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Learning from games: Does collaboration help?

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Abstract

This paper examines whether people benefit more from playing a commercial off-the-shelf game in pairs rather than in solitary mode. The basic idea behind this didactic method is that there is a serious risk that solitary game play yields insufficient articulation and explanation for learning to take place. Participants in the experimental condition played a strategy game in collaborative mode (pairs). Solitary play formed the control condition. During game play data were gathered about engagement (ie, flow). Also, the dialogues of the pairs were recorded. After game completion participants individually completed a knowledge test. For solitary players this ended the session. Collaborating pairs could discuss test answers (without receiving experimenter feedback) and give a final group answer. Collaboration was found not to affect game engagement and also did not affect individual knowledge test scores. The collaboration presumably did not advance the players' individual knowledge because the game dialogues mainly dealt with superficial game features such as move proposals. The collaborating players benefitted significantly from the opportunity to discuss test scores. The discussion revolves around game selection and game didactics (including scripted collaboration and debriefing) as routes for future studies to follow in ways of improving game utilisation in school.

Introduction

Computer games are extremely popular nowadays. They can be so engaging that players may lose all sense of time and place; players often display a phenomenal fascination and concentration. Schools generally do not provide a similar experience. Many students lack engagement, finding it difficult to remain concentrated on school work for an extended period of time. Yair's (2000) study is illustrative. This research, involving 865 students from 33 elementary and secondary schools, indicated that students were alienated from classroom instructions for almost half their time.

It is therefore not surprising that educators have began to examine whether games can contribute to student interest and learning (Dawes & Dumbleton, 2001; Gee, 2003; Kiili, 2007; Kirriemuir & McFarlane, 2004; Squire, 2006; Van Eck, 2006). There are two trajectories in this research effort. One approach revolves around the question of which characteristics of games transfer to the design of educational software. The other approach, which is taken in the present study, revolves around the question of how existing games can be functionally employed in school.

Games do not automatically qualify as suitable learning materials. Vital demarcation points on an implementation route are game selection and game 'didactics'.

Utilising games in education

An important aspect of game selection concerns the contribution of a game to the school curriculum and learning goals (Dondi & Moretti, 2007; Moreno-Ger, Burgos, Martinez-Ortiz, Sierra & Fernandez-Manjón, 2008; Squire, 2007). Some games more easily fit here than others and game selection should probably be based on these criteria. We should be careful here not to exclude attitudinal goals. As Squire (2007) states, 'from my experiences playing … I developed a surprising depth of knowledge … *and maybe more importantly, an affiliation* … that paid off in school (p. 51, italics added). In addition, in line with the current emphasis in education on evidence-based practices, one could argue that only games that have proven their worth for yielding learning outcomes should be considered for inclusion.

Not all games deal with a subject matter that is part of the school curriculum; some games better relate to learning objectives of schools than others. Adventures and strategy and simulation games have educational potential. They can serve a varied set of educational purposes as shown in utilisation studies with commercial off-the-shelf (COTS) games (eg, Dawes & Dumbleton, 2001; Kirriemuir & McFarlane, 2004). These games can support skills in strategic thinking, planning, communication, data handling and the like. In addition, they can contribute to students' knowledge development because they are based on an underlying domain model.

Action games generally are not very useful from an educational point of view. Such games can, however, serve dedicated educative purposes as illustrated in the recent research of Rosser *et al* (2007). In that study participants, physicians, significantly improved their eye–hand coordination in performing surgical tasks after having played three popular video games (ie, *Super Monkey Ball 2*, *Star Wars Racer Revenge* and *Silent Scope*) for 3 months.

Another important issue in game utilisation in schools relates to game 'didactics'. Games capitalise on learning-by-doing. The players' moves are, to a large degree, evoked by elements of the (learning) environment and often have a large trial-and-error component (Kirriemuir & McFarlane, 2004). For the employment of games in school, this raises the question of whether students will and can self-regulate in ways that are meaningful for efficiently acquiring deep-seated knowledge or problem-solving skill.

There is a serious risk that students never engage in the articulation and explanation that is critical for such learning outcomes to appear (Leemkuil, 2008). Self-regulative actions therefore probably should be stimulated or scaffolded by external elements in COTS games. This study examines whether collaborative gameplay can provide such scaffolding. Does playing a game in a collaborative mode carry special advantages for learning over playing in solitary mode?

