Does Collaborative Self-debriefing Scaffold Digital Game-based Learning Better than Individual Self-debriefing Does?

Juo-Lan Li (s0216526)

Supervised by Dr. H.H. Leemkuil & Dr. H. van der Meij

University of Twente
Faculty of Behavioural Sciences
Educational Science and Technology
# Table of Content

Abstract .......................................................................................................................... 3  
Introduction.................................................................................................................... 4  
Debriefing in Digital Game-based Learning .................................................................. 4  
Research Questions ...................................................................................................... 8  
Methods.......................................................................................................................... 10  
   Participants .................................................................................................................. 10  
   Materials ...................................................................................................................... 10  
      Game ......................................................................................................................... 11  
      Game Experience Questionnaire ............................................................................. 11  
      Game Motivation Questionnaire ............................................................................. 12  
      Debriefing Questions .............................................................................................. 12  
      Knowledge Test ...................................................................................................... 13  
   Procedure .................................................................................................................... 14  
   Analyses ...................................................................................................................... 14  
Results ............................................................................................................................ 15  
Discussion ....................................................................................................................... 18  
Reference ......................................................................................................................... 20
Abstract

Research on digital games indicates that their benefit for education depends on the added presence of scaffolding. Without additional support learning from games is meagre at best. This study focuses on debriefing as a promising type of support. Historically, debriefing has always been considered an important after-experience method that can significantly enhance learning. Effect studies on debriefing are scarce, however. This study examines the potential of self-debriefing as a means to enhance game-based learning. In self-debriefing people are stimulated to reflect upon their game experiences with a set of leading questions. Two conditions of self-debriefing are examined in an experiment: individual and in pairs. In the study 45 Taiwanese high school students first played a strategy game, Lemonade Tycoon Deluxe, whereafter their knowledge was tested. Next there was self-debriefing, another round of game play and a final test. The findings show that students in both conditions considerably improved their game knowledge from the first moment of testing to the last. Students who engaged in individual self-debriefing realized a significantly stronger knowledge gain than students who self-debriefed in pairs. The discussion revolves around the design of the self-debriefing questions and the differences between individual and group self-debriefing.
Introduction

Along with the development of information and communication technology, digital games have been used more and more widely in the education settings. To make digital game-based learning more effective, studies indicate it is necessary to add scaffoldings and supports within the game or in the context of game learning (Garris, Ahlers, & Driskell, 2002). Debriefing, a post-experience analytic process (Lederman, 1992), has been thought of as an important after-game didactic to enhance experiential learning. However, experienced debriefers are not many and easily accessible in every game learning context. To this problem, self-debriefing, in which learners debrief themselves with leading debriefing questions, can be the solution. Digital games are not only used in educational institutes, they are also mostly used in e-learning environment in which self-debriefing could be more feasible than instructor-facilitated debriefing. Self-debriefing could be held individually, in pairs or in groups. The latter two forms in which participants reconstruct experiences together through communicating with each other correspond to the idea of collaborative learning. This study aims to investigate whether individual or collaborative self-debriefing makes a difference in digital game-based learning. In this way, we may have more understanding about the possibilities of self-debriefing, its relevant forms and future application.

Debriefing in Digital Game-based Learning

Digital game-based learning needs scaffoldings or supports to make learning effective and explicit. Garris et al. (2002) point out that people do not learn from simple exposure or experience alone so that the use of tools, either embedded within or outside of the games, or the help of other people, can facilitate the learning. Leemkuil (2006) summarized several possible scaffoldings and supports to games such as feedback, additional assignments, collaboration, or debriefing etc. Not all games are specifically tailored to match certain subject matter or learning objectives of schools. When using commercial off-the-shelf (COTS) games in educational settings, considering the feasibility and cost, it is more practicable for instructors to apply game didactics such as collaboration or debriefing in the learning scenario, rather than to incorporate supports into games, which asks for the ability of game designing. In the discussion of the study, Van derMeij, Albers, & Leemkuil (2010) thought the reason why collaboration in game learning did not have predicted beneficial effect resulted from the superficial level of collaborative discussion. Therefore, they proposed collaborative scripts during the process of game playing and debriefing as after-game scaffolding for future studying. Debriefing is a process where learners reflect and analyze what they did and felt with respect to existing concepts and new generalizations so that they can develop hypotheses to be tested in future experiences (Warrick, Hunsaker, Cook, & Altman, 1979). Its purpose is to assist players to clarify what they just experience, change their view from subjective to objective and to clear up misunderstanding or mistakes (Ments, 1999).
In general, debriefing is a post-experience group discussion guided by a facilitator. However, qualified debriefers are not available in every educational setting. Fanning and Gaba (2007) indicate that self-debriefing can solve the problem in lack of expert debriefers and cost of employing them. Lennon (2006) also endorses the idea of self-debriefing. He recommends the digital games, especially those played at home or in a non-school context, should be equipped with a guided self-debriefing at the end of the games to enhance their educational value. An empirical study conducted in the field of anaesthesiology also favours the application of self-debriefing. The study aims to compare the effectiveness of self-debriefing to instructor debriefing in improving the non-technical skills of hospital residents. The results highlight the role of self-debriefing of simulation-based education and suggest that effective teaching of non-technical skills can be achieved even when instructors are not available (Boet, Bould, Bruppacher, Chandra, & Naik, 2010).

