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THE EFFECTS OF CONCEPT MAPPING IN GAME-BASED LEARNING

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of Concept Mapping in Game-based Learning**

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Abstract

Research on digital games indicates that games can be more effective for education when a learning support is added. This study examined whether different forms of concept mapping affects students' game motivation as well as the effects on learning outcomes. Concept maps are considered as an effective visualized learning tool that assist the development of conceptual knowledge, supporting students with the use of correct information and choices that have to be made.

In this study participants were randomly assigned to a condition: a student-constructed concept map condition, a pre-generated concept map condition, and a control condition that played the game *Lemonade Tycoon 2 New York* without the use of a concept map. Participants in the student-constructed condition built their own concept map using given terms and concepts from the game. Participants in the pre-generated group received a pre-made concept map made by the researcher using the same game concepts.

It was predicted that the use of concept maps as learning support in game-based learning would improve students' learning outcomes. However, results showed no statistically significant effects on learning outcomes. Regarding students' motivation, the combination of the game and concept mapping was predicted to have a negative effect. However, results showed that the concept map in both experimental conditions did not decrease the positive perceptions towards the game. Also, no correlations were found between the game scores and the knowledge test scores. Indicating that participants who did relatively well in the game, did not score better in the knowledge test. The discussion reveals aspects of concept mapping as learning support that may be relevant for student learning in game-based learning environments.

Keywords: game-based learning, concept mapping, learning support.

Introduction

Nowadays, digital games are very popular. According to Dorsselaer et al. (2016), 68 percent of Dutch students in secondary education and 87 percent of Dutch pupils in primary education regularly play digital computer games. Several studies have reported that learning through digital games, known as game-based learning, is effective for improving students' learning engagement, learning outcomes, and motivation (e.g. Barzilai & Blau, 2014; Sung & Hwang, 2018). Games can be so engaging that players may lose sense of time and place, resulting in high fascination and concentration. These experiences are often not seen in traditional learning strategies where students may lack engagement, having difficulties remaining concentrated (van der Meij, Albers, & Leemkuil, 2011).

However, the use of computer games in education is not always sufficient for learning (e.g. Li & Tsai, 2013; Vandercruysse, Vandewaetere, Cornillie, & Clarebout, 2013). Researchers found that game-based learning is generally experiential, where learning takes place through experience, and often contains complex learning environments. Students can be overwhelmed due to complexity of the tasks, large amounts of information that has to be processed, and choices that have to be made (Wouters, van der Spek, & van Oostendorp, 2011). It is a challenge to help students make the connections between the experiential knowledge learned in the game and knowledge learned at school when games are used for formal learning in education (Quintana et al., 2004). To solve this problem and assist students in their learning process, games can be supported with instructional learning supports to facilitate learning in game-based education (Charsky & Ressler, 2011; Clark et al., 2011; Garris, Ahlers, & Driskell, 2002; Wouters & van Oostendorp, 2013).

A type of learning support that might help facilitate learning in a game-based environment is concept mapping (Charsky & Ressler, 2011). Concept mapping is widely used as an effective learning support in traditional experiential learning. During concept mapping learners organize, restructure, and represent what they know about a topic to form new connections between prior knowledge and new knowledge (Novak & Canas, 2008). However, very limited research is conducted on the effectiveness of concept maps on students' learning outcomes within digital game-based learning environments. Therefore, it is important to explore the integration of effective concept mapping strategies in game-based learning.

In addition, researchers (Ebner & Holzinger 2007; Papastergiou, 2009) have indicated that games have great potential to promote students' motivation. Game features like goals, challenge, and control may increase students' motivation. A high level of motivation is necessary for success, leading students towards higher learning achievements (Ebner & Holzinger, 2007). However, the addition of learning supports might negatively impact students' motivation and enjoyment in the game (Barzilai & Blau, 2014; Charsky & Ressler, 2011). Therefore, a better understanding of the effects of learning supports in game-based learning is needed to design learning supports that enhance learning and maintain motivation. Consequently, this study focuses on how concept maps affect students' learning outcomes and motivation within game-based learning.

1. Theoretical framework

1.1. Digital game-based learning

Digital games

Several definitions of computer games are provided by researchers (e.g. Garris et al., 2002; Prensky, 2001). For the purpose of this study, computer games are defined as a set of interactive components and activities in a digital environment (Prensky, 2001), directed towards clear goals (Malone, 1981), agreed rules and constraints (Garris et al., 2002), which are frequently provided with feedback (Prensky, 2001) in the form of hints or scores that enable players to monitor their progress (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Games may be powerful for learning since they trigger motivation through its interesting, involving, and fun characteristics (Prensky, 2001). The nature of games ensures that players put energy and effort in gameplay to achieve higher game scores and overcome challenges and mistakes (Prensky, 2001).

Digital computer games can be used in education to explore new skills, practice and drill existing skills, and promote self-esteem (Dempsey, Rasmussen, & Lucassen, 1996 as cited in Leemkuil, 2006). Rich digital game environments act as powerful contexts for learning (Admiraal, Huizinga, Akkerman, & Dam, 2011) where learners are confronted with complex problems (Bakker, van den Heuvel-Panhuizen, & Robitzsch, 2016; Garris et al., 2002; Li & Tsai, 2013; Malone, 1981), receiving immediate feedback to help them make progress in the interactive process of reacting, hypothesizing, and planning (Oblinger, 2004).

The advantages of digital game-based learning have been reviewed in several studies (e.g. Bakker et al., 2016; Garris et al., 2002). For example, Papastergiou (2009) indicated that game-based learning generates powerful interactions and facilitates students' motivation, which improves learning achievements. Furthermore, Garris et al. (2002) and Wouters et al. (2013) suggested that educational games could evoke students' motivation through game features as goals, challenge, and control. This will lead to engaged, focused, and self-determined students who enjoy what they are doing. Sitzmann (2011) also reported that educational games improved students' learning outcomes and self-efficacy, and Yang (2015) indicated the potential of digital game-based learning for improving students’ higher order thinking. In addition, Leemkuil and de Jong (2004) pointed out the advantage of simulating specific moments in the virtual world, which players could never have experienced in the real world.

Learning in a game-based environment

Rich digital game environments ensure powerful contexts for learning (Admiraal, Huizinga, Akkerman, & Dam, 2011; Quintana et al., 2004) where learners are confronted with complex problems, and receive immediate feedback in a risk-free environment (Bakker et al., 2015; Li & Tsai, 2013; Garris et al., 2002; Malone, 1981). Game-based learning is facilitated through experiential learning; students are committed and motivated through experiences with the game environment (Kiili, 2005). The nature of games enables players to put energy and effort in gameplay to overcome challenges and mistakes, resulting in higher game scores. Foster (2008) states that attempting challenges is a human instinct considering the enhancement of motivational aspects such as engagement, self-determination, and enjoyment. Since challenges are related to useful and important information in a game, players naturally acquire knowledge or change their behaviour towards the game content (Prensky, 2001).

Theories have been developed emphasizing the importance of cognitive processes involved in information processing and learning. For example, Mayer (2001) identified three types of cognitive processes in his theory of multimedia learning; the *selection* of relevant information, *organizing* this new information in a consistent structure, and *integrating* this structure with prior knowledge. In addition, according to Kolb's (1984) theory of experiential learning, learning begins with a concrete experience followed by data collection and reflective observations about the experiences. For example, when learners enter a game for the first time, learning will start with exploring the game environment looking for indications of actions that need to be performed to reach the goal. In this phase, players reactivate and use information that is already available in their memory (Leemkuil, 2006). Learners generalize, draw conclusions, and form hypotheses about the experience after which the learner tests these hypotheses and ideas through active experimentation in a new context (Kolb, 1984). Game characteristics as goals, rules, feedback, and challenges can facilitate these learning processes in several ways. First, by influencing active and experiential learning, and second by influencing motivation (Wouters et al., 2013). Game players will use an experiential learning strategy as long as useful information of certain actions is available in the game environment or in their memory (Leemkuil, 2006). Nevertheless, game knowledge is often implicit and represented in the game visuals, controls, and feedback systems, while students require knowledge at school in an explicit way that involves language (Clark et al., 2011). To gain explicit insights and strategies, students must play with a combination of experiential and reflective learning strategies. Reflective learning requires more structure and cognitive effort since it aims at explicit learning and memorizing knowledge (Taatgen, 1999 as cited in Leemkuil, 2006). Students reflect on previous game actions and try to develop new rules and/or procedures.

However, game players do not automatically engage in these reflective learning strategies. As a result, they may only learn through an experiential learning strategy where little or no reflective learning takes place. This may lead to players that are often not aware of the concepts, principles and structures used in the game, resulting in difficulties applying the elements they have learned in other contexts (Clark et al., 2011; Leemkuil, 2006). There are several reasons why this may happen. First of all, research of Dempsey, Haynes, Lucassen, and Casey (2002) showed inefficient and ineffective trial-and-error strategies among players performing actions. Players repeatedly try a variety of actions until there is a moment of success or the player stops trying. This absence of a systematic strategy in playing the game prevents players to learn with a reflective learning strategy. Second, games often contain complex learning environments where players can be overwhelmed as a result of large amounts of information that has to be processed, the choices that have to be made, and the complexity of the tasks (Wouters et al., 2013). Game players may also be so involved in the game that they are guided by the context. This overload of information may result in an implicit unselective learning strategy, leading to context specific knowledge that is difficult to transfer to other situations (Leemkuil, 2006).

To solve this problem and assist students to use a reflective learning strategy instead of only an experiential way of learning, strong and focused learning support is needed in game-based education (Barzilai & Blau, 2014; Charsky & Mims, 2008; Leemkuil, 2006; Leemkuil & de Jong, 2004). This assumption is confirmed by previous research conducted by Ke (2009) and Wouters and van Oostendorp (2013) stating that games with instructional supports improve students' learning.

1.2. Learning supports

Adding learning supports is assumed to be necessary in game-based learning environments in order to facilitate and stimulate students' learning (Ke, 2009; Vandercruysse et al., 2016). Learning supports assist the process of students' performance and learning, that enables them to succeed in problems that would otherwise be too difficult to complete (e.g. Reiser, 2004; Pea, 2004; Quintana et al., 2004). For example, a teacher or tool may assist with setting appropriate goals, provide strategic guidance, or perform difficult parts of the task. The idea behind learning supports is derived from Vygotsky's (1978) theory of the zone of proximal development, which describes the area of tasks between what the learner could succeed in doing on their own and what he or she could accomplish with help from others (Rogoff, 1990 cited in Quintana et al., 2004).

The aim of a learning support in a game is to convert the implicit knowledge gained in the learning environment into explicit knowledge, focusing students' attention on certain elements, supporting them in the problem-solving process, and making them aware of the concepts, principles, and structures of the game (Leemkuil & de Jong, 2004). Wood et al., (1976) discussed three ways how problem-based learning can be supported by learning supports. First, difficulties and problems are reduced, leading to an increase in students' motivation. Second, learning supports reduce uncertainties by providing appropriate support, guiding towards a clear goal. Lastly, critical information or problems are highlighted allowing students to identify the concepts they need for the task. However, learning supports do not directly improve students' learning, but may lead them in the right direction, triggering learning-relevant cognitive activities and content understanding rather than simply revealing the answers (Quintana et al., 2004).