Collaborative learning in games

Collaboration can be defined as a situation in which two or more people share and co-construct knowledge in solving a problem. A considerable number of educational studies and metastudies show that learners benefit from collaboration (eg, Cohen, 1994; Johnson & Johnson, 2002; Webb, 1989). Advantages have been reported for process and product measures.

Most of the studies on collaboration do not involve games, however. The research from Inkpen, Booth, Klawe and Upitis (1995) illustrates a rare investigation on the advantages of collaborative gameplay. Participants, elementary school children, played a game called *The Incredible Machine* where players received a collection of parts from which they were to assemble a Goldberg style machine—absurdly connected machines functioning in extremely complex and roundabout ways to produce a simple end result (see http://rubegoldberg.com). There were three conditions:

solitary play, parallel play and collaborative play. In parallel play, participants were situated next to each other. In collaborative play, partners shared one computer. Collaborative play resulted in significantly higher scores on motivation and learning outcomes than the other modes. Inkpen *et al* speculated that this was the result of the verbal interactions between the players. During collaboration, so they guessed, players discussed their game, verbalising game moves, ideas and arguments.

The advantage of collaboration over solitary work that is reported in many educational studies is often ascribed to its stimulating effect on verbalisation. Not all verbalisations contribute equally to knowledge and skills development, however. Some dialogic acts are more useful than others; differences in the epistemic qualities of dialogues have been found to correlate with differences in learning outcomes (eg, Dillenbourg, Baker, Blaye & O'Malley, 1995; Springer, Stanne & Donovan, 1999; Webb, 1989). For a study on the contribution of collaboration on learning from games, one should therefore also look at the qualities of the dialogue.

Research questions

The study tests the following predictions:

1. *Collaborative gameplay diminishes the players' engagement (hypothesis 1)*. This hypothesis examines the question of whether adding the component of collaboration has any negative influence on the attractivity of the game to the player. To our knowledge, there are no empirical studies comparing game engagement in solitary mode with game engagement in collaborative mode. Our tentative prediction is that the partnership mode slightly reduces game engagement because the communication between partners may distract them from playing the game (compare Inal & Cagiltay, 2007). Game engagement is measured through the concept of flow which refers to the degree of absorption or concentrated effort in a progressing activity (Csikszentmihalyi, 1990). Flow has been reported in a variety of activities of people, including gameplay. In learning contexts, flow has been found to significantly affect the outcomes (eg, Vollmeyer & Rheinberg, 2006).
2. *Collaborative gameplay increases the learning outcomes (hypothesis 2)*. Participants in the control condition of the study play a game in solitary mode. In the experimental condition, two participants play the game together. The prediction is that collaboration yields higher learning outcomes on a knowledge posttest because the collaboration stimulates players to articulate and explain their thoughts about the game. Recordings of the dialogues are analysed to explore the nature of the communications during gameplay. After individual test completion, players in the experimental condition can discuss answers to give a collaborative response. We explore whether the partnered score that results from this second moment of discourse yields a higher outcome. Although no feedback is given on test answers, the moment provides another opportunity for reflection and articulation that can be helpful.

Method

Participants

Participants were students from Twente University in the Netherlands. The average age of the students was 21 years and 1 month. A total of 18 men and 27 women participated. Twelve participants received study credits for partaking in the study. The others were volunteers. Fifteen participants played the game in solitary mode, 30 participants played the game in pairs in collaborative mode. For the partnerships, we selected pairs of participants who already knew each other to ensure us of the presence of a positive social relationship between partners that is considered a vital basis for effective collaboration (Johnson & Johnson, 2002). Because this meant a nonrandom allocation to conditions, we checked whether prior game experience and game motivation, two important input factors, differed between conditions at the start and whether these factors interacted with (possible) effects of conditions.

Materials

Game

Participants played *Lemonade Tycoon*, a COTS strategy game whose main goal is to set up a successful lemonade business. The game revolves around the law of supply and demand. It requires skilful use of strategies in manipulating variables such as hiring staff, recipe(s) for making lemonade, stock, location, stand, price of lemonade and marketing expenditure. Success further depends on factors such as weather situations, news, and popularity of and satisfaction with the lemonade. The game has been designed as a one-player game. Pilot testing revealed that the game was suitably challenging for the participants and could be completed within 60 minutes.

Game experience questionnaire

The game experience questionnaire asks three closed questions about participants' prior experience with games (eg, For the last month, how many hours for the average week did you spend on playing strategy games like The Sims, SimCity, Civilization?). Answers can be given in predetermined categories for ranges of hours or experience.