Self-debriefing could be held individually, in pairs or in groups. Each has its own strengths and weaknesses. In individual self-debriefing the individual learner records what s/he just experiences, and then listens to and comments on what is recorded (Schoepfle & Werner, 1999). It allows learners to reconstruct truly their own experience for reflection without bias from others. It also prevents learners from stress of ridicule and rejection in traditional group debriefing, and encourages especially shy learners to engage in debriefing. On the other hand, pairing and group self-debriefing provide learners with an opportunity to share experiences, perspectives and insights, and generalize common understanding as collaborative learning does. Through collaborative learning, learners can come up with new ideas, debug their ideas, and notice the complexity of concepts and skills (Leemkuil, de Jong, de Hoog, & Christoph, 2003). Peters and Vissers (2004) discussed the relation between individual and collective learning in debriefing. They reviewed that learning in debriefing is almost invariably described as a process within individual and it is sufficient if simulation game aims at learning by individual participants. On the other hand, if the objectives are more complicated such as creating a shared vision or joint problem solving and decision making, debriefing should focus on group-level. Nevertheless, further empirical studies are required to validate the effectiveness.

Under the conditions of self-debriefing, written debriefing has advantages over oral debriefing. Written debriefing, in essence a form of self-debriefing, guides learners to undertake debriefings with supports such as suggestions or concepts on paper (Petranek, 2000). Through putting down in words, facilitators are able to examine each learner’s learning progress and clarify misconception that might occur in self-debriefing. In addition, it allows learners to substantiate what they just experience, analyze it, and reflect on their own actions. In this way, learners actually see what they debrief by which they can analyze their learning processes systematically and share with peers as well.

It must be noted that learners are not able to undergo self-debriefing without any support. To perform self-debriefing effectively, a set of comprehensive questions designed on learning objectives are needed to direct learners to what they have thought of and what they have not discovered yet. Kriz (2010) confirms it is worthwhile to formulate some leading questions which steer learners’ thoughts of
debriefing in a structured manner. In line with this view, the content of debriefing questions plays a key role in the whole self-debriefing. Using an activity, named diary authors, as a means of written debriefing, Kriz proposes four possible reflection dimensions of debriefing questions: chronological development perspective (of the complete process), topic-centred perspective (contents), group-related perspective, and personal centred perspective (learner himself or other person/s). Sims (2002) also uses journal writing to apply written debriefing and suggests a general guideline composed of three elements: experience, theory, and application. Both Kriz and Sims focus on guiding learners to reconstruct experiences step by step, to discover or realize the learning objectives, and to plan for possible future application.

For the important sake of the content of debriefing questions, it is worth while examining the subject more closely. Many authors, as listed in Table 1, have proposed various frameworks and often divided a debriefing session into several phases or stages with descriptions or example questions. Though there are similarities and discrepancies among the frameworks, they all follow the natural order of human processing: to experience an event, to reflect on it, to discuss it with others, and learn and modify behaviours based on the experience (Fanning & Gaba, 2007). Basically, each framework for debriefing contains learners’ experience reconstruction, reflection about the outcomes, and possible applications in real-world situations. In consideration of the natural order of human processing and that debriefing is to enhance experiential learning, the four phases of Kolb’s experiential learning cycle (1984) are used as basis to examine each of these frameworks.

The initial concrete experience phase involves learners in new experiences fully and without bias. They are supposed to objectively describe the experience and subjectively describe their feelings, perceptions and thoughts about the experience. The second reflective observation phase asks learners to reflect and observe their experiences from different viewpoints so as to add more meanings and perspectives to the experience. The following abstract conceptualization phase is the time for learners to create concepts that integrate their observations into logically sound theories. Learners incorporate the experience within their own concepts, theories or models. In the last active experimentation, learners make decisions and solve problems. They can explore what has been learned in the experience thorough ‘What if’ scenarios and further apply it to the parallel real world (Kolb, 1984; Sims, 2002).

