of the game, and answer the given contextualized problem by using facilities of the game. In the story of the game, the player is to basically solve serious problems of a nuclear energy plant; the player(s) has to virtually travel to the plant to repair broken equipments. Then they have to come back. Whilst travelling to and from the plant, the players are to remove obstacles in the route by using, altering and balancing properties of atoms of the obstacles within ten pre-specified tasks. The facilities in the game include a number of chemical elements, electron microscope, scale, see-saw, neutralizer, ionizer, electropor and a tabulator. One of the challenges to players is to avoid ions in the environment; the game was programmed so that ions will affect the traveler at least three times in one way journey. The game had two purposes for this, one is to increase pace of the game/journey, and speed of ions, second is to increase the ion charges. The game rules included relations of variables of the content (such as electron number, proton number), and principles of estimating mass of particles. All different knowledge representation of the learning unit is processed through operators and objects of the game. The game provides hints to remind its player about the rules. The language of the rules contains both terms of scenario of the game and of the learning unit. A player uses the facilities through a mouse and arrow keys of a keyboard.

In addition to the game, two achievement tests for the learning unit were developed; one as a pre-test to measure how much students know about the learning content, another as a post-test to measure how much students learnt about the content. The two tests for the unit targeted the same instructional objectives, had the same number (16) of multiple choice items with four alternatives. Content validity properties of the tests were merely checked on the basis of instructional objectives the game targeted.

Students of the two classrooms and their science teacher in a state school, located at a lower-middle class residential area of a metropolitan city, helped to conduct the experiments in their computer laboratory with 15 computers. Before the sample played the game, their teacher administered the pre-tests in the classrooms. Then the sample groups were taken to the lab to play the game in two lesson hours. During the experiments only the researcher was present with the students.

The individual-play group was taken to play the game first in two sessions, because the lab had only 15 computers, and the collaborative group played next. Just before the students started to play, the researcher introduced the game and its goals, including its instructional goals. The students in this group had to complete all tasks to travel to and from the plant alone. So, they had more chance of controlling the manipulation devices than the collaborative group students who were paired on the basis of their selection of a partner, received the same explanations from the researcher, but they were informed about episodal turn-taking control procedure: The control of the manipulation devices will be handled by one of the students in a pair when travelling to the virtual plant, and handled by the other student when travelling back from the plant. An episode is a part of a sequence of a body of work. In the context of the study, an episode is a one-way journey to/from the plant. Control of the manipulation device in a particular episode is called episodal control, and since members of a pair takes the mouse control in order, we called this particular mode of control as episodal turn-taking control. The pairs were also instructed in that (i) they must agree on each action to take in completing tasks of the game, (ii) spend enough time to discuss, share opinions and agree, and (iii) it is important to complete all tasks of the game. The individual play-group finished the game in an average of 29 minutes, and paired students in 38 minutes. A usability test was then administered. The classroom teachers administered the post-tests two weeks after the implementation.