Motivation questionnaire

The motivation questionnaire is based on a validated instrument (Rheinberg, Vollmeyer & Burns, 2001). After describing the future task, four constructs are measured: interest (eg, I like it that you learn new things with this task), probability of success (eg, I believe I will succeed on this task), anxiety (eg, This task worries me) and challenge (I'm eager to do well on this task). Answers can be given on a 7-point Likert scale. Cronbach's alpha for the constructs varied between 0.71 and 0.89.

Flow questionnaire

The flow questionnaire is based on a validated instrument from Rheinberg, Vollmeyer and Engeser (2003). The questionnaire consists of 11 questions (eg, 'I didn't notice time passing', 'I feel that I have everything under control'). Answers can be given on a 7-point Likert scale. Cronbach's alpha was 0.90.

Observation scheme

Dialogues were registered on a voice recorder, written out and scored with an observation scheme based on research literature on collaborative dialogues in education (eg, Gunawardena, Lowe & Anderson, 1997; Hämäläinen, Oksanen & Häkkinen, 2008; Ohlsson, 1996; Wegerif, 2000). The scheme proposes a classification of dialogic acts into different functional levels of gameplay (see Table 1). First-level verbalisations deal with expressions about visible aspects of gameplay. Second-level verbalisations deal with game actions that players are contemplating. Third-level verbalisations refer to expectations about reactions to game moves. Fourth-level verbalisations go to the heart of attempts to understanding the game.

A large majority of dialogic acts fitted comfortably within one of these categories. Occasionally, expressions belonged to more than a single category (eg, a move proposal might include a prediction or explanation). For these 'doubles', a score was awarded in both categories. Interrater agreement for the dialogic acts was satisfactory (Cohen's kappa of 0.83).

Knowledge test

The knowledge test measures knowledge about game concepts, principles and structures. There are three questions about definitions of concepts (eg, customer satisfaction and popularity).

Table 1: Scheme of dialogic acts in collaborative gameplay

Activity	*Definition*	*Example*
Fourth-level verbalisations		
Relating to prior knowledge	Indicating having seen or done something before	'It looks just like J-builder, that program also says there is an error find out for yourself where the error is.'
Explaining/arguing	Accounting for and reasoning out ideas	'We have 100 lemons so we can make 25 pitchers.' 'Because that is cheaper.' 'That's because we don't have upgrades.'
Third-level verbalisations		
Predicting	Forecasting future situations and effects	'We will not get more than 60 customers.' 'We will get famous.'
Second-level verbalisations		
Explicating/proposing		
Making a proposal	Suggesting what actions to take	'Click on that button.' 'Let's start the day.' 'Do $1.20 then?'
Reacting to a proposal	Responding to and/or evaluating a proposal	'Yes, let's do it.' 'I don't know if that is important to do.' 'Yes, make it 1.20.' 'No, don't.'
First-level verbalisations		
Describing	Telling what happened in an event	'All the ice cubes melted.' 'The clients hate the lemonade.'
Querying the interface	Inquiries about the interface	'He says that it is too expensive or something like that?' 'What is this?'

Players receive a score for concepts that are not defined in the game but that do play a role in the game. Players should infer their meaning from playing the game. There are also three questions about principles. The game is built around the main principle that events and actions influence each other, as well as the outcomes. An example is the principle that more advertising yields a higher popularity. The coherence between the various principles together yields a structure for the game. Once players know this structure, they should also know the principles involved in new situations and can predict outcomes. Structural knowledge is assessed with three open questions that describe a situation. Participants must indicate the principles involved and predict the outcome. The maximum score on the knowledge test is 25 points.

Procedure

Before the start of the game, participants filled in the game experience and motivation questionnaire. Next, they played *Lemonade Tycoon*, which they all completed within 60 minutes. Thereafter, participants filled in the flow questionnaire and took the knowledge test. Players were not told in advance of these assessments. All participants completed the knowledge test individually (solitary knowledge). For solitary players, the session ended here. Players in the experimental condition could discuss test answers with each other to give a group response (partnered knowledge). Test answers were not disclosed to participants at any time during the study.

Analyses

Checks on equal distributions of prior game experience and game motivation (treating partnerships as a unit) revealed no statistically significant differences between conditions. Because there were also no significant interactions with effects of conditions on flow and learning outcomes, these factors are further ignored. In computing percentages for dialogic acts, we have used the sum of all coded dialogic acts as the denominator. Just to make sure, we also computed scores in which we corrected for doubles. These analyses yielded nearly identical outcomes. Differences between conditions for the solitary knowledge test scores were measured with an analysis of variance (ANOVA). A repeated measures ANOVA was used to test for differences between knowledge test outcomes in the experimental condition. For significant results, we used Cohen's *d*-statistic to report effect size.