### Table 1 Comparison of different debriefing phases/stages

<table>
<thead>
<tr>
<th>Author</th>
<th>Beginning of debriefing</th>
<th>End of debriefing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lederman, 1992</td>
<td>Introduction to systematic reflection and analysis (*)</td>
<td>Intensification and personalization (1)</td>
</tr>
<tr>
<td>Steinwachs, 1992</td>
<td>Description (1)</td>
<td>Analogy/Analysis (4)</td>
</tr>
<tr>
<td>(Thiagarajan, 1992)</td>
<td>How do you feel? (1)</td>
<td>Do you agree? (3)</td>
</tr>
<tr>
<td></td>
<td>What happened? (1)</td>
<td>Do you agree? (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Déjà vu? (3,4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What would you do differently? (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can you improve this activity? (*)</td>
</tr>
</tbody>
</table>
Self-debriefing in DGL

<table>
<thead>
<tr>
<th>(Ments, 1994)</th>
<th>Establishing the facts (1)</th>
<th>Analyzing the causes of behaviour (2)</th>
<th>Planning action (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(El-Shamy, 2001)</td>
<td>What happened in the game (1)</td>
<td>Significance of those happenings (2)</td>
<td>Plan for the application of what was learned (4)</td>
</tr>
<tr>
<td>(Petranek, 1994)</td>
<td>Events (1)</td>
<td>Emotions (1)</td>
<td>Empathy (2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Sims, 2002)</th>
<th>Concrete experience (feeling) (1)</th>
<th>Reflective observation (watching) (2)</th>
<th>Abstract conceptualization (thinking) (3)</th>
<th>Active experimentation (doing) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Kriz, 2010)</td>
<td>How did you feel? (1)</td>
<td>What has happened? (1)</td>
<td>In what respects are events and reality connected? (4)</td>
<td>What did you learn? (3)</td>
</tr>
</tbody>
</table>

Kolb’s Experiential Learning Cycle: Concrete Experience (1), Reflective Observation (2), Abstract Conceptualization (3) and Active Experimentation (4)

Outside of the four phases (*)

From Table 1 it can be observed that elements of all the authors’ frameworks can be categorized to the four phases of Kolb’s experiential learning cycle. Except the framework of Petranek and that of Sims, the others do not fully meet all the phases. However, Petranek’s and Sims’ frameworks can be further improved with the other’s strengths, such as elaborating with example questions or dividing the first phase more specifically. After a comparative analysis, a framework for debriefing content, integrating the strengths of the above frameworks and referring to example questions of the empirical studies, can be reorganized as follows:

Table 2 Reorganized framework of debriefing content with example questions

<table>
<thead>
<tr>
<th>Concrete experience</th>
<th>Events</th>
<th>What has happened?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emotions</td>
<td>How did you feel?</td>
</tr>
<tr>
<td>Reflective observation</td>
<td>Empathy</td>
<td>What did you observe in others?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What did the exercise mean for you and in relation to others?</td>
</tr>
<tr>
<td>Abstract conceptualization</td>
<td>Explanations</td>
<td>Do you agree?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What did you learn?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What would have happened if . . . ?</td>
</tr>
<tr>
<td>Active experimentation</td>
<td>Every day</td>
<td>In what respects are events and reality connected?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What if…?</td>
</tr>
<tr>
<td></td>
<td>Employment</td>
<td>What would you do differently?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How do we go on now?</td>
</tr>
</tbody>
</table>

Table 2 clearly indicated a detailed sequence that guides learners how to make the best learning of their own experiences. Instead of aimless reflection or discussion, the table can be integrated with learning objectives of the desired experiential activities so as to lead learners systematically to undergo the learning process. Hence, the design of debriefing questions used in this research is founded on this reorganized framework and will be elaborated in accordance with learning objectives of the game in the material section.
Research Questions

Though debriefing is widely thought of as effective and necessary as a wrap-up session in experiential learning, only one empirical study in anaesthesiology was conducted to examine the effectiveness of self-debriefing. There is no study found on the different effects between individual and collaborative self-debriefing. Besides, most studies on debriefing were done with real-world activities such as simulations or games rather than learning through digital games. Consequently, it is of my interest to test which form of self-debriefing serves as better scaffolding in digital game-based learning.

The research question is:

Does collaborative self-debriefing scaffold digital game-based learning better than individual self-debriefing does?

In order to adequately evaluate the different effectiveness between collaborative self-debriefing and individual self-debriefing, the outcomes on game learning should be specified. Leemkuil (2006) presents a model of game-based learning, which distinguishes information processing and learning into two modes. When playing the game in search mode or experiential mode, players learn in implicit unselective mode, which means they unintentionally learn certain things in the game such as facts, procedures, or sequences of actions at first and then new abstractions, rules or insights. This kind of learning leads to intuitive or context specific knowledge that is difficult to verbalize. On the other hand, when players process the information in reflective mode, they use learning strategies aimed at explicitly learning, comprehending or memorizing. Thus, learning occurs in an explicit or selective mode.