In the past years, researchers have examined various learning supports for bridging the gap between implicit and explicit knowledge in digital learning environments. (Garris et al., 2002; van der Meij, Albers, Leemkuil, 2011; Quintana et al., 2004; ter Vrugte & de Jong, 2012). The most commonly used learning supports in educational games are modelling, advice, collaboration, interactivity, narrative elements, and feedback (Wouters & van Oostendorp, 2013). Research studies have found positive benefits of learning supports in digital learning environments. For example, Garris et al. (2002) found that reviewing and analysing occurring game events, also known as debriefing, supports learning in creating connections between game representations and real events. Hagemans, van der Meij, and de Jong (2012) investigated the effects of adding a concept map-based support to a simulation-based learning environment on kinematics, revealing positive effects on the combination between colour coding and optimal routing signals. Sun, Merrill, and Peterson (2001) studied visual hints, strategy hints, and direct guidance as learning support in a computer game. Results showed significant improvement in game performance and decreased frustration among participants.

However, not all games are suitable for learning purposes of specific learning objectives. Designing a completely new game takes educators a lot of time and effort. Therefore, an alternative is to choose an already existing game and embed external learning supports into it for instructional purposes (Kao et al., 2017). An example of existing games are commercial off-the-shelf games. They are created for pure entertainment purposes. Some commercial off-the-shelf games involve intellectual challenges and content which can be easily implemented in an educational setting. For example, the game *Civilization* can be used to teach concepts related to military, technology, politics, and socioeconomic development while players build an empire from scratch (Cheon, Chung, Song, & Kim, 2013).

1.3. Concept mapping

A type of learning support that might facilitate learning in a game-based learning environment is concept mapping (Charsky & Ressler, 2011; Kwon & Cifuentes, 2009). Concept maps are graphical tools for organizing and representing knowledge. They consist of concepts, referring to facts or definitions that are placed within circles or boxes. These concepts are connected with lines, including short words or phrases to represent their relationships (Novak & Canas, 2008). A characteristic of concept maps is the hierarchical layer system. The most important concepts are placed at the top of the map, while specific, less general concepts are hierarchically placed below (Novak & Gowin, 1984). Since the structure depends on the content of a specific topic, referencing to a specific learning objective makes it easier and more clearly to structure the considered knowledge and prevents learners to deviate from the learning goal (Novak & Canas, 2008).

In addition to concepts and labelled links, concept maps can contain cross-links. Cross links connect two concepts of separate parts of the map, they show how concepts in different segments of the map are related to each other. Also, examples can be added to the map to refine the meaning of the concept. Since these examples do not represent concepts, they are usually not placed in circles or boxes. Figure 1. represents an example of a concept map describing the structure and characteristics of itself.

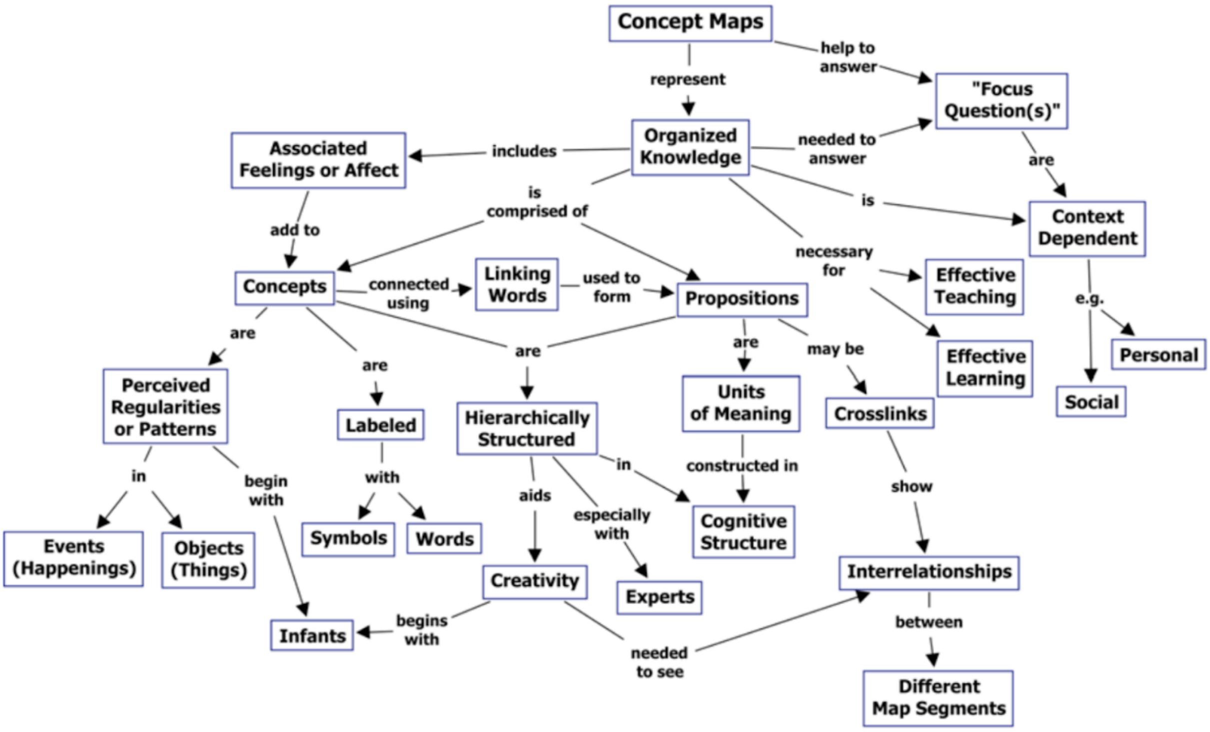


Figure 1. A concept map showing the key features of concept maps (Novak & Canas, 2008).

Concept maps are considered as an effective visualized learning tool that supports learners identifying concepts, topics, ideas, and their relationships, making sure learners actively reflect on their own interpretation and construct meaningful learning (Charsky & Ressler, 2011; Novak & Canas, 2008). According to Hilbert and Renkl (2008), concept maps have various functions. First, the elaborative function shows the relationship between concepts, making it easier to make the link with prior knowledge. Second, the reductive function makes it easier for students to recognize the most important concepts, since only these are shown in the map. Thirdly, the coherence function ensures a logical structure of knowledge.

Lastly, a metacognitive function ensures that students are able to reflect on themselves to make sure they did, or did not, fully understood the content and the links of the map (Hilbert & Renkl, 2008). These functions are in line with Mayer's (2001) cognitive theory of multimedia learning stating that concept mapping focuses on two types of cognitive information processing. First, the selection of relevant information by paying attention to the presented material and organizing the new information in a consistent structure. Second, concept maps contribute to explicit learning because students visualise, construct, and reflect on their implicit knowledge using a schematic diagram.

Several studies have examined the role of concept mapping within game-based learning environments. For example, Coller and Scott (2009) used concept maps as an evaluation instrument for a game-based course. They found that concept mapping has the potential for improving students' learning performance. Kwon and Cifuentes (2009) explored the differences in effectiveness of collectively and individually constructed concept maps through game play, resulting in equally positive effects on science concept learning with higher quality concept maps in the collaborative condition.

There are several methods to use concept maps as learning support. McCagg & Dansereau's (1991) presented pre-generated concept maps and student-constructed concept maps. Pre-generated concept maps are designed by content experts or instructors provided for students as a graphical overview or advanced organizer (Hagemans, van der Meij, & de Jong, 2012). Learning from pre-made examples has proven to be very effective in initial skill acquisition (e.g. Atkinson, Derry, Renkl, & Wortham, 2009 as cited in Hilbert, Nuckles, & Matzel, 2008) and prevents learners from using load-intensive strategies by focusing their attention on learning (Sweller & Cooper, 1985). They support students with the identification of the main ideas and structures of the topic by displaying the interrelationships between new information with their own prior knowledge (Novak & Canas, 2008). According to Ausubel's (1968) theory, advanced organizers are introduced prior to learning. They assist students in their orientation activities by displaying the main topics and learning components. They may serve as an overall scheme for focusing the learner on information that is important, so students can better process the information that follows (Hartley & Davies, 1976; Tan, 2000 as cited in Hagemans et al., 2012).

Studies examining pre-generated concept maps as learning support are rare in the domain of concept mapping. Nevertheless, results of O'Donnell et al. (2002) point out that learning with teacher prepared maps (i.e. pre-generated maps) as teaching materials, can be more effective than learning from text. In addition, learners with low prior knowledge of the specific content also profit from learning with worked-out maps (O'Donnell & Dansereau, 2000). Furthermore, research of Alias and Tukiran (2009) and Hilbert, Nuckles, and Matzel (2008) revealed that learners profited more from studying with a pre-generated map compared to traditional learning methods. Pre-generated concept maps may be an effective teaching and learning tool for promoting students' learning.

Canas, Reiska, and Novak (2016) presented several recommended criteria for the right quality and size of concept maps. First, the concept map should answer the specific problem or question. Second, the concept map should be to the point regarding the topic. Third, all propositions and concepts should be relevant to the topic. Fourth, no 'unnecessary' concepts, propositions, or cross links should be added. Lastly, there are no missing relevant concepts or propositions.

Student-constructed concept maps are created by students during learning. They are a representation of information about a specific topic (McCagg & Dansereau, 1991) and created based on prior knowledge or a given list of concepts. Student-constructed concept maps may have less depth and may be less complex than pre-generated concept maps, but do assist students in organizing, restructuring and representing information (Charsky & Ressler, 2011).

It should be noted that using learning supports, where students have to re-examine concepts from the game in formal terms, might negatively impact students' motivation and their game experiences (Barzilai & Blau, 2013; Charsky & Ressler, 2011). For example, Charsky and Ressler (2011) found that adding concept maps to a game might negatively impact students' motivation and feelings of learning and enjoyment in the game. The learning support might focus students' attention on learning the concepts, which may stress extrinsic motivation leading to less fun gameplay.

2. Research questions

This experimental study with three groups (non-concept map, student-constructed concept map, and pre-generated concept map) focuses on two constructs that are used to compare the effects of concept maps in a game-based learning environment. First, game scores and knowledge test scores as learning outcomes. Second, participants' motivation. Three research questions are stated based on the literature above.

First, *to what extent does the implementation of concept maps in game-based learning influence students' initial motivation (interest, challenge, probability of success, and anxiety) compared to learners who play the game without concept maps*? It is hypothesised that both students playing the game with and without concept maps should be motivated, since gameplay should evoke motivation through game features as goals, challenge, and control, leading to engaged students who enjoy what they are doing (Wouters et al., 2013). However, it is expected that students in the control condition will be more motivated after playing the game than students in the experimental conditions. This is hypothesised because the concepts from the game need to be re-examined in formal terms by the experimental conditions using concept maps. Barzilai and Blau (2013) concluded that this might negatively impact students' understandings of the game and their game experiences.

Second, *to what extent does the use of concept maps in a game-based learning environment improve students' learning outcomes compared to learners who play the game without concept maps?* If so, what type of concept maps (pre-generated or student-constructed) show higher learning outcomes in game score and the knowledge test? The prediction is that students in the experimental groups using concept maps will use a reflective learning strategy. As a result, the learning outcomes of these students should be higher than the learning outcomes of the students in the control condition, of which is expected that they will play with more experiential learning strategies. Furthermore, the prediction is that students in the pre-generated concept map group receive more in-depth knowledge since the concept map is constructed in a logical, organized way by the researcher (McCagg & Dansereau, 1991). As a result, the learning outcomes of students in the pre-generated group should be higher than the learning outcomes of students in the student-constructed group since student-constructed concept maps have less depth and are less complex (Novak & Canas, 2008). However, students in the student-constructed concept map group create and adjust their own concept map, which might lead to more moments of reflective learning and in-depth thinking than students working with a pre-generated concept map. Therefore, no concrete hypothesis can be stated for the direction of the effect of concept map type on students' learning outcomes.

Third, *is there a relationship between game score and knowledge test score?* It is hypothesized that students who score high in the game, will also score high on the knowledge test. The game score should have construct validity and should correlate positively with the test scores since both measures are about the same concepts and constructs. Therefore, it is hypothesized that there is a relationship between the game score and the knowledge test score.