Results

Does collaboration affect engagement?

We found no differences between conditions on participants' experience of flow, $F(1, 28) = 1.37$, *ns*. Solitary and partnered participants indicated having experienced a similar level of engagement in playing the game. The mean score in each condition is slightly above the scale midpoint, showing a fair degree of concentrated effort (see Table 2). This finding is a positive sign that adding collaboration onto a COTS game can be done without serious loss of engagement.

What dialogic acts are there in the partnerships?

The dialogic acts of the players in the experimental condition are presented in Table 3. By far, the most prevalent dialogue in the partnership revolves around explicating/ proposing. Such a dialogue sits well with the essence of playing strategy games that primarily calls upon making strategic choices in an unfolding scenario. The collaboration stimulates bringing these choices out into the open; it encourages partners to describe possible courses of actions so that each knows the move the other is contemplating. This type of dialogic act naturally arises when partners communicate about their gameplay, and it is an important benefit of collaborative gaming that such verbalisations occur. Explicating/proposing involves only superficial aspects of the game, however. With the exception of occasional doubles, there is no conversation about game concepts, principles or structures. Players just state their ideas about a next move without any further reasoning. The partner's reactions to a proposal likewise consist of merely an expression of (dis)agreement without further argumentation behind the acceptance or rejection of a proposed course of action.

The next most frequent dialogic act is describing and querying. In describing, partners inform each other about effect(s) of game moves. Describing merely draws the attention of the other player to this feedback. Just as explicating/proposing, it misses any reasoning about deep-seated

Table 2: Mean results (standard deviations [SD] between parenthesis) for flow and knowledge test** scores in the two conditions*

	Flow	*Solitary knowledge*	*Partnered knowledge*
	Mean (SD)	*Mean (SD)*	*Mean (SD)*
Solitary mode	4.37 (0.71)	9.30 (2.84)	n.a.
Collaborative mode	4.04 (0.93)	9.98 (2.47)	11.92 (2.91)

*Scores on a 7-point scale; higher means a more concentrated effort.
**Maximum score of 25.
n.a., means not applicable.

Table 3: Distribution of dialogic acts (in percentages) in all partnerships

	Mean (SD)
Fourth-level verbalisations	
Relating to prior knowledge	0.1 (0.2)
Explaining/arguing	5.9 (1.4)
Third-level verbalisations	
Predicting	6.0 (1.7)
Second-level verbalisations	
Explicating/proposing	62.2 (7.1)
First-level verbalisations	
Describing	15.4 (3.9)
Querying the interface	10.4 (4.1)

SD, standard deviation.

game features. It is a first step towards a reasoned account of gameplay, but it deals only with superficial aspects of game actions and reactions. In querying the interface, partners generally do not discuss domain aspects of gameplay. Instead, they communicate mainly about interface issues that partners find unclear and wish to discuss. Questions raised by one of the partners received a response in most (84%) of the dialogues.

Together these dialogic acts constitute almost 90% of all communications between partners. They also encompass the two most basic verbalisation levels. Talk on higher levels was found to be scarce to non-existent.

Does collaboration affect learning outcomes?

Contrary to our prediction, collaborative gameplay did not positively influence scores for players. Solitary knowledge scores were similar in both conditions, $F < 1$, *ns*. The reason may be the lack of depth of the dialogues. Partners mainly discussed superficial game features.

In the experimental condition, partners could discuss their solitary posttest answers and give their final answers as a group (ie, partnered knowledge). At no time during this discussion did they receive any feedback on the test. Even so, players in the experimental condition gave significantly more correct test answers, $F(1, 44) = 25.55$, $p < 0.001$, $d = 0.92$. The mean gain for a partnership was 1.9 points, or a 19% increase from their solitary knowledge score.

Discussion

Selection for the use of games in school can be based on their possibilities to realise goals for knowledge, attitudes or skills development that fit within the curriculum. Also, one might want to concentrate on games that have proven to be effective. A corollary of this requirement is that there should be a valid test to assess the learning outcomes from a game. For many COTS games no such test is available and needs to be developed. For *Lemonade Tycoon*, we devised a test to measure the fundamentals of that game. In future studies, it will be important to go beyond the specifics of a game. It should also be examined whether players have developed strategic abilities that they can use in other situations and games. Finally, the choice for game use in schools can be based on its suitability for solitary and/or multiplayer gaming. The *Lemonade Tycoon* game studied in this paper was seen as befitting both types of play.