Not all the learning outcomes turn out to be explicit. In the study, Leemkuil (2006) indicated a study as an example of implicit learning in which students could not make explicit what they learned, but could apply new insights or skills. And though game scaffoldings are designed to support players to use reflective mode of information processing and not only experiential mode, or to use the reflective mode more effectively, it is possible to enhance explicit learning while affect implicit learning. This is proved with a study by Leutner (as cited in Leemkuil, 2006). Results of the experiments show that advice as scaffolding in the game increased verbal domain knowledge, but decreased game performance. Qudrat-Ullah (2007) also indicates that the task performance and task knowledge are not the same. Task practice can help learners to perform better but not to improve their ability to answer verbal questions on tasks. On the contrary, verbal instructions can improve question-answering ability but not task-control performance. In the study, he evaluated the effectiveness of group debriefing on multidimensional performance outcomes, including task performance, structural knowledge, heuristics knowledge, and decision time. Among them, structural knowledge pertains to knowledge about principles, concepts, and facts about the underlying model whereas heuristics knowledge concerns how learners actually control or manage a task. Heuristic knowledge is described as the use of the general knowledge gained by experience, sometimes expressed as ‘using a rule-of-thumb.’ Further definition comes from Collins,
Brown and Holum (1991) who divides knowledge into four categories. In their viewpoints, domain knowledge includes the concepts, facts, and procedures explicitly identified with a particular subject matter, and heuristic strategies are generally effective techniques and approaches for accomplishing tasks that might be regarded as ‘tricks of the trade.’

Concluding from the aforementioned explanations, concepts in this research represents the terms appearing in the game and its meaning in the game context. Principles signify the relationships among the events, actions, and outcomes in the game, composing an underlying model of the game. Both of them make up structural knowledge. As for heuristic knowledge, it stands for how learners tackle with a given problem in the game based on their playing experiences. In other words, learners may not know clearly each concept and principle, but they can devise an overall strategy to deal with a new context out of instinct.

Turning back to the issue of how to measure learners’ learning outcomes more precisely, the implicit learning outcomes are evaluated with game performance and heuristic knowledge whereas the explicit learning outcomes are evaluated with structural knowledge consisting of concepts and principles of the game.

The research model that evaluates the influence of individual self-debriefing and collaborative self-debriefing in digital game-based learning is schematized in Figure 1.

![Figure 1 Research model](image)

In this study, participants come from the same class and are randomly assigned to different groups. In consideration of prior difference among participants, questionnaires on game experiences and game motivation are distributed before any intervention to examine whether the two groups are similar so as to control the possible effects of these two variables on the learning outcomes. Following this begins the experiment which is depicted in Figure 1. The first game playing provides scores of the first game performance and test 1 offers participants’ paper-based scores, both of which are used as a covariate for the results of the second game playing. Afterwards, participants self-debrief either individually or in pairs. Lastly, the second game playing is held to collect game scores, and next the experiment ends with the second paper-based knowledge test.
The corresponding sub-questions are:

1. Do the two groups differ in game experience?
2. Do the two groups differ in game motivation?
3. Do learners with collaborative self-debriefing perform better in game score than learners with individual self-debriefing?
4. Do learners with collaborative self-debriefing gain more structural knowledge than learners with individual self-debriefing?
5. Do learners with collaborative self-debriefing gain more heuristic knowledge than learners with individual self-debriefing?

Providing that the two groups have no difference both in game experience and game motivation, learners with collaborative self-debriefing would have better learning outcomes than learners with individual self-debriefing. With the opportunity of collaboration, learners are supposed to have more chance to clarify their concepts and principles and get deeper impression through mutual discussion. Similarly, with information exchanging, learners are supposed to reconstruct more complete experiences in game playing. They would play games more specifically with the winning-proof strategies on the strength of mutual experiences or in a more conservative way, namely not to repeat each others’ errors, so that their game performance and heuristic knowledge might increase more than learners with individual self-debriefing.

Methods

Participants

Participants of the study were 45 Yi-Lan Senior High School students. The average age was 17 years old. Since it was a boy’s high school, all the participants were male. Participants came from the same class and had already known each other for one school year. They were randomly assigned to each of the two groups. 15 participants took individual self-debriefing and 30 participants took collaborative self-debriefing in pairs.

The native language of the participants was Mandarin and they had learned English for seven years. Assessed by the English teacher and two pilot testings, they were capable of playing the English-interface game of the study. In addition, all the key terms in the game were written both in English and Mandarin on the whiteboard of the PC room for reference. They were merely literally translated. Participants could also look up the unknown words in the dictionary or asked the experimenter if any.

Materials

The materials used in the research are game, game experience questionnaire, game motivation questionnaire, debriefing questions and knowledge test. The questionnaire on game motivation and
game experience is used to test the difference among participants. Learning outcomes are measured with game performance and paper-based knowledge test. They were measured twice, one is before and the other after the debriefing. Except for the game, all the other materials were in Mandarin.

Game

The game context is provided with a commercial off-the-shelf (COTS) strategy game, Lemonade Tycoon Deluxe ([http://www.shockwave.com/gamelanding/lemonade.jsp](http://www.shockwave.com/gamelanding/lemonade.jsp)). The main mission of the participants as lemonade vendors is to set up a successful lemonade business. In order to maximize the profits, they have to apply different strategies based on the adjustable variables such as location, rent, recipe, price, marketing, or stock to deal with various external factors such as weather, current event, customers’ satisfaction or popularity of lemonade. Participants have to set the adjustable variables to start a day/round in the game. Both during and after the game day participants receive feedback to modify their strategies for the next game day.