3. Method

3.1. Participants

Participants were 50 first- and second-year bachelor students from the University of Twente. All participants were students from the BMS faculty. 12 males and 38 females, with a mean age of 19.9 years (*SD* = 1.876) participated in this study. Students registered voluntarily via the "Sona-systems" program of the university to receive credits for their mandatory hours as a test person in research within the BMS faculty. Participants were randomly assigned to either the student-constructed concept map condition (*n* = 16), the pre-generated concept map condition (*n* = 16), or the control condition (*n* = 18). Students were not informed about the different conditions within this research.

3.2. Materials

Materials and instruments used in this study are the game *Lemonade Tycoon 2 New York*, introduction materials for concept mapping, materials for students to construct a concept map, a pre-generated concept map of *Lemonade Tycoon 2 New York,* a game experience questionnaire, a game motivation questionnaire, and a knowledge test.

Lemonade Tycoon 2 New York

The game-based learning environment used in this study is the commercial-off-the-shelf strategy game *Lemonade Tycoon 2 New York*. In this single-player business strategy game, students need to setup and run a successful lemonade business. The game has two modes: *Time Challenge* and *Career*. In this study the Time challenge mode is used where the main goal of the participants is to set up a successful lemonade business and maximise profit within a time limit. Participants have to adjust variables such as location of the stand, recipes and price of the lemonade, upgrades, and marketing budget before starting the day. The lemonade ingredients influence the costs of the lemonade and determines, together with the price, the profit per sold cup of lemonade. Before the start of the day participants have to order stock for producing the lemonade. Insufficient stock may result in lost sales or spoiled stock. The success of the business also depends on external factors such as weather, customer satisfaction, news, and the popularity of the lemonade. During and after each game day, players receive feedback which allows them to see how well they did and how their lemonade was appreciated. Depending on this feedback, players have to decide whether improvements are possible and adjust their strategies for the following day in order to increase their profits. Only the variables recipe and price can be manipulated during the day.

In this study participants' game performance is measured by using the profit report after the 15th game day in Time challenge mode. Cash, stock, and equipment participants have gained at the end depends on the performed strategies and actions. The profit of each game day, the number of assets, stock, and equipment are shown in the profit report. The total amount of profit for the game session of 15 days represents the final game score.

Game experience questionnaire

Information about participants' game experience is important for the data-analyses since experienced gamers have a better understanding of how games are designed and how they work (Kiili, 2005). Therefore, they will have an advantage over students with fewer gaming experience. The game experience questionnaire, inspired on research of van der Meij, Leemkuil, and Li (2013), consists of four closed questions about participants' prior experiences in playing games. Answers are given in predetermined categories for specific ranges of hours or experience. Questions are based on time spent on playing digital games, strategy games, and *Lemonade Tycoon* or other versions of the game. Based on a five-point Likert scale, participants scored their self-perception in game experience from 'almost no experience' to 'very experienced'. The game-experience questionnaire can be found in appendix IV and V.

Game motivation questionnaire

The game motivation questionnaire developed by Rheinberg, Vollmeyer, and Burns (2001) is used in this study to measure participants' current motivation and attitude towards running a lemonade business before the first and after the second game session (appendix II and IX). Rheinberg, Vollmeyer, and Burns (2001) found the scales' reliability to be sufficient (a Cronbach's alpha between 0.72 – 0.85 for anxiety, a Cronbach's alpha between 0.68 – 0.88 for probability of success, a Cronbach's alpha between 0.71 – 0.90 for interest, and a Cronbach's alpha between 0.66 – 0.81 for challenge). Before completing the questionnaire, students were informed about the main idea and the goal of the game. Questions were given on a 7-point Likert-scale ranging from 'disagree' to 'agree' measuring students' *probability of success*; which refers to the belief that the student can succeed (e.g. 'I think everyone could do well on this task'), *anxiety*; which can be interpreted as a fear of failure in a specific situation (e.g. 'I feel under pressure to do this task well'), *interest*; which refers to positive effects and evaluations regarding the topic (e.g. 'After hearing the introduction, the task seems to be very interesting to me'), and *challenge*; which refers to the effort the students wants to put in to achieve success (e.g. 'I am strongly determined to try as hard as I can on this task'). *Interest* and *anxiety* were measured with five questions each, *challenge* and *probability of success* were measured with four questions each.

Introduction to concept mapping handouts

Before participating in the study, all participants in the experimental conditions received an introduction to concept mapping with detailed examples of a concept maps on neutral topics. Also, participants received oral and written instructions describing a series of steps for constructing concept maps to first learn to read and process concept maps in general (McCagg & Dansereau, 1991). Referring back to the instructions and examples was allowed in the experimental conditions. All materials and content in the introduction are unrelated to the learning content of this research. The learning materials can be found in appendix VII and VIII.

Pre-generated concept map

A pre-generated concept map is used to assist the participants during gameplay. Although success in *Lemonade Tycoon 2 New York* depends on finding the right balance between adjustable variables and external factors, understandings of these variables may be intuitive and tacit. Even successfully playing students might not form explicit and abstract understandings regarding the concepts within the game and their relations. To support students to use a reflective learning strategy, a pre-generated concept map is developed based on Novak and Canas' (2008) research. First, the main topic was constructed that clarifies the problem the concept map has to resolve. In this study, the aim is to maximise profits in a lemonade business. Second, given the selected domain and problem, game concepts of *Lemonade Tycoon 2 New York* were identified by playing the game and by using previous research with the same game (Albers, 2008; Van der Meij et al., 2013; & Walther, 2013). These concepts were listed and ranked from the most general, to the most specific concepts. After this, the map was constructed with labelled links. Finally, the map was revised, concepts were re-positioned for more clarity, and cross-links were added. The pre-generated concept map used in this study is reported in Figure 2.

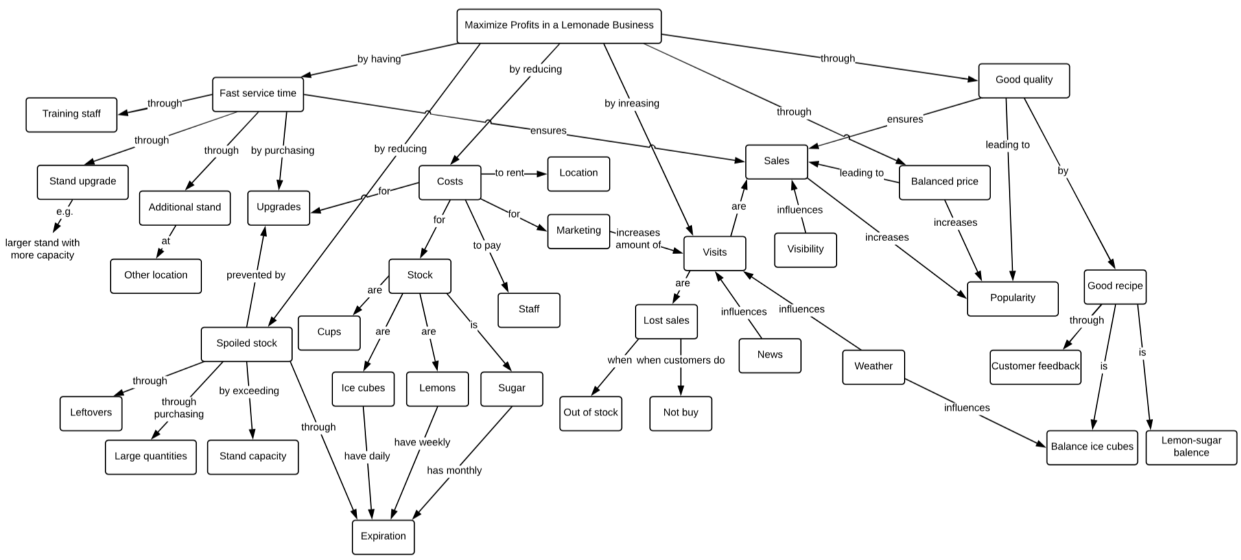


Figure 2.: *Pre-generated concept map Lemonade Tycoon 2 New York*

Student-constructed concept map materials

To support students constructing their own concept map about maximising profits in a lemonade business a list of game concepts and a whiteboard-system was provided. Previous research of Ruiz-Primo, Schultz, and Shavelson (1996) compared student-constructed and assessor-generated concept maps and found that some students in the student-constructed condition provided related but non relevant concepts to the topic. They pointed out that it might be problematic if students generate their own concepts. Also, Schau and Mattern (1997) have argued that asking students to draw a map from scratch imposes a high cognitive demand to produce meaningful representations of their knowledge. To prevent this from happening, the same list with already made game concept was provided for the student-constructed condition. This would enable students in the different conditions to acquire the same knowledge and reduce the chance that they will illuminate a wrong topic in their concept map. This list also ensures that the development of the concept map is faster, and the possibility of getting overwhelmed will be reduced (McCagg & Dansereau, 1991). A whiteboard-system, consisting of plasticized concepts, a plasticized sheet, and a whiteboard marker with an eraser, makes it easy for the students to adjust mistakes and construct the concept map.

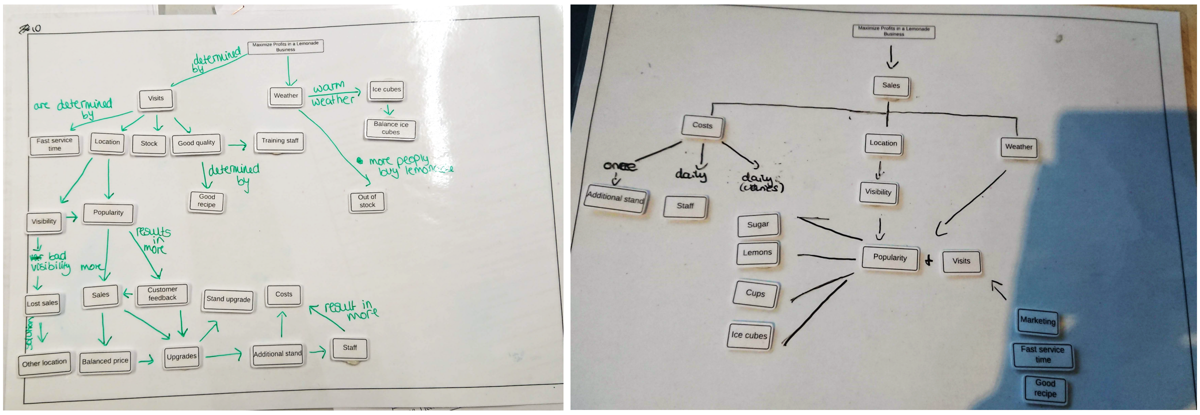


Figure 3.: *Student-constructed concept map examples*

Knowledge test

A post-test questionnaire based upon the ones used in Albers (2008), Van der Meij et al. (2013) and Walther (2013) is developed to assess students' understanding about the underlying concepts and principles of *Lemonade Tycoon 2 New York*. The questions focus on important concepts, principles, and heuristics. Concepts and principles are not explicitly mentioned within the game, but have a great influence on the game progress. Conceptual knowledge refers to facts and definitions of the game. Principle knowledge refers to specific steps and actions students have to do to resolve a problem. Heuristic knowledge is a practical method using knowledge gained by experience to deal with other situations. Prior to the research, a pilot study was carried out in order to avoid ambiguities from the knowledge test. After this, the questions have been adjusted and a final version has been made (appendix X).