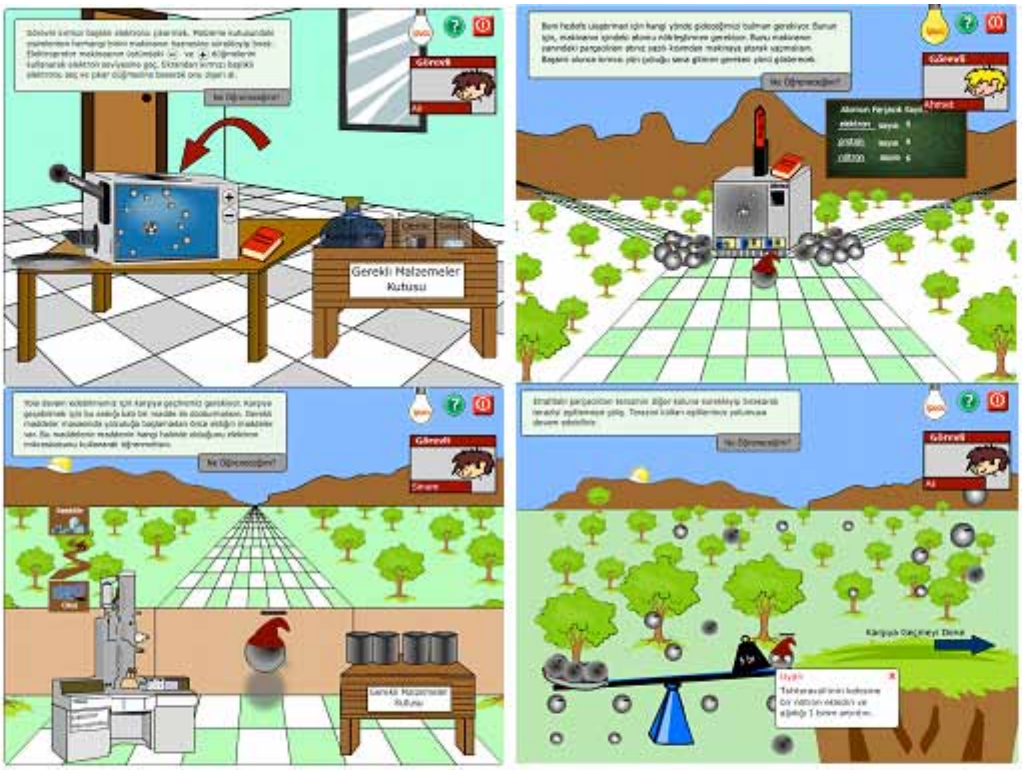

Figure 2: Learning game interface of ElektronKosuyor

Data analysis and findings

The difference between pre-test, post-test and progress (post-test minus pre-test) scores of the two groups was first compared (see Table 1). Before the comparison, each score of the pre and the post-tests (x out of 16) was converted into base-ten scores (x out of 10). Because of relatively small sample size, the data did not show a normal distribution. For this reason, multiple comparisons between the medians of the pre-tests, the post-tests and progress scores of the two groups were first made using the Kruskall-Wallis test (Chi-square=6,85; p =0.03). Since the Kruskal-Wallis test showed that the medians are not equal across sets of the scores, Mann- Whitney U tests were used to compare two sets. First follow-up Mann- Whitney U test revealed that the pre-test scores of the two groups were similar. Another Mann-Whitney U test was conducted to evaluate the hypothesis that collaboratively played students would score higher in the post-test and their progress score would be higher, on the average, than individually played students. The results of the test were in the expected direction and significant, (for the post-test scores $Z = 4.09$, $p<0.001$, and for the progress scores $Z = 2.59$, $p<0.05$), progress scores of individually played students had an average rank of 16.42, while collaboratively played students had an average rank of 26.11. The Cohen's d effect size estimation also highlighted contribution of the collaborative mode in the designed game environment to learning outcomes.

A further Mann-Whitney test was conducted to test whether the turn taking control style designed in the game play had any effect on the students' progress scores. The test (U=67.00; p>0.05) showed that whilst collaboratively playing the game, taking the first (mean rank=10.91; mean=1.45; std.dev.=2.25) or second (mean rank= 12.09; mean=1.91; std.dev.=2.26) turn in controlling the game did not affect the progress scores, also expressed by Cohen's d (0.23). Both groups welcomed studying the science topic in the game mode.

Table 1.
Data analysis for the experimental studies

	group	n	Mean	Std. Dev.	Mann-Whitney U	Z	p	Cohen's d effect size
pre-test scores	1	20	5.35	2.62	244.50	0.63	0.533	0.21
	2	22	5.77	1.41				
post-test scores	1	20	4.75	2.05	381.00	4.09	0.001	1.43
	2	22	7.45	1.82				
Progress (Post & pre-test difference)	1	20	-0.60	2.72	321.50	2.59	0.010	0.95
	2	22	1.68	2.21				