Lemonade Tycoon Deluxe includes two playing modes: Career mode and Challenge mode. Career mode is an open-ended game, where participants can play as long as they want. Challenge mode has a 30-game-day limitation for participants to make as much money as possible within the limited time. In the study the game was played in Challenge mode which had a 15-game-day limitation for participants to make the maximum profits. Pilot testing showed that 15 game days were enough for participants to experience the game within 25 minutes and had suitable time for the subsequent debriefing and tests.

One of the participants’ learning outcomes is measured by the game performance. In the game the main goal is to earn the most profit which is indicated with the amount of assets displayed in the profit report after each game day. In addition to the cash that participants possess at the end of the game, the assets contain the value of stock and equipments both of which are earned depending on participants’ strategies and actions. For that reason, the total amount of assets in the game, displaying at the end of 15th game day, is used to represent participants’ game score. The higher the game score is, the better the participants perform the game.

Game Experience Questionnaire

The questionnaire on game experience is made up of five closed questions about participants’ previous experience in game playing. Three questions are concerning the time spent on playing digital games, playing strategy games and playing Lemonade Tycoon Deluxe (e.g. How many hours per week averagely do you play games in recent months?) Answers are given in predetermined categories for ranges of hours, from 0 hour to more than 10 hours. Another question is about participants’ self-perception in game experience. This question is answered in a 5-point Likert scale ranging from ‘almost no experience’ to ‘very experienced.’ If 0 hour is given as an answer in the previous question which asks about playing time, participants are directed to skip this question. When storing the data, they are categorized as 0, meaning no experience at all. The other question is about the preference for
playing mode (e.g. In what mode do you usually play games?) Answers are given in predetermined categories such as ‘alone against the computer’, ‘against or with a remote partner’, ‘against or with a partner behind the same computer’, and ‘against or with multiple players over a network.’

**Game Motivation Questionnaire**

The questionnaire on game motivation is on the basis of a validated instrument (Vollmeyer & Rheinberg, 2000). It is composed of four constructs: interest (e.g. The task seems very interesting to me), probability of success (e.g. I think I can cope with the demands of this task), anxiety (e.g. I feel embarrassed if I fail at this task) and challenge (e.g. The task is a challenge for me).

After a brief description of the game, the participants completed the game motivation questionnaire. Each construct is measured with five items, making the questionnaire comprise 20 items. Answers are given on a 7-point Likert scale. After adjustment by removing one item in probability of success and another one in anxiety, the reliabilities of the four constructs are interest (Cronbach’s $\alpha = 0.90$), probability of success (Cronbach’s $\alpha = 0.85$), anxiety (Cronbach’s $\alpha = 0.80$) and challenge (Cronbach’s $\alpha = 0.85$). This indicates that the four constructs in the questionnaire have adequate reliabilities.

**Debriefing Questions**

Debriefing questions are used to assist the participants to do the self-debriefing. Analyzing the content of Lemonade Tycoon Deluxe derives the learning objectives. Integrating with the debriefing guidelines for debriefing questions mentioned in the previous section, a set of debriefing questions are designed in the form of open-ended questions. In accordance with the first concrete experience phase, the questions are designed to have participants recall what they have done in the given condition, and are sequenced along with the progress of a game day, from ‘before starting a day’ to ‘after a day’, to guide participants to systematically reflect on what they have experienced. The questions are like, ‘When you were playing, how did you choose your location?’ or ‘What kinds of customer’s complaints have you experienced?’

In order to lead participants to go through the second reflective observation phase, focusing on the learning objectives, the questions provide different actions that might be taken to allow participants to compare with their own move, and ask them to reason the difference so as to arouse their reflection. For example, learners were guided to examine their experience on advertising by the questions, ‘Another player stated that spending money on advertising is not profitable. Do you agree? Why (not)?’

The third phase is to assist participants to generalize the abstract conceptualizations on the basis of their recalled experience in the first phase and the reflection with information from different perspectives in the second phase. In this aspect, debriefing questions are designed to ask participants in the way like, ‘Why did this happen?’ or ‘Do you agree? Why (not)?’
After participants have generated a general framework of the game, the questions are further designed to direct them to the active experimentation phase, where they are asked to ponder upon what they will do to deal with a new given situation, such as ‘What will you do if two variables conflict with each other? For example, there is a festival on the beach but it is rainy and cold?’

The debriefing questions used in both groups were identical. In individual self-debriefing group the participants debriefed themselves with the debriefing questions and wrote the reflection down. In collaborative self-debriefing, one of the paired participants triggered the collaborative communication by asking the debriefing questions. After discussion, they wrote down their conclusions.