The first five items of the knowledge test ask for game concepts of *Lemonade Tycoon 2 New York*. In one true/false question (e.g. 'Indicate whether the following statement is true or false: Popularity represents the percentage of people who come to your stand') and four open-ended items (e.g. 'Except for making lemonade, please name three possible expenses for running the business') participants defined concepts like popularity and customer satisfaction. Followed by eight questions about game principles. Principle knowledge items assessed learned knowledge about connections and relationships between events, actions, and game concepts that influence each other. There are four multiple-choice items (e.g. 'Which of these actions is better to attract more customers? Please explain your answer. Investing more money in advertising, or purchase an upgrade that increases popularity') and four open-ended items (e.g. 'Visits and service time are two concepts influencing sales. Name for each concept four actions you can do to increase the amount of sales'). The last set of items is about heuristic knowledge, these items focus on specific actions in possible game situations. All four items are open-ended where participants were asked to explain their actions and reasoning in the specific game situation (e.g. 'Your popularity with a stand in the park is 30%. The news report states: "*Children think lemonade is not 'cool'.*" The weather forecast indicates rainy weather with around 15°C (60°F). Your recipe is set to 8 lemons, 3 sugar, and 3 ice cubes and the price is set to $2.25. Many customers say it is too expensive. Please describe in a detailed way which actions you are going to do to prepare for the next day and provide a reason for each action').

The knowledge test is scored according to a codebook, which specifies the correct definitions and concepts that should be displayed in the answer. This codebook was developed as a result of studies of Albers (2008), Van der Meij et al. (2013), and Walther (2013), definitions of game concepts, the game *Lemonade Tycoon 2 New York,* and answers given by the students. True/false and multiple-choice items are scored with 1 point for the correct answer. Open-ended items were not allowed to overlap and are scored with 0.5 point per correct answer and 0.5 point for correct reasoning with a maximum score of 3 or 4 points. The codebook can be found in appendix XI.

3.3. Procedure

Preceding the gathering of data, the ethics commission of the University of Twente was asked for approval to carry out this study. The experiment was conducted over one 90-minute session and consisted of five phases. In the first phase, participants were randomly assigned to one of the three conditions. Second, each participant received and completed an informed consent form, the game experience questionnaire, and game motivation questionnaire with short introduction about the game *Lemonade Tycoon 2 New York*. In the third phase, all participants were asked to play the game *Lemonade Tycoon 2 New York* for fifteen game days in *Time Challenge Mode* starting with a game walkthrough. This first round is played to learn the game mechanics and to prevent possible beginners' mistakes from learning the game in the second round. In the fourth phase of this study, participants in the experimental conditions received the introduction materials, participants in the pre-generated condition received the already constructed concept map, and participants in the student-constructed condition received the concept map materials to construct their own concept map. Students have been given time to read and learn the pre-generated map, or construct their own concept map about maximising profits in a lemonade business. After this, a second round of fifteen game days was played. Participants of the experimental conditions had access to the pre-generated map and were given time to adjust their concept maps during gameplay. After playing the second game round, scores were noted and students reviewed and adjusted their final concept map versions. In the last phase, all participants completed the game motivation questionnaire and knowledge test.

3.4. Analysis

Game experience

Before analysing the results, reliability checks were performed on the test and questionnaires. The constructs *game experience in general, game hours in general, strategy game hours,* and *Lemonade Tycoon hours* are evaluated. Kruskal-Wallis H tests were used per construct in order to test whether there is significant difference between the three conditions in game experience.

General game experience was measured with five ordinal values ranging from "very experienced" to "no experience". Results (Figure 4.) reveal approximately the same distribution among the three conditions in general game experience. However, a few more participants in the student-constructed condition scored themselves '*very experienced'* compared to the pre-generated and control condition. A Kruskal-Wallis H test showed no significant differences in *general game experience* between the different concept mapping treatments, $\chi^2(2) = 1.765$, $p = 0.414$.

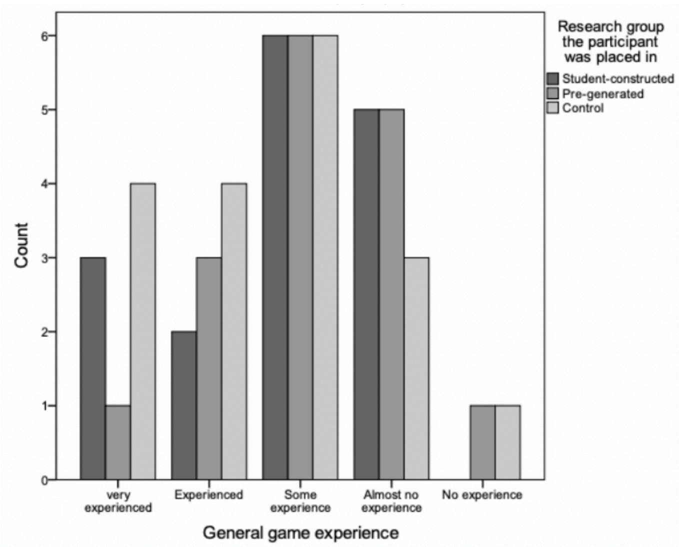


Figure 4.: *General game experience within conditions*

In addition to the perception of their own level in game experience, the actual *game hours in general* was measured with a 5-point scale, ranging from 0 hours, 1 to 3 hours, 4 to 6 hours, 7 to 9 hours, to 10 or more hours. Result in Figure 5. reveals a higher average score for the control group on this construct. A Kruskal-Wallis H test showed significant differences in *game hours in general* between the different conditions, $\chi^2(2) = 9.622$, $p = 0.008$, with a mean rank game experience score of 21.63 for student-constructed group, 20.44 for pre-generated group and 33.44 for the control group, meaning that there is a difference in *general game hours* among the groups. Post-hoc analysis revealed that the differences can be found in the higher score of the control condition, concluding that the students in the control group spent more hours on playing games.

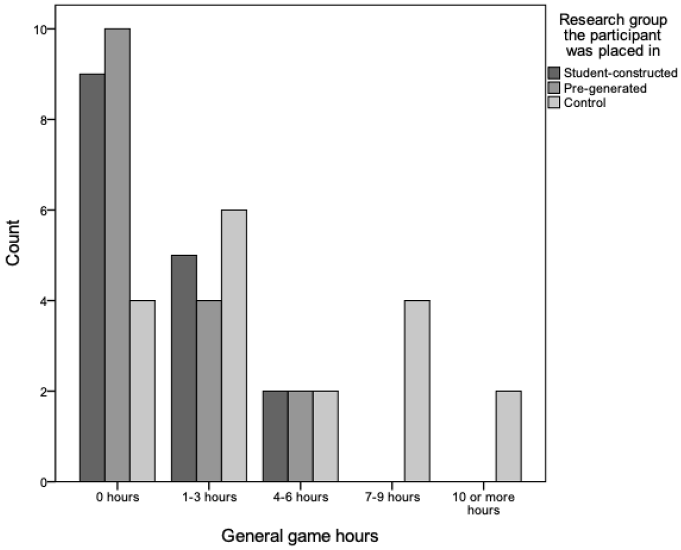


Figure 5.: *General game hours within conditions*

Students *strategy game hours* is measured with the same ordinal values as the construct *game hours in general.* The higher score represents the more hours students spent on playing strategy games. Results in Figure 6. show an approximately same distribution among the conditions. A Kruskal-Wallis H test also showed no significant differences in *strategy game hours* between the different concept mapping treatments, $\chi^2(2) = 1.309$, $p = 0.520$.

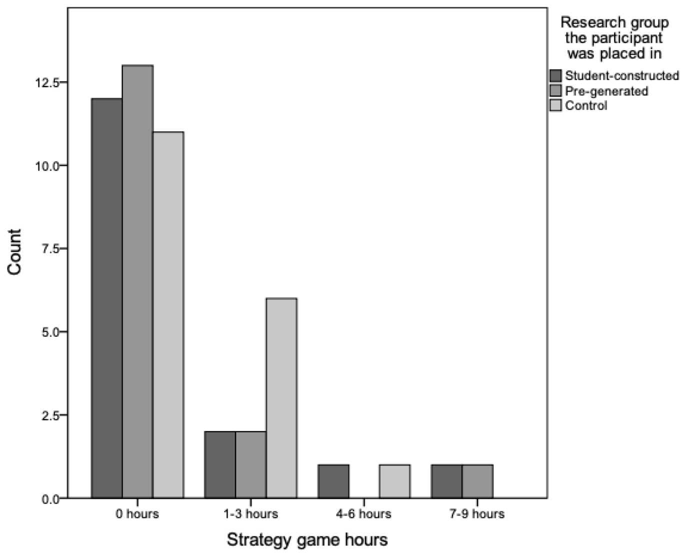


Figure 6.: *Strategy game hours within conditions*

The construct *Lemonade Tycoon hours* was measured with the same scale values as *game hours in general* and *strategy game hours.* Since no student ever played a lemonade tycoon game, no differences were found between the three conditions.

It can be concluded that the three conditions are not statistically different in their own perception of level of game experience, strategy playing time and *Lemonade Tycoon* playing time. However, a statistically significant difference was found in the general hour's students played games. As a result, this construct will be used as a covariate in further analysis.

Game motivation

Before conducting the statistical tests regarding students' motivation, the assumption of reliability was evaluated and determined using the internal consistency coefficient of the game motivation questionnaire. The internal consistency coefficient of the constructs *interest*, *probability of success*, *challenge*, and *anxiety* are shown in Table 1. Although the internal consistency of the construct *challenge* is lower than .7, the reliability of this subscale in the original instrument (Rheinberg, Vollmeyer, and Burns, 2001) is high enough. Therefore, all subscales where considered reliable and where used for further analyses.

Furthermore, the assumption of homogeneity of variances was tested and satisfied for the construct's *probability of success* and *interest* with Levene's F test, $F(47,2) = .079$, $p = .924$ for *probability of success,* and $F(47,2) = 2.111$, $p = .132$ for *interest.* Levene's F test for the constructs *challenge* and *anxiety* revealed that the assumption for homogeneity of variances was not satisfied with $F(47,2) = 4.366$, $p = .018$ for *challenge*, and $F(47,2) = 3.425$, $p = .041$ for *anxiety*.

Since the assumption for homogeneity of variances was not met for the construct *anxiety*, further analysis is carried out with a non-parametric Kruskal-Wallis test. As well as the assumption for homogeneity of variances and internal consistency of the construct *challenge* was not met, the construct *challenge* is not used for further analysis.

Table 1.: *Internal consistency (Cronbach's Alpha) of the motivation scales*

Construct	Number of items	Cronbach's Alpha
Interest	5	.667
Probability of success	4	.718
Challenge	4	.365
Anxiety	5	.835

Game scores

Prior to analysing whether there is a statistically significant difference between the conditions in game score, the assumption of homogeneity of variances was tested and satisfied with Levene's F test, $F(47,2) = 1.325$, $p = .276$. Significant difference between the conditions in game scores was tested with two one-way analyses of variances (ANOVA) for the first and second game round with corresponding post hoc tests if necessary.

Knowledge test scores

Furthermore, prior to analysing the knowledge test scores, the assumption of homogeneity of variances was tested and satisfied with Levene's F test, $F(47,2) = 1.090$, $p = .345$. Results of the knowledge test were evaluated with a one-way ANOVA test. Correlations between the game scores and the knowledge test have been evaluated.

Student- constructed concept map analyses.

Concept maps can be scored according to a four-level system in which the number of valid propositions (connections between concepts), valid hierarchies, valid cross links, and valid examples are counted (Novak & Gowin, 1984). A weighted concept map scoring system awards higher scores for maps with deeper and more complex understanding: one point is given for each correct valid proposition, five points were awarded for each level of hierarchy, 10 or 5 point, regarding significance, for cross links, and examples were awarded one point. A mean score was calculated for each criterion and the total score of the maps. Table 2. illustrates how the student-constructed maps are scored based on these criteria. The pre-generated concept map in this study is used as a standard. Using the concept map assessment criteria, the score of the expert map was derived. Likewise, the student-constructed maps were scored using the same criteria. However, with this calculation it may be possible for students to obtain a higher score than the pre-generated map.