1. Individual; 2. Collaborative

Discussion and Conclusions

The learning game designed according to a hybrid set of guidelines, was played to learn a learning unit in science. Students who either played it individually or shared and played it with a partner in accordance with the script of the game had similar characteristics and prior knowledge of the learning unit. However, the students collaborated with a partner scored (mean=7.45; sd=1.82) significantly better than individually played students (mean=4.75, sd=2.05) in the post-test, and, in turn, their progress scores were also greater. The individually playing students controlled and completed all tasks alone in the game, the paired students directly controlled tasks delegated for one-way trip (half of the tasks), and completed all tasks in the game with a partner. The two groups' average game completion time differed as expected, because the paired students would spend some time on opinion sharing and on possible discussions. The seemingly more direct control of the environment in the individual mode did not affect learning as much as collaborative thinking and working/playing. The current report is aware that the pre and post tests developed had not been pilot tested, and their reliability and validity was not statistically studied, but only an expert opinion validated the tests. Hence the test results of the study ought to be interpreted cautiously.

The result verified the previous findings favoring collaborative mode of learning (e.g. Anderson et al, 2006; Kirschner et al, 2008), and game based learning (e.g. Barab et al, 2007; Karakus, Inal & Cagıltay, 2008; Tüzün et al, 2009; van Reijmersdal et al, 2010). This study validates that games should also be designed for collaborative learning strategies following the proposed model. Moreover, the result consolidated arguments raised by researchers (e.g. Brush, 1998; Strijbos & de Laat, 2010; Pilkington & Walker, 2003) that the scripted roles played by students in a pair while carrying out tasks get learners to be dependent to each other, that, the designed tasks, in turn, get students to develop a contributive style to negotiate and share with a partner. Unlike collaboratively playing students, the individually playing students did not have the opportunity to develop alternative perspectives to their own views and understanding of the content. Furthermore, as addressed by Goh, Ang and Tan (2008), Hamlen (2010), Infante et al, (2009), Jones & Issroff (2005) and Neal (1990) the developed collaborative game managed to ensure a balance of control amongst students; give opportunities to each student to control the interface, to control of their learning process; to have responsibility and choice of strategies and to discover immersed knowledge.

The students in the collaboration group selected their own partner, to ensure that the students in the collaboration group select a partner who is a socially similar and close-friend, the study allowed them to select their own partner. The game was designed in a way that it provides information about consequences of students' action, and the partner may also provide feedback and/or confirm feedback messages of the game. Further, the materials and processes engaged the students to spend as much time as they wanted on the tasks, allowing students to make mistakes and to correct them. The assigned tasks were balanced in a way that cognitive workload of the activities is similar for each student. Finally the course of the scenario was completed by each student through having identical amount of control over the interface.

In comparison to collaborative control studies, different from the studies by Abbnett et al (2001), Benford et al (2000), and Scott, Mandryk and Inkpen (2003) where multiple mouse is used in CSCL, and either poor learning was observed or learning depended on many other variables (see Abbnet et al, 2001, Infante et al, 2009; Villalta et al, 2011), in this study, the script/ scenario of the game required students to play a collaborative role resulting in engagement with the environment. Further, the study conducted to test a SCSS by Kerawalla et al (2010) reported students' copying actions without cognitive engagement, and students in pairs evaded discussion and collaboration with each other. Conversely, in this study, the turn-taking scheme over a series of tasks rather than just after the partner completes a single task minimized chance of replicating the friend's work. That required the second-turn student do the same task after carrying out some other tasks in an episode. In addition, one of the most critical difference in this study was that the scenario of the environment was in a game format where students selected their own partner with whom they feel safe to play together (Kirschner et al, 2008). If it is well scripted (Inkpen et al, 1997), episodal turn-taking for mouse-driven control of a game cursor in a collaborative environment can have significant influence on students' achievement.

The motivational and immersive characteristics of game-based learning have been intensely examined in the literature, but the systematic design and implementation of collaborative learning games is unexplored and remains a notoriously difficult topic. Hopefully this study may provide a validation of the collaborative learning game design, and further work augments guidelines and explores the multi player learning games played in a networked settings. It may be concluded that collaborative game style does indeed affect the patterns of interactions among pairs of users; further work should also focus on adding up new episodes to the scenario to advance students' learning under possibly different study regimes. Finally, to enable teachers' possible intervention in a task regime, a control panel for teachers should be implemented to the game.

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