**Knowledge Test**

Based on the content analysis of Lemonade Tycoon Deluxe, the paper-based knowledge test is designed to measure the concepts, principles and heuristic knowledge of the game. After the first draft of knowledge test was completed, a pilot testing was held to examine the items. The procedure of the pilot testing was the same with the formal research, except that there were only three participants, one self-debriefed individually and the other two in pairs. After the pilot testing, participants were asked about the clarity and comments on the items, which were used to revise the second draft of the knowledge test. The same process was done for the second pilot testing with another three participants, and subsequently the final version was completed.

The knowledge test is divided into two sections. In the first section are 11 close-ended questions. The first five of them are about the game concepts and the rest six are about the game principles. The answer to each question was evaluated as correct (one point) or incorrect (zero point). The concepts are not specifically defined in the game but do play a role in the game. Take popularity for example, it is not explained in the game but represents implicitly the percentage of people who know the lemonade stand in every location. So is the case for principles. The underlying model of the game is composed of many principles. External events, participants’ actions and outcomes interact with each other. The time of staying in the same location, for instance, increases the popularity of the lemonade stand in that location. Participants are supposed to discover the meanings of the concepts and infer the interactions among variables by playing the game.

In the second section, heuristic knowledge is measured with 3 open-ended questions each of which describes a detailed new situation. Participants have to answer with actions they would take and related reasons or effects they think of. Scores are given to the two parts separately. If participants answer action correctly, they get one point whereas if they answer the reason correctly, they get another point for it. **The maximum score for this section is four.** With the experiences accumulated in game playing, participants are supposed to be aware of the interactions of game elements and thus can devise the most beneficial strategy in certain situation.

The items of the two knowledge tests are comparable, different in content but similar in the type and the number of items.
Procedure

The participants were randomly assigned to the individual self-debriefing group or the collaborative self-debriefing group. Individual group and collaborative group sat in two separate areas of the classroom so that the debriefing session was not affected by other groups. After a brief description of the game, questionnaires on game experience and on game motivation were distributed to participants and filled in.

After completing the questionnaire, participants played the game ‘Lemonade Tycoon Deluxe’. Participants in both groups played alone in Challenge mode. Right after finishing the 15th game day, participants stopped and then the first knowledge test was taken individually. Communicating with each other was not permitted.

In the following debriefing session, individual group debriefed their experiences alone with the debriefing questions and wrote corresponding reflection down. Collaborative group discussed in pairs with the debriefing questions and wrote down the conclusion. The oral communication of the collaborative group was recorded. The debriefing session took a maximum of 30 minutes.

After the debriefing, participants started the second game playing. The game was reset as a whole new round. It was played in Challenge mode and stopped at the end of 15th day as well. The second paper-based knowledge test was held subsequently. Participants took the test individually.

Analyses

The direction of the items in questionnaire was arranged first. A Mann-Whitney U test was conducted to evaluate whether there was significant difference between the two groups in game experience and $\chi^2$ test was conducted to evaluate whether there was significant difference between the two groups in game playing mode. Game motivation is composed of four constructs: interest, probability of success, anxiety, and challenge. Each construct was tested with one-way ANOVA to evaluate whether there was significant difference between the two groups. If the two groups turned out to be significant different in game experience and game motivation, both the two variables would be further checked to see if there were significant interactions with the learning outcomes.

The samples of the two groups were unequal so Levene’s test was required to examine the homogeneity before the analysis of covariance for the learning outcomes.

One-way ANCOVA was used to test whether there was significant difference between the two groups in the second game score, using the first game score as a covariate. The same method was used to test whether there was significant difference between the two groups in the scores of the second knowledge test, using the scores of the first knowledge test as a covariate. Knowledge test consists of three parts: test on concepts, test on principles, and test on heuristic knowledge. All the three tests in the second test were separately analyzed with ANCOVA, using the corresponding scores in the first test as a covariate.
Results

1. Do the two groups differ in game experience?

A Mann-Whitney \( U \) test was conducted to evaluate whether there is significant difference between the two groups in game experience and \( \chi^2 \) test was conducted to evaluate whether there is significant difference between the two groups in game playing mode. A summary of mean and standard deviation in game experience is shown in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Individual self-debriefing group</th>
<th>Collaborative self-debriefing group</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP01 game playing time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 hr</td>
<td>1 ~ 5 hrs</td>
</tr>
<tr>
<td>Mean Rank = 26.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP03 strategy game playing time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Rank = 24.43</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Mean Rank = 22.28</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>EP05 Lemonade Tycoon playing time</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Mean Rank = 21.50</td>
<td>Mean Rank = 22.24</td>
<td></td>
</tr>
<tr>
<td>EP02 subjective game experience</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Mean Rank = 24.23</td>
<td>Mean Rank = 22.38</td>
<td></td>
</tr>
<tr>
<td>EP04 game playing mode</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

The first question asks about participants’ average hours per week spending on playing games in recent months. It is designed to answer with four ordinal values, ranging from 0 hour, 0 to 5 hours, 5 to 10 hours, to more than 10 hours. The higher score represents the more hours participants spent on playing games. The individual group averagely scored 2.87 and the collaborative group averagely scored 2.50. There is no significant difference in the hours spent on playing games between the two groups (Mann-Whitney \( U = 179.5, z = -1.17, p = 0.24 \). The individual self-debriefing group had an average rank of 26.03, while collaborative self-debriefing group had an average rank of 21.48).