Table 2.: *Concept map assessment criteria*

Criterion	Score description
Proposition	Is the relationship between two concepts indicated by a connecting line and/or linking word(s)? For each meaningful valid proposition, score 1 point
Hierarchy	Does the map show hierarchy? Is each subordinate concept more specific and less general than the concept drawn above it? Score 5 points for each valid level of the hierarchy.
Cross-link	Does the map show meaningful connections between one segment of the concept hierarchy and another segment? Score 10 points for each cross link that is both valid and significant, and 5 points for each cross link that is valid.
Example	Specific events or object that are valid instances of those designated by the concept label can be scored 1 point each.

Source: Novak and Gowin (1984)

4. Results

This section presents the results for each research question. First, the research question whether concept mapping affects students' game motivation is presented. Then, results of the second research question whether concept mapping improves students' learning outcomes will be discussed. Thereafter, the correlation between game score and knowledge test score is presented.

To what extent does the implementation of concept maps in game-based learning influence students' initial motivation (interest, challenge, probability of success, anxiety) compared to learners who play the game without concept maps?

Students' game motivation is measured with three constructs: *interest, probability of success,* and *anxiety.* The constructs *interest* and *anxiety* are measured with five items on a 7-point Likert scale, and *probability of success* is measured with four items on a 7-point Likert scale. The descriptive statistics associated with students' pre- and post-test game motivation scores across the three conditions are reported in Table 3.

It can be seen that all conditions scored, on average, slightly lower on all constructs in the post-test compared to the pre-test. These results indicate that for all conditions the amount of interest in the game decreased. Participants' also had fewer positive considerations about their ability to succeed in the game.

Students anxiety for not succeeding in the game approximately stayed the same after playing the game, only the control group scored slightly higher on anxiety in the post-test.

Table 3: *Descriptive statistics game motivation*

	Student-constructed group (n = 16)		Pre-generated group (n = 16)		Control group (n = 18)	
Construct	Mean[1] (SD)	Mean[2](SD)	Mean[1] (SD)	Mean[2] (SD)	Mean[1] (SD)	Mean[2] (SD)
Interest	24.56 (5.164)	19.56 (7.339)	23.44 (4.163)	19.81 (7.494)	24.39 (4.381)	22.44 (5.883)
Probability of success	19.44 (4.115)	13.25 (5.837)	19.50 (3.246)	13.75 (5.398)	20.28 (4.738)	16.00 (4.765)
Anxiety	16.56 (6.782)	16.38 (7.518)	17.06 (6.577)	15.75 (5.871)	16.50 (6.671)	16.94 (5.385)

Note. The maximum score for the constructs *interest* and *anxiety* is 35, and 28 for *probability of success* and *challenge*. Mean[1] refers to the pre-test motivation questionnaire. Mean[2] refers to the post-test motivation questionnaire.

In order to test the hypothesis that adding a concept map as learning support to game-based learning (student-constructed, and pre-generated) had an effect on students' motivation, two separate univariate analyses of covariance (ANCOVA) for the constructs *interest, probability of success,* and a non-parametric Kruskal-Wallis H test for *anxiety* were carried out.

A higher score for the construct *interest* represents the more interest students had in the game. The average scores on the post-test was 20.44 for the student-constructed group, 20.19 for the pre-generated group, and 17.56 for the control group. An independent between subjects ANCOVA, with the game motivation pre-test as covariate, showed no significant differences in *interest* between the different concept mapping treatments with $F(2, 46) = 1.977$, $p = .150$.

A higher score for *probability of success* represents students' considerations about their ability to succeed in the game. The average scores on the post-test was 18.75 for the student-constructed group, 18.25 for the pre-generated group, and 16.00 for the control group. An independent between subjects ANCOVA, with the game motivation pre-test as covariate, showed no significant differences in *probability of success* between the conditions with $F(2, 46) = 1.154$, $p = .324$

A higher score for *anxiety* represents more fear of not succeeding in the game. The average scores on the post-test was 23.63 for the student-constructed group, 24.45 for the pre-generated group, and 23.06 for the control group. A non-parametric Kruskal-Wallis H test revealed no significant differences in the construct *anxiety* between the different concept mapping treatments $\chi^2(2) = .229$, $p = .892$, with a mean rank score of 25.09 for student-constructed group, 26.91 for pre-generated group and 24.61 for the control group.

To what extent does the use of concept maps in a game-based learning environment improve students' learning outcomes compared to learners who play the game without concept maps?

Participants started their gameplay with 500 dollars. Depending on their strategies participants made a profit or loss during the day. Students game score is measured after playing fifteen game days in Time Challenge mode. The lowest score participants can achieve is -500, lower is not possible since students are bankrupt at that moment. The highest score in this research was $409.56. The descriptive statistics associated with students' first and second game score are reported in Table 4. In order to test the hypothesis that adding a concept map as learning support to game-based learning (student-constructed, pre-generated) had an effect on students' game score, two one-way ANOVAs were performed.

It can be seen that all conditions scored on average slightly higher in the second round of gameplay compared to their first round of gameplay. The control group has achieved the highest average with -45.02 in the first round, and -3.12 in the second round. Furthermore, for the experimental groups the standard deviations increased a little on average in the second game score in comparison with the first game score, in contrast to the control group where the standard deviation has decreased.

Table 4: *Descriptive statistics game scores*

	First round of gameplay	Second round of gameplay
Condition	Mean (SD)	Mean (SD)
Student-constructed group (*n* = 16)	-269.52 (276.07)	-156.30 (299.23)
Pre-generated group (*n* = 16)	-308.56 (171.53)	-270.56 (255.71)
Control group (*n* = 18)	-45.02 (275.48)	-3.12 (220.31)

First, the in-game performance from the different groups was explored. A one-way ANCOVA was conducted to compare the scores of the first round of gameplay between the three conditions, using *general game hours* as a covariate. Results showed a significant difference in the first game score with $F(2, 46) = 3.452$, $p = .040$. A Bonferroni post hoc test revealed there was a significantly difference between the pre-generated group and the control group ($p = .005$). Comparing the estimated marginal means showed the highest scores were achieved in the control group (mean = -61.676), compared to the student-constructed (mean = -260.87) and pre-generated condition (mean = -298.47). Another one-way ANCOVA was conducted to compare the scores of the second game round between the three conditions, using *general game hours* as a covariate. Results showed no significant difference in the second game score with $F(2, 46) = 2.146$, $p = .129$.

Second, significant results between the first- and second rounds of game play among the three conditions were examined. Results of three paired sampled t-tests showed no significant results with $t(15) = -1.685$, $p = .113$ for the student-constructed group, $t(15) = -.778$, $p = .448$ for the pre-generated group, and $t(17) = -,717$, $p = .483$ for the control group.

In order to test the hypothesis whether games supported with concept maps could yield higher learning outcomes on the knowledge test than games without a learning support, the differences of average scores from the knowledge test between the experimental groups and the control group was compared with an ANOVA test. The descriptive statistics associated with students' knowledge test scores are reported in Table 5. It can be seen that each condition had about the same average score for the knowledge test. The student-constructed group and control group scored on average slightly higher than the pre-generated group.

Table 5: *Descriptive statistics knowledge test*

Condition	Knowledge Test Mean (SD)
Student-constructed group (n = 16)	19.50 (4.99)
Pre-generated group (n = 16)	18.18 (4.05)
Control group (n = 18)	19.53 (3.85)

Note. The maximum score for the knowledge test is 34.

An independent between-subject ANOVA revealed no statistically significant effects. Results showed no significant differences in knowledge test scores between the conditions with $F(2, 47) = .517$, $p = .600$. Therefore, these results indicate that the three conditions do not differ in knowledge test scores.

Is there a relationship between game score and knowledge test score?

Correlations have been performed to evaluate whether the game score is related to the score obtained in the knowledge test. No statistically significant correlation has been found between the game score in the first round and the knowledge test score (r = -.03, p = .82). Also, no significant correlation was found between the game score in the second round and the knowledge test score (r = .25, p = .08).

Therefore, it can be concluded that there is no relationship between the game scores and the knowledge test scores.

Concept map scoring

Results in Table 6. shows the student-constructed concept maps had a lower score compared to the pre-generated concept map. These results are expected since the pre-generated map is designed by the researcher for students to provide an overview of the learning content. Student-constructed maps have less depth and may be less complex compared to the pre-generated map. However, although some student-constructed maps scored above average, a number of students scored low to very low on their concept map.

Examples of a student-constructed concept maps about maximising profits in a lemonade business is shown in Figure 3. The first photo shows a decent quality concept map; there are many valid propositions and a clear hierarchy between the concepts. Nevertheless, there was no cross link or example included in this map. The second photo shows a poor example of a student-constructed concept map: there are a few propositions but most of them have invalid relationships. For example, the popularity of the stand should not be linked to the supplies; sugar, lemon, ice cubes, and cups but to the concept's visibility or marketing etc. There were also no cross links or examples included in this map.

Table 6: *Descriptive statistics student-constructed concept maps (n = 16)*

Criterion	Pre-generated	Mean student-constructed (SD)	Minimum score observed	Maximum score observed
Propositions	46	25.94 (7.009)	10	37
Hierarchy	25	15.63 (7.274)	0	25
Cross links	30	6.25 (10.408)	0	20
Examples	1	.13 (.500)	0	0
Total score	102	47.94 (17.525)	10	82

5. Discussion and conclusion

This study aimed to determine the cognitive effects of two concept mapping methods in a game-based learning environment by examining students' learning outcomes. Also, the effects on learners' motivation when adding concept mapping strategies were evaluated. Furthermore, the relationship between the game score and knowledge test was examined. In the following paragraphs interpretations of these findings are given, limitations of this study are discussed, and opportunities for future research are suggested.

Research has shown that learning with digital game-environments can be facilitated and stimulated when they are supported with learning supports (e.g. Wouters et al., 2013). Concept maps can be used as an effective visualized learning tool helping students linking new learning experiences with their prior knowledge in an organized manner (Chiou, 2008; Coller & Scott, 2009). In addition, pre-generated concept maps can be used as learning support by focusing the learner on the information that is important, supporting them with the processing of information in a way that is less load intensive (Ausubel, 1960). For these reasons it was assumed that students in the experimental conditions would score better in both the game and the knowledge test than students in the control condition who played the game without a concept map.

However, the study revealed no significant improvement in game score in the second game round. Game scores revealed that learners were not very successful in the game, as indicated by the negative average scores of all conditions. Playing the game in combination with concept mapping as learning support was predicted to have a positive effect on the game score since concept maps enable students to succeed in problems that may otherwise be too difficult (e.g. Quintana et al., 2004). However, participants in the experimental groups using a concept map did not improve their game score more that participants who played the game without a concept map.

In addition, no significant difference in the knowledge test score was revealed between the conditions. The knowledge test scores, which related to the game content, were relatively average. Participants in the experimental conditions did not score higher on the knowledge test than participants in the control group. Playing the game with a concept map was predicted to have a positive effect on students' learning gains. However, this outcome indicates that concept mapping did not stimulate learning with games. Further analyses revealed no differences between the student-constructed condition and the pre-generated condition.

Also, no correlations were found between the game scores and the knowledge test scores. This result indicates that participants who scored well in the game, did not achieved a better knowledge test score than participants who had a lower game score. This indicates that a higher game score does not assure a higher knowledge test score. This result is the opposite of what was expected, since the game score has construct validity and should correlate positively with the test scores since both measures are about the same concepts and constructs.