Collaboration has repeatedly been found useful in educational settings (eg, Cohen, 1994; Johnson & Johnson, 2002; Webb, 1989). It contributes to better articulation and argumentation which should be especially beneficial for learning from games. We therefore explored the contribution of collaboration in a COTS game. Our study started with free collaboration because there have been almost no studies on collaboration in gameplay. In addition, free collaboration as a game didactic is unobtrusive and easily applied, and would therefore constitute a perfect means to enhance learning from games. In the experiment it did, however, not have the predicted beneficial effect. The absence of an effect of collaboration has also been found in various educational studies where it prompted the development of scripted collaboration. In such a collaboration, partners are assigned different epistemic or social roles and tasks (eg, Hämäläinen *et al*, 2008; Weinberger, Ertl, Fischer & Mandl, 2005). Scripting can also be explored as a means to enhance learning from games in a collaborative mode. A good candidate for scripted collaboration in games is the conflict-script. Such a script capitalises on conflicts (eg, physical or mental obstacles, opponents and dilemmas) that play a vital role in games as well as in collaboration (Fullerton, Swain & Hoffman, 2008). For example, in *Lemonade Tycoon*, one partner can be asked to play the role of an investor aiming for long-term benefits, while the other is asked to go for the 'quick buck'.

In the study, we also explored another method to stimulate students to articulate their game knowledge, namely where we invited partners to discuss test answers. Even though there was only the dialogic opportunity, and no feedback on answers, this yielded a partnered knowledge score that was almost 20% higher than the solitary knowledge score. This finding indicates that an after-games didactic can significantly affect learning (see Van Ments, 1994). It also raises the question of what other after-game didactics, for play in solitary mode as well as in collaborative mode, have potential for enhancing learning outcomes.

A varied set of promising methods come from exploiting testing and feedback in more ways than has been done in the present study. Testing was now used only to assess what players had spontaneously learned. But testing usually also informs players about the knowledge they are expected to learn; a test can alert players to the knowledge or skill they should gain from playing the game. Thus, it makes sense to let players engage in another gameplay after being tested to see if this makes them more focused and subsequently yields more learning.

For feedback, there are several possibilities. One option is to reveal only the total test score. Players can use this score to compete against themselves, to see if their game performance and test score improve game after game. Other feedback possibilities vary in degree of detail about (in)correct answers. Generally, a distinction is made between feedback in the form of knowledge of results (KR), knowledge of correct results (KCR) and knowledge of correct results plus additional information. KR feedback merely informs people about the correctness of their answer to a test item. KCR feedback tells people which is the correct answer. KCR plus feedback further adds information about the correct answer. Results for these types of feedback have varied across studies, but KCR usually leads to better learning than KR (see Cameron & Dwyer, 2005; Corbalan, Kester & Van Merriënboer, 2009). An important consideration in deciding what kind of after-game feedback to give is whether one would plan for players to discover fundamental concepts, principles and the like themselves, or whether to instruct them about these game features.

Test feedback can be combined with a 'debriefing' about important game features (eg, fundamental game elements). Having experienced first how various game elements conspire during play, students are likely to be appreciative and benefit considerably from debriefing (Garris, Ahlers & Driskell, 2002). To quote Van Ments (1994) here: 'there is no doubt that for many purposes it is the debriefing period which establishes the learning … at this point the consequences of actions can be analysed and conclusions drawn … at this point also mistakes and misunderstandings can be rectified' (p. 49). Debriefing may also, and perhaps more effectively, be learner-led and teacher facilitated.

It is desirable that games are seen and studied as an integrated part of the curriculum. Future research on the utilisation of games should therefore (also) address the issue of how game use can best be combined with other instructional methods. Several authors (eg, Shaffer, Squire, Halverson & Gee, 2005; Williamson & Facer, 2004) indicate that game research should include the wider cultural and media contexts for games (eg, online game communities, game magazines, Q & A). For *Lemonade Tycoon*, students can be stimulated to learn more about the game by entering the social community of its players who exchange experiences, 'cheats' and insights.

To conclude, in order for the use of COTS games to become more commonplace in school, it seems important that research establishes the situations in which they best can be employed, as well as the scaffolding activities that enhance the articulation and explanation that is vital for learning from games.

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