Participants’ average hours per week spending on playing strategy games in recent months is also asked with four ordinal values, ranging from 0 hour, 0 to 5 hours, 5 to 10 hours, to more than 10 hours. The higher score represents the more hours participants spent on playing strategy games. The individual
group averagely scored 1.87 and the collaborative group averagely scored 1.70. There is no significant difference in the hours spent on playing strategy games between the two groups (Mann-Whitney \(U = 203.5, z = -0.57, p = 0.57\). The individual self-debriefing group had an average rank of 24.43, while collaborative self-debriefing group had an average rank of 22.28).

As for the hours spent on Lemonade Tycoon Deluxe, it is also designed with the same four ordinal values. Only one participant in the collaborative self-debriefing group had played it for 0 to 5 hours. Consequently, there is no difference between the two groups.

In addition to the actual hours of playing games, participants were also asked about the perception of their own level in game experience. They had to indicate how experienced they were in playing game based on a 5-point Likert scale, ranging from almost no experience to very experienced. **Besides, those who did not have to fill in this question due to spending no time playing any games were categorized as 0, indicating no experience at all.** The individual group averagely scored 3.13 and the collaborative group averagely scored 2.83. It shows no significant difference between the two groups (Mann-Whitney \(U = 206.5, z = -0.46, p = 0.65\). The individual self-debriefing group had an average rank of 24.23, while collaborative self-debriefing group had an average rank of 22.38).

The game playing mode is designed to be answered with four nominal values, ‘alone against the computer’, ‘against or with a remote partner’, ‘against or with a partner behind the same computer’, and ‘against or with multiple players over a network.’. It also shows no significant difference between the two groups (\(\chi^2 (2, N = 45) = 3.48, p = 0.18\)).

It is consequently concluded that the two groups of participants are not different in game experience.

**2. Do the two groups differ in game motivation?**

Game motivation is composed of four constructs: interest, probability of success, anxiety, and challenge. Each construct is measured with five items on 7-point Likert scale. One-way ANOVA was conducted to evaluate whether there was significant difference between the two groups. A summary of mean and standard deviation in game motivation is shown in Table 4.

<table>
<thead>
<tr>
<th>Table 4 Summary of mean and standard deviation in game motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Interest</td>
</tr>
<tr>
<td>Probability of success</td>
</tr>
<tr>
<td>Anxiety</td>
</tr>
<tr>
<td>Challenge</td>
</tr>
</tbody>
</table>
Analyzing the scores of interest, the average score of the individual self-debriefing group was 5.33 and 4.96 for the collaborative self-debriefing group. A higher score represents the more interest participants had in the game. There is no significant difference between the two groups ($F (1, 43) = 1.24$, $p = 0.27$).

The average score of probability of success in the individual self-debriefing group was 4.39 and 4.49 for the collaborative self-debriefing group. A higher score indicates that participants think they have more chance of success. There is no significant difference between the two groups ($F (1, 43) = 0.10$, $p = 0.75$).

The average score of anxiety was 4.25 in the individual self-debriefing group and 3.79 in the collaborative self-debriefing group. A higher score means that participants have more fear of completing the task unsuccessfully. There is no significant difference between the two groups ($F (1, 43) = 1.89$, $p = 0.18$).

The average score of challenge was 5.57 in the individual self-debriefing group and 5.02 in the collaborative self-debriefing group. A higher score shows that participants find the game more challenging. There is no significant difference between the two groups ($F (1, 43) = 3.41$, $p = 0.07$).

The four results lead to the conclusion that the two groups of participants do not differ in game motivation.

3. **Does collaborative self-debriefing group perform better in game score than individual self-debriefing group?**

One-way ANCOVA was used to test whether there was significant difference between the two groups in the second game score, using the first game score as a covariate. Table 5 summarizes the mean and standard deviation of the two game scores for each group. The results shows that the first game playing has significant correlation with the second game playing ($r = 0.41$, $p = 0.01$). There is no significant difference in game score of the two groups ($F (1, 43) = 1.58$, $p = 0.22$). Therefore, individual self-debriefing and collaborative self-debriefing make no difference in improving learner’s game performance.

4. **Does collaborative self-debriefing group score higher in knowledge test than individual self-debriefing group?**

One-way ANCOVA was used to test whether there was significant difference between the two groups in the scores of the second knowledge test, using the scores of the first knowledge test as a covariate. The results shows that the first knowledge test has significant correlation with the second knowledge test ($r = 0.36$, $p = 0.01$). There is significant difference in the scores of knowledge test between the two groups ($F (1,43) = 4.95$, $p = 0.03$). This reveals that individual self-debriefing and
collaborative self-debriefing have different effects in knowledge test on scaffolding digital game-based learning.