Regarding motivation, adding concept maps as learning support did not significantly decrease students' motivation towards the game. Adding a learning support was predicted to have a negative effect since students needed to re-examine concepts from the game in formal terms, possibly leading to less fun gameplay (Barzilai & Blau, 2013; Charsky & Ressler, 2011). However, results of this study showed no statistically significant differences in game motivation among the three conditions, concluding that concept mapping in both experimental conditions did not decrease the positive perceptions towards the game.

Game score results revealed a higher score in the second game round for all conditions. However, all mean scores are negative in all three conditions. These scores may reflect on possible difficulties participants had with the game. It could be that participants did not understand the intuitive knowledge representations in the game on how they needed to make as much profit as possible in the game, or they may be affected by the large amount of information and choices in the game (Wouters et al., 2013). Because of this, transfer to explicit understandings about the concepts: costs, price, profit, and their relationships in the knowledge test may not happen, resulting in relatively average scores in the knowledge test.

This could be explained due to the fact that participants learned through an experiential learning strategy and did not engage in reflective learning strategies. The concept mapping strategies used in this study may not have supported students enough to develop understandings about concepts, principles, and structures used in the game, resulting in difficulties applying the elements they have learned in other contexts (Leemkuil & de Jong, 2004; Leemkuil, 2006). According to Canas, Reiska and Novak (2016) concept maps need to cover several criteria in order to achieve a decent quality. Three of the five criteria were already covered in this study since the main problem of the topic and a list of possible concepts was given ensuring that all concepts were relevant and the opportunity to deviate from the subject was minimized. However, results of the student-constructed maps differed widely. Good quality concept maps were developed, but some concept maps were not sufficient in quality due to missing concepts and invalid relationships. For example, some students only used a few concepts from the provided list. In other cases, students continued adding more and more concepts without relevant relationships and structure. This shows that students might have had difficulties building a good concept map.

A disadvantage of concept maps is the need for experience to learn from them. Because of the complexity of the maps, students can sometimes be overwhelmed and demotivated. Students need training before they can use concept maps the right way (Davies, 2011). This disadvantage has been attempted to eliminate by providing concept map examples and training materials. Materials included a brief explanation in advance with examples about reading and constructing concept maps. However, it could be that students did not understand the techniques completely and therefore had trouble reading and creating the concept maps used in this study. This is in line with previous research suggesting that students tend to be focused on the nodal rather than the relational information when reading a pre-generated concept map. Even though the links and labels presented in the concept map provide meaningful information, students may ignore this (McCagg & Dansereau, 1991). Several researchers have suggested that mastering the techniques to construct a concept map may be difficult and time-consuming (Camperell & Reeves, 1982; Camperell & Smith as cited in McCagg & Dansereau, 1991). The non-significant results of the game scores and knowledge test scores in this study could be a result of insufficient training materials and practice time. It is therefore advisable in follow-up research to take students' prior knowledge of concept mapping into account. A recommendation for future research would be to offer more practice for students to learn the mechanics behind concept mapping.

Another reason for the non-significant results may be related to students' behaviour. It might be difficult to activate participants' intrinsic motivation. Students' participated in this study in order to receive mandatory study credits, resulting in students' who are extrinsically motivated instead of intrinsically motivated. This was also reflected in the given answers of the knowledge test. Participants had to answer open-ended questions in short sentences or phrases, with a maximum of four answers per question. However, regarding the length of the answers it has to be noted that they differed widely from each other. While many participants took the time and effort to answer these questions, quite a few did not answer all questions optimally. It was notable that some students began to write answers in a hurry when they approached the end of the appointment or other students had already left the room. In doing so, they may have lost focus during the answer process, leading to incomplete answers and therefore not receiving all the points they could get. Therefore, it is highly recommended for future research to focus on settings where there is no possibility for participants to be extrinsically motivated.

In addition to this, it could be that students in the experimental conditions did not took the time to read or use the materials. Despite the fact that they were stimulated to do so, they could not be forced to read the pre-generated map or construct a concept map of good quality (VanderCruysse et al., 2016). Previous studies already showed that instructional supports remain frequently unused (Nelson, 2007 as cited in VanderCruysse et al., 2016). If the students have not used the provided materials and information in a proper way, the experimental groups may act like the control condition. However, giving students the freedom to plan, monitor, and perform their own learning activities is in line with the idea that learners should be active agents in their own learning process (Bransford et al., 2002).

It may be that students have answered the questions of the knowledge test with their own prior knowledge. The game *Lemonade Tycoon 2 New York* is a simulation of a small real-life business in a realistic way, what also provides the suitability for learning. Since it is about a relatively simple business, participants may have used their logical knowledge to think about what is involved in running a lemonade stand. This may lead to questions being answered in a logical way without the need to play the game correctly (Walther, 2013). This may result in the non-significant differences between the experimental and the control groups in the knowledge test and the non-relationship between the game score and knowledge test score. It is therefore advisable to implement quantitative data analyses in future research to examine the underlying principles of students' critical thinking and learning with concept maps as learning support.

The learning support did have a negative impact on students' motivation. Results revealed a higher score in positive attitude towards the game with the constructs *interest,* and *probability of success* in the control group. Although the result is not significant, a possible reason for the higher scores in the control group can be related to students' game experience. Since students in the control group had on average more experience playing digital games. They may have had an advantage since their experience could have ensured that they understood the game faster and may have had more fun (Kiili, 2005), resulting in a higher score for interest and motivation. This is in line with Vollmeyer and Rheinberg (2006) stating that the duration and frequency of the learning activity can mediate the effect of motivation on learning.

A similar result was found in research of Charsky and Ressler (2011), who conducted a related study and examined participants' learning outcomes after developing concept maps based on game content. Results revealed significantly lower learning motivation in the experimental condition after playing the game, compared to students who learned only with the game. According to the researchers, the cause for these lower results after playing the game would have been the interruption of the game process. Constructing the maps was an interference to the students instead of a learning support. These experiences are a result that concept mapping is not always effective if there is not carefully considered when and how the learning support is implemented in the learning process (Hwang et al., 2013). Concluding, the lower, although not significant, motivational results of this study could be due to bad integration of the concept maps in the specific game since the concept maps are offered externally. Charsky and Ressler (2011) also concluded that using concept maps could cause negative results unless the learning support can be well integrated in the game. Therefore, an internally supported concept map approach may assist students in better learning performances. Comparing and analysing students' learning progress with internally and externally integrated concept maps as learning support in a game-based environment is a suggestion for future research.

As mentioned before, another reason for the non-significant results of participants' motivation might be the difficulty to establish desirable motivational conditions in this study. It could be expected that results will differ in an actual classroom setting instead of the extrinsically rewarded setting used in this study.

However, there are limitations that should be considered when interpreting the results discussed above. First of all, the game *Lemonade Tycoon 2 New York* is a commercial-off-the-shelf computer game, not a game designed for educational learning purposes. Learning objectives may be hidden in the game so they are not necessarily easy to identify for students. These learning objectives will be easier to find in a game specifically designed for game-based learning. Second, no statistically significant effects of adding concept mapping as learning support were revealed. This may be caused by the short period of time for this research. It may be possible that students did not have enough time to learn the game or process the concept map. It could also be that the time students paid attention to the concept map was too short to remember all concepts and relationships, leading to non-significant results for the learning outcomes and correlation between the game score and the knowledge test. It can be assumed that scores are more likely to improve and more likely to correlate to the test score when students have more time and opportunities to play the game (Van der Meij et al., 2011). Third, this study only focused on two concept mapping techniques based on previous research: student-constructed and pre-generated concept mapping. Other methods of concept mapping may lead to other results, partially-filled concept maps for example. Finally, this study was designed for this specific game. Consequently, the results may not be generalisable to other contexts and games. Therefore, it might be beneficial to use other types of games in future research to examine the effects of pre-generated and student-constructed concept maps in game-based learning environments. Also, it would be interesting to take the possibility of providing direct feedback into account for student-constructed concept mapping techniques to improve the quality of the constructed maps.

The purpose of this study was to examine the effects of concept mapping strategies as learning support in a game-based learning environment on students' learning outcomes and motivation. From what has been discussed above, adding concept mapping as learning support in a game-based learning environment did not improve participants' learning outcomes compared to the control group for this specific game setting. This may conclude that adding concept maps to a game-based learning environment did not sufficiently support students to achieve better learning outcomes. Suggesting that the concept mapping methods used in this study may not have supported students enough to actively reflect on their own interpretation to construct meaningful learning and did not convert students' implicit knowledge gained in gameplay into explicit knowledge. In addition, it can also be concluded that concept mapping does not affect students' motivation towards playing a game. It is possible that outcomes will differ if measured in another context or time period. Regardless, the results point to the need for educational designers to reconsider concept mapping techniques as learning support in game-based learning environments since non-concept mapping interventions may have equally outcomes for students.

References

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart & Winston.

Admiraal, W., Huizenga, J., Akkerman, S., & Dam, G. T. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior, 27*(3), 1185-1194.

Albers, E. (2008) *Het Collaboratief Spelen van een Educatieve Game.* Master thesis, Enschede, University of Twente.

Bakker, M., Van den Heuvel-Panhuizen, M., & Robitzsch, A. (2016). Effects of mathematics computer games on special education students' multiplicative reasoning ability. *British Journal of Educational Technology, 47*(4), 633-648.

Barzilai, S., & Blau, I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences. *Computers and Education*, *70*, 65–79. https://doi.org/10.1016/j.compedu.2013.08.003

Cañas, A. J., Reiska, P., & Novak, J. D. (2016, September). Is My Concept Map Large Enough? In International Conference on Concept Mapping (pp. 128-143). Springer, Cham.

Charsky, D., & Mims, C. (2008). Integrating commercial off-the-shelf video games into school curriculums. *TechTrends*, *52*(5), 38–44. https://doi.org/10.1007/s11528-008-0195-0

Charsky, D., & Ressler, W. (2011). ‘Games are made for fun’: Lessons on the effects of concept maps in the classroom use of computer games. *Computers and Education*, *56*(3), 604–615. https://doi.org/10.1016/j.compedu.2010.10.001

Cheon, J., Chung, S., Song, J., & Kim, Y. (2013). An investigation of the effects of a graphic organizer in an online serious game on learning outcomes and attitudinal perceptions. *Interactive Learning Environments,23*(4), 437-452. doi:10.1080/10494820.2013.788030

Clark, D. B., Nelson, B. C., Chang, H.-Y., Martinez-Garza, M., Slack, K., & D’Angelo, C. M. (2011). Exploring Newtonian mechanics in a conceptually-integrated digital game: comparison of learning and affective outcomes for students in Taiwan and the United States. Computers and Education, 57(3), 2178–2195.

Coller, B.D., and Scott, M.J. (2009) “Effectiveness of using a video game to teach a course in mechanical engineering”, Computers & Education, Vol. 53, No. 3, pp 900-912.

Cramer, D., & Howitt, D. (2004). *The SAGE dictionary of statistics.* London: SAGE.

Dempsey, J., Haynes, L., Lucassen, B., & Casey, M. (2002). Forty simple computer games and what they could mean to educators. *Simulation & Gaming, 33*(2), 157-68.

Dorsselaer, van S., Tuithof, M., Verdurmen, J., Spit, M., Van Laar, M. & Monshouwer, K. (2016). *Jeugd en Riskant gedrag 2015*. Kerngegevens uit het Peilstationonderzoek scholieren.

Utrecht: Trimbos instituut.

Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education,49*(3), 873-890. doi:10.1016/j.compedu.2005.11.026

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation Gaming, 33*(4), 441–467. http:// dx.doi.org/10.1177/1046878102238607.