Knowledge test consists of three parts: test on concepts, test on principles, and test on heuristic knowledge. All the three tests in the second test are separately analyzed with ANCOVA, using the correspondent scores in the first test as a covariate. All of them pass Levene’s test. There is no significant difference between the two groups in the test on concepts (F (1, 43) = 1.48, p = 0.23) and in the test on principles (F (1, 43) = 1.62, p = 0.21).

As for the result of heuristic knowledge, there is nearly significant difference between the two groups (F (1, 43) = 4.04, p = 0.05). The mean score of heuristic knowledge of individual group is 6.53, higher than the one of collaborative group (mean = 4.67).

The three results indicate that the effectiveness of self-debriefing mainly have influence on heuristic knowledge and individual self-debriefing scaffolds digital game-based learning better than collaborative self-debriefing.

Table 5 Summary of mean and standard deviation in the second game performance and knowledge test

<table>
<thead>
<tr>
<th></th>
<th>Individual self-debriefing group</th>
<th>Collaborative self-debriefing group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Test 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game score</td>
<td>164.85</td>
<td>74.32</td>
</tr>
<tr>
<td>Knowledge test</td>
<td>12.07</td>
<td>4.03</td>
</tr>
<tr>
<td>Test on concepts</td>
<td>6.53</td>
<td>1.73</td>
</tr>
<tr>
<td>Test on principles</td>
<td>2.67</td>
<td>1.76</td>
</tr>
<tr>
<td>Test on heuristic knowledge</td>
<td>2.87</td>
<td>2.48</td>
</tr>
<tr>
<td>Test 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game score</td>
<td>199.29</td>
<td>69.99</td>
</tr>
<tr>
<td>Knowledge test</td>
<td>17.60</td>
<td>4.60</td>
</tr>
<tr>
<td>Test on concepts</td>
<td>7.47</td>
<td>1.96</td>
</tr>
<tr>
<td>Test on principles</td>
<td>3.60</td>
<td>1.45</td>
</tr>
<tr>
<td>Test on heuristic knowledge</td>
<td>6.53</td>
<td>2.48</td>
</tr>
</tbody>
</table>

Discussion

Overall, the results have some positive implications. The empirical findings seem to warrant two conclusions: in scaffolding digital game-based learning, self-debriefing assists learners to perform better and gain more knowledge averagely; and individual self-debriefing and collaborative self-debriefing make a difference in gaining heuristic knowledge.

In the study participants averagely increase 38.12 points in game performance and 3.76 points in knowledge test. Thus we see the effectiveness of debriefing in scaffolding digital game-based learning are consistent with the findings of Qudrat-Ullah (2007). Furthermore, the debriefing in this study was performed by participants themselves, proving the feasibility and effectiveness of self-debriefing, which is in complete agreement with the results of Boet et al (2010).
Viewed in this light, the debriefing questions can be regarded as a useful aid in supporting self-debriefing. Literature on self-debriefing in digital game-based learning was rarely found, let alone detailed instruction on how to design corresponding debriefing questions. Pertaining to experiential learning, digital game-based learning can achieve its learning goals if the debriefing questions correspond to the four phases of Kolb’s experiential learning cycle. The reorganized framework for debriefing content, which integrates strengths of several authors’ frameworks, provides the research a reference for designing required debriefing questions. Debriefing questions are suggested to cover the ‘Six Es of Debriefing’ as Petranek proposes. Participants’ average improvement indicates the designing of debriefing questions has its function. Thus, it can serve as an example for people who are interested in self-debriefing in digital game-based learning.

The other finding is that individual self-debriefing scaffolds digital game-based learning significantly better than collaborative self-debriefing. Though only heuristic knowledge shows significant difference between the two groups, the other three scores of individual self-debriefing group are all higher than those of collaborative self-debriefing group. The results are inconsistent with the hypothesis that learners with collaborative self-debriefing are supposed to perform or learn better through communication. A possible explanation for this may lie in the nature of the game. As mentioned in previous section, Peters and Vissers (2004) discussed the relation between individual and collective learning in debriefing. They reviewed that learning in debriefing is almost invariably described as a process within individual and it is sufficient if simulation game aims at learning by individual participants. On the other hand, if the objectives are more complicated such as creating a shared vision or joint problem solving and decision making, debriefing should focus on group-level. In view of this, Lemonade Tycoon Deluxe does not possess complicated objectives that specifically require collaboration. In addition, within the same limited time, individual self-debriefing allows learners to fully concentrate on reconstructing their own experience, which may result in a more complete reflection on the game. A more complete perception, therefore, may lead to more complete consideration of every aspect in the game when dealing with new situation.

It should be concluded, from what has been discussed above, that self-debriefing has its potential for scaffolding digital game-based learning and what influences its effectiveness may lie in the nature of games. It is hoped that this study can serve as a basis for further study in the application of debriefing in digital game-based learning. Future research should be undertaken to investigate the correlation of game types to the form of self-debriefing and the design of debriefing questions.
Reference