Hagemans, M.G., Van der Meij, H., & De Jong, T. (2013). The effects of a concept map-based support tool in simulation-based inquiry learning. *Journal of Educational Psychology*, 105(1), 1-24)

Hilbert, T. S., Nuckles, M., & Matzel, S. (2008). Concept mapping for learning from text: evidence for a worked-out-map-effect. ICLS, 1, 358-365.

Hilbert, T., & Renkl, A. (2008). Concept mapping as a follow-up strategy to learning from texts: What characterizes good and poor mappers? *Instructional Science, 36*(1), 53-73.

Ke, F. (2009). A Qualitative Meta-Analysis of Computer Games as Learning Tools. *Gaming and Simulations*. doi:10.4018/9781609601959.ch701

Kiili, K. (2005). Digital game-based learning: towards an experiential gaming model. The Internet and Higher Education, 8, 1, 13–24. doi: 10.1016/j.iheduc.2004.12.001.

Kolb, D. A. (1984). *Experiential Learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Kwon, S. Y., & Cifuentes, L. (2009). The comparative effect of individually-constructed vs. collaboratively-constructed computer-based concept maps. Computers & Education, 52(2), 365–375.

Leemkuil, H. (2006). *Is it all in the game?* Doctoral dissertation, Enschede, University of Twente.

Leemkuil, H., & de Jong, T. (2004). Games en gaming. In P. Kirschner (Ed.), *ICT in het onderwijs: The next generation* (pp. 41-63). Alphen aan de Rijn: Kluwer B.V

Lemonade Tycoon 2 - New York Edition. (n.d.). Retrieved from http://www.shockwave.com/gamelanding/lemonade2.jsp

Li, M., & Tsai, C. (2013). Game-Based learning in science education: A review of relevant research. *Journal of Science Education and Technology, 22*(6), 877-898.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 5*(4), 333–369.

Mayer, R. E. (2001). *Multimedia learning*. New York: Cambridge University Press.

McCagg, E. C., & Dansereau, D. F. (1991). A convergent paradigm for examining knowledge mapping as a learning strategy. *Journal of Educational Research, 84*, 317–324.

Novak, J. & Canas, A. (2008). The theory underlying concept maps and how to construct and use them. *Práxis Educativa, 5*(1), 9-29.

Novak, J. D., & Gowin, D. B. (1984). Learning how to learn. Cambridge: Cambridge University Press.

Oblinger, D. (2004). The next generation learner. Retrieved november 24, 2018, from https://net.educause.edu/Elements/Attachments/conference/aascu08/presentation_1.pdf

O'Donnell, A. M., and Dansereau, D. F. (2000). Interactive effects of prior knowledge and material format on cooperative teaching. J. Exp. Educ. 68: 101–118.

O'Donnell, A.M., Dansereau, D.F. & Hall, R.H. Educational Psychology Review (2002) 14: 71. https://doi.org/10.1023/A:1013132527007

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1-12.

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *Journal of the Learning Sciences, 13*, 423–451.

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

Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Duncan, R. G., . . . Soloway, E. (2004). A Scaffolding Design Framework for Software to Support Science Inquiry. *Journal of the Learning Sciences,13*(3), 337-386. doi:10.1207/s15327809jls1303_4

Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *Journal of the Learning Sciences, 13,* 273–304.

Rheinberg, F., Vollmeyer, R., & Burns, B. D. (2001). FAM: Ein Fragebogen zur Erfassung aktueller Motivation in Lern- und Leistungssituationen. *Diagnostica, 47*(2), 57–66. http://dx.doi.org/10.1026//0012-1924.47.2.57

Shapiro, S. S., & Wilk, M. B. (1965). An Analysis of Variance Test for Normality (Complete Samples). *Biometrika, 52*(3/4), 591-611.

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology, 64*, 489–528.

Sun, R., Merrill, E., & Peterson, T. (2001). From implicit skills to explicit knowledge: *A bottom-up model of skill learning. Cognitive Science, 25*, 203-244. doi: dx.doi.org/10.1016/S0364-0213(01)00035-0

Sung, H. Y., & Hwang, G. J. (2018). Facilitating effective digital game-based learning behaviors and learning performances of students based on a collaborative knowledge construction strategy. *Interactive Learning Environments*, *26*(1), 118–134. https://doi.org/10.1080/10494820.2017.1283334

Sweller, J., & Cooper, G. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction, 2*(1), 59-89.

ter Vrugte, J., & de Jong, T. (2012). How to adapt games for learning: The potential role of instructional support. In S. Wannemacker, S. Vandercruysse, & G. Clarebout (Eds.), *Serious games: The challenge*. Berlin, Germany: Springer Berlin Heidelberg.

Van der Meij, H., Albers, E., & Leemkuil, H. (2011). Learning from games: Does collaboration help? *British Journal of Educational Technology, 42*(4), 655-664. doi:10.1111/j.14678535.2010.01067.x

Van der Meij, H., Leemkuil, H., & Li, J. L. (2013). Does individual or collaborative self-debriefing better enhance learning from games? *Computers in Human Behavior*, *29*(6), 2471–2479. https://doi.org/10.1016/j.chb.2013.06.001

Vandercruysse, S., Vandewaetere, M., Cornillie, F., & Clarebout, G. (2013). Competition and students' perceptions in a game-based language learning environment. *Educational Technology Research and Development*. https://doi.org/10.1007/s11423-013-9314-5

Vandercruysse, S., Vrugte, J. T., Jong, T. D., Wouters, P., Oostendorp, H. V., Verschaffel, L., . . . Elen, J. (2016). The effectiveness of a math game: The impact of integrating conceptual clarification as support. Computers in Human Behavior,64, 21-33. doi:10.1016/j.chb.2016.06.004

Vygotsky, L. S. (1978). Mind in Society: the Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

Walther, L.R.F.Z.J (2013) *Debriefing Topics and Their Effect on Learning with Computer Games.* Bachelor thesis, Enschede, University of Twente.

Wood, D., Bruner, J. S. & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17, 89-100.

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van Der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, *105*(2), 249–265. https://doi.org/10.1037/a0031311

Wouters, P., van der Spek, E. D., & van Oostendorp, H. (2011). Measuring learning in serious games: A case study with structural assessment. *Educational Technology Research and Development*, *59*(6), 741–763. https://doi.org/10.1007/s11423-010-9183-0

Wouters, P., & Van Oostendorp, H. (2013). A meta-analytic review of the role of instructional support in game-based learning. *Computers and Education*, *60*(1), 412–425. https://doi.org/10.1016/j.compedu.2012.07.018

Yang, Y. T. C. (2015). Virtual CEOs: A blended approach to digital gaming for enhancing higher order thinking and academic achievement among vocational high school students. *Computers & Education, 81*, 281–295.

Appendices

I. Informed Consent Form

INFORMED CONSENT FORM

Information sheet

Project Title
A study about learning support during gaming.

Purpose of the Study
This research is being conducted by Natascha Kranenburg, master student Educational Science and Technology. You are going to participate in this research project about learning support in game-based learning. The purpose of this research project is to measure the effect of a specific learning support on students' learning outcomes through digital games.

Procedures

You will participate in an experiment lasting approximately 90 minutes. You will complete questionnaires about previous game experience and motivation, and play a digital game for approximately 60 minutes. After this session you will complete a knowledge test based on game content. The given information and answers are confidential, your name is not being included on the forms, only a number will identify you, no one else except the researcher will have access to the questionnaires and test.

Potential Risks and Discomforts

There are no obvious physical, legal, or economic risks associated with participating in this study. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question.

Potential Benefits
As a Psychology or Communication bachelor student, registered via Sona-Systems, you will gain experience of empirical research and receive test-subject points.

Confidentiality
Your privacy will be protected to the maximum extent allowable by law. No personally identifiable information will be reported in any research product. Within these restrictions, results of this study will be made available to you upon request. At the start of the research your name will be coded, asking for personal data after participation is not possible.

Questions

If you have any questions related to the research or this consent, you can ask them now or later. If you wish to ask questions later, you may contact: n.a.kranenburg@student.utwente.nl
This study has been reviewed and approved by the BMS Ethics Commission whose task it is to make sure that research participants are protected from harm. If you wish to know more about the BMS Ethics Commission, the Secretary of the Ethics Commission of the faculty Behavioural, Management and Social Sciences at University Twente may be contacted at ethicscommittee-bms@utwente.nl

Statement of Consent

Your signature indicates that you have read this consent form, your questions have been answered to your satisfaction, and you voluntarily agree that you will participate in this research study.

I agree to participate in a research project led by N.A. Kranenburg. The purpose of this document is to specify the terms of my participation in the project.

1. I have been given sufficient information about this research project. The purpose of my participation in this project has been explained to me and is clear.

2. My participation in this project is voluntary.

3. Participation involves completing questionnaires about game experience and motivation, playing a digital game, and completing a knowledge test based on game content. The experiment will last approximately 90 minutes. It is clear to me that I may, at any time, withdraw from participation.

4. I have been given the explicit guarantees that, the researcher will not identify me by name in any reports using information obtained from this research, and that my confidentiality as a participant in this study will remain secure.

6. I have been given the guarantee that this research project has been reviewed and approved by Dr. H.H. Leemkuil and by the BMS Ethics Committee. For research problems or any other question regarding the research project, the Secretary of the Ethics Commission of the faculty Behavioural, Management and Social Sciences at University Twente may be contacted through ethicscommittee-bms@utwente.nl

7. I have read and understood the points and statements of this form. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

Name Participant	Signature	Date
Name Researcher	Signature	Date

II. Game Motivation Questionnaire - Pre-test

Participant number: ___ Age: ___ Sex: Male/Female/Other

Carefully read the task description below.

You are going to play the game *Lemonade Tycoon 2 New York.* The goal of this game is to set up a successful lemonade business. You are going to try to make as much profit as possible within 15 game days. To run your business, you have to adjust variables such as the location of your lemonade stand, the recipe and price of the lemonade, upgrades, and marketing budget before starting each game day. The success of the business also depends on various external factors such as weather, customer satisfaction, news and the popularity of the lemonade. Based on the adjustable variables profit will rise or fall.

Gameplay and expectations

Before every day in the game you have to analyse the situation. Depending on your strategy and external factors you adjust the variables for the day. After clicking on the '*start the day'* button, your day will start and your lemonade stand is in operation. During the day you cannot adjust your variables anymore, except for the variables recipe and price, they can be manipulated during the day. You can also fast forward your day, this is recommended to speed up your gameplay.

<u>There is an option to skip the day, please **DO NOT** use this button, the game will skip the day completely and you will not receive any feedback to adjust your strategy or variables.</u>

During and after each game day, you receive feedback which allows you to see how well you did and how your lemonade is appreciated by the customers. Examples of feedback are: a notification when you do not have enough stock to start the day, a report of your profit, assets and stock, how many lemonades you have sold, and customer satisfaction about the lemonade. Depending on this feedback, you have to adjust your strategies for the following day. Try to make as much profit as possible within 15 days in the game.

Please turn the page and complete the game motivation questionnaire.

Please rate your current attitude towards the described task. Choose and mark the number that corresponds to your current attitude best.

	Disagree						Agree
1. I like this kind of strategy games	1	2	3	4	5	6	7
2. I think I am up to the difficulty of this task	1	2	3	4	5	6	7
3. I probably won't manage to do this task	1	2	3	4	5	6	7
4. While doing this task I like the role of a lemonade seller who is making as much profit as possible	1	2	3	4	5	6	7
5. I feel under pressure to do this task well	1	2	3	4	5	6	7
6. This task is a real challenge for me	1	2	3	4	5	6	7
7. After hearing the introduction, the task seems to be very interesting to me	1	2	3	4	5	6	7
8. I am eager to see how I will perform in the task	1	2	3	4	5	6	7
9. I am afraid I will make a fool out of myself	1	2	3	4	5	6	7
10. I am strongly determined to try as hard as I can on this task	1	2	3	4	5	6	7
11. For tasks like this I don't need a reward, because they are fun	1	2	3	4	5	6	7
12. It would be embarrassing to fail at this task	1	2	3	4	5	6	7
13. I think everyone could do well on this task	1	2	3	4	5	6	7
14. I think I won't do well on this task	1	2	3	4	5	6	7
15. If I can do this task, I will feel proud of myself	1	2	3	4	5	6	7
16. When I think about the task, I feel somewhat concerned	1	2	3	4	5	6	7
17. I would work on this task even in my free time	1	2	3	4	5	6	7
18. I feel nervous by the demands of this task	1	2	3	4	5	6	7

III. Game Motivation Questionnaire - Constructs

	Construct
1. I like this kind of strategy games	Interest
2. I think I am up to the difficulty of this task	Probability of success
3. I probably won't manage to do this task	Probability of success (-)
4. While doing this task I like the role of a lemonade seller who is making as much profit as possible	Interest
5. I feel under pressure to do this task well	Anxiety
6. This task is a real challenge for me	Challenge
7. After hearing the introduction, the task seems to be very interesting to me	Interest
8. I am eager to see how I will perform in the task	Challenge
9. I am afraid I will make a fool out of myself	Anxiety
10. I am strongly determined to try as hard as I can on this task	Challenge
11. For tasks like this I don't need a reward, because they are fun	Interest
12. It would be embarrassing to fail at this task	Anxiety
13. I think everyone could do well on this task	Probability of success
14. I think I won't do well on this task	Probability of success (-)
15. If I can do this task, I will feel proud of myself	Challenge
16. When I think about the task, I feel somewhat concerned	Anxiety
17. I would work on this task even in my free time	Interest
18. I feel nervous by the demands of this task	Anxiety

IV. Game Experience Questionnaire - Experimental Groups

Participant number: ___

Please answer the following questions about your experiences with computer games.

1. How much experience do you have with computer games in general?
    a. Very experienced
    b. Experienced
    c. Some experience
    d. Almost no experience
    e. No experience

2. On average, how many hours per week did you play games in recent months?
    a. 0 hours
    b. 1 - 3 hours
    c. 4 - 6 hours
    d. 7 - 9 hours
    e. 10 or more hours

3. On average, how many hours per week did you play a strategy game like the *Sims*, *SimCity* or *Civilization* in recent months?
    a. 0 hours
    b. 1 - 3 hours
    c. 4 - 6 hours
    d. 7 - 9 hours
    e. 10 or more hours

4. How many hours experience you have with playing *Lemonade Tycoon* (version 1, version 2, and/or *Sim Lemonade Millionaire).*
    a. 0 hours
    b. 1 - 3 hours
    c. 4 - 6 hours
    d. 7 - 9 hours
    e. 10 or more hours

Now you are going to play the game Lemonade Tycoon. In total, two rounds are played. You are going to try to make as much profit as possible in 15 days. You have to keep in mind that you stop at the 15th day, since the game automatically continues. Notify the researcher if you are finished with the 1st round, then your game score will be noted and the next step will be explained to you.
Have fun!

V. Game Experience Questionnaire - Control Group

Please answer the following questions about your experiences with computer games.

1. How much experience do you have with computer games in general?
    a. Very experienced
    b. Experienced
    c. Some experience
    d. Almost no experience
    e. No experience

2. On average, how many hours per week did you play games in recent months?
    a. 0 hours
    b. 1 - 3 hours
    c. 4 - 6 hours
    d. 7 - 9 hours
    e. 10 or more hours

3. On average, how many hours per week did you play a strategy game like the *Sims*, *SimCity* or *Civilization* in recent months?
    a. 0 hours
    b. 1 - 3 hours
    c. 4 - 6 hours
    d. 7 - 9 hours
    e. 10 or more hours

4. How many hours experience you have with playing *Lemonade Tycoon* (version 1, version 2, and/or *Sim Lemonade Millionaire).*
    a. 0 hours
    b. 1 - 3 hours
    c. 4 - 6 hours
    d. 7 - 9 hours
    e. 10 or more hours

Now you are going to play the game Lemonade Tycoon. In total, two rounds are played. You are going to try to make as much profit as possible in 15 days. You have to keep in mind that you stop at the 15th day, since the game automatically continues. Notify the researcher if you are finished with the 1st round, then your game score will be noted and the next round will start.
Have fun!

VI. Game Experience Questionnaire - Scoring

Participant number: ___

Please answer the following questions about your experiences with computer games.

5. How much experience do you have with computer games in general?
    a. Very experienced (1)
    b. Experienced (2)
    c. Some experience (3)
    d. Almost no experience (4)
    e. No experience (5)

6. On average, how many hours per week did you play games in recent months?
    a. 0 hours (1)
    b. 1 - 3 hours (2)
    c. 4 - 6 hours (3)
    d. 7 - 9 hours (4)
    e. 10 or more hours (5)

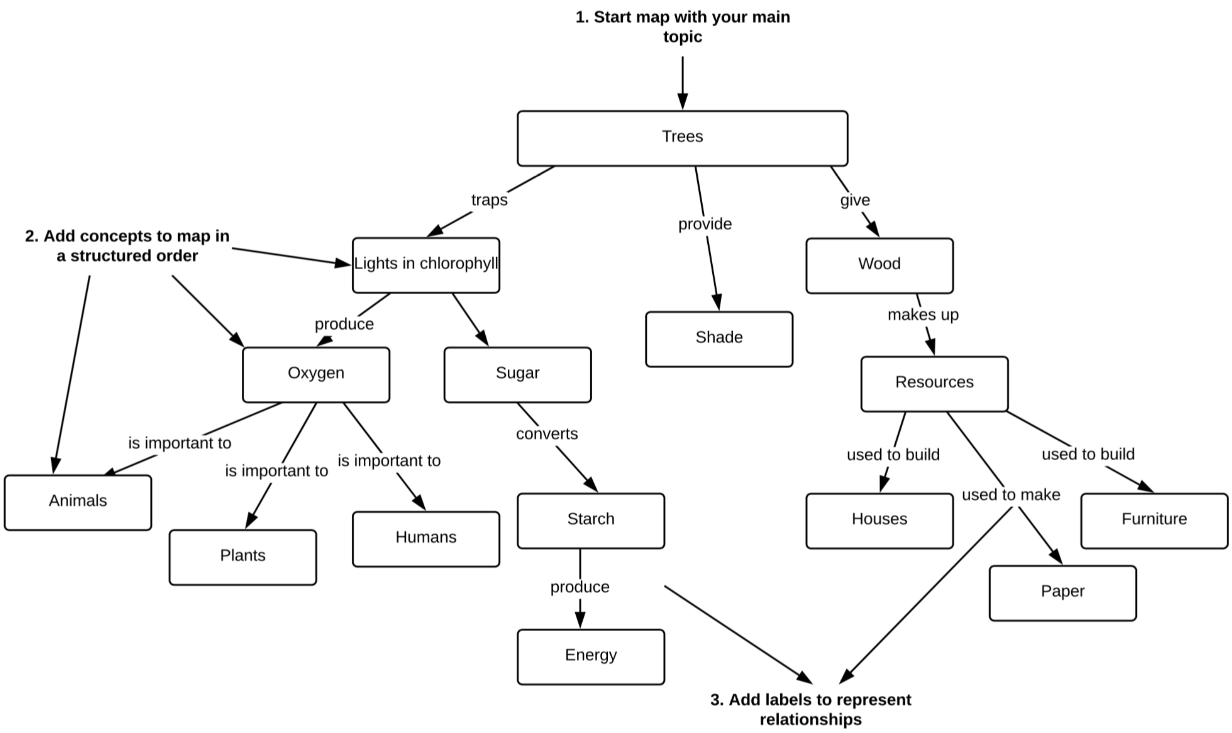
7. On average, how many hours per week did you play a strategy game like *Civilization, Age of Empires,* or *Roller-coaster Tycoon* in recent months?
    a. 0 hours (1)
    b. 1 - 3 hours (2)
    c. 4 - 6 hours (3)
    d. 7 - 9 hours (4)
    e. 10 or more hours (5)

8. How many hours experience you have with playing *Lemonade Tycoon* (version 1, version 2, and/or *Sim Lemonade Millionaire).*
    a. 0 hours (1)
    b. 1 - 3 hours (2)
    c. 4 - 6 hours (3)
    d. 7 - 9 hours (4)
    e. 10 or more hours (5)

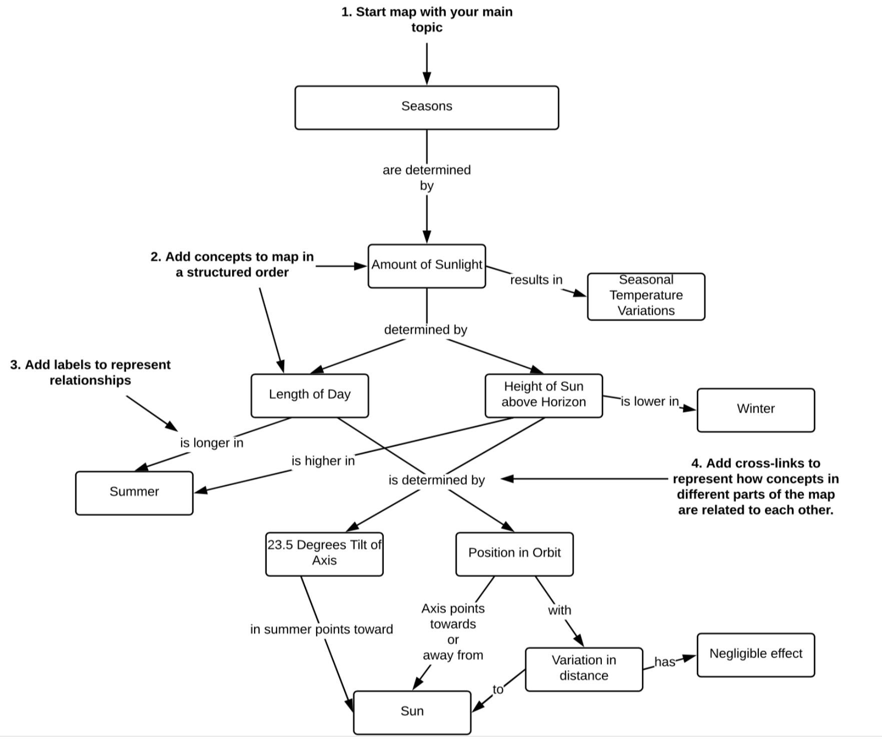
VII. Concept Mapping Training Materials – Student-Constructed Condition

Introduction to concept mapping

Concept mapping is used as a learning and teaching technique, and is a type of graphic organiser to help students organize and represent knowledge of a topic, visually illustrating the relationships between concepts and ideas. Concepts, represented in circles or boxes, are linked by words and phrases that explain the connection between them. Most concepts maps are represented in a hierarchical structure, starting with a main idea or concept and then branch out to show how that main concept can be broken down. The most general concepts are placed at the top, and the more specific, less general concepts are placed below. Additional cross-links represent the relationships between concepts in different areas of the map, this is shown in example II. Examples of a concept map are given below.



Example I - Concept map



Example II - Concept map with cross-links

As part of this research you will create a concept map about the game content of lemonade tycoon. The aim of your concept map is to get an overview of how to maximise the profit in a lemonade business. You will construct your concept map during or after gameplay, using plasticized concepts and a whiteboard system for easy use. The starting point and a list of concepts is already given, you may add new concepts yourself.

How to construct a concept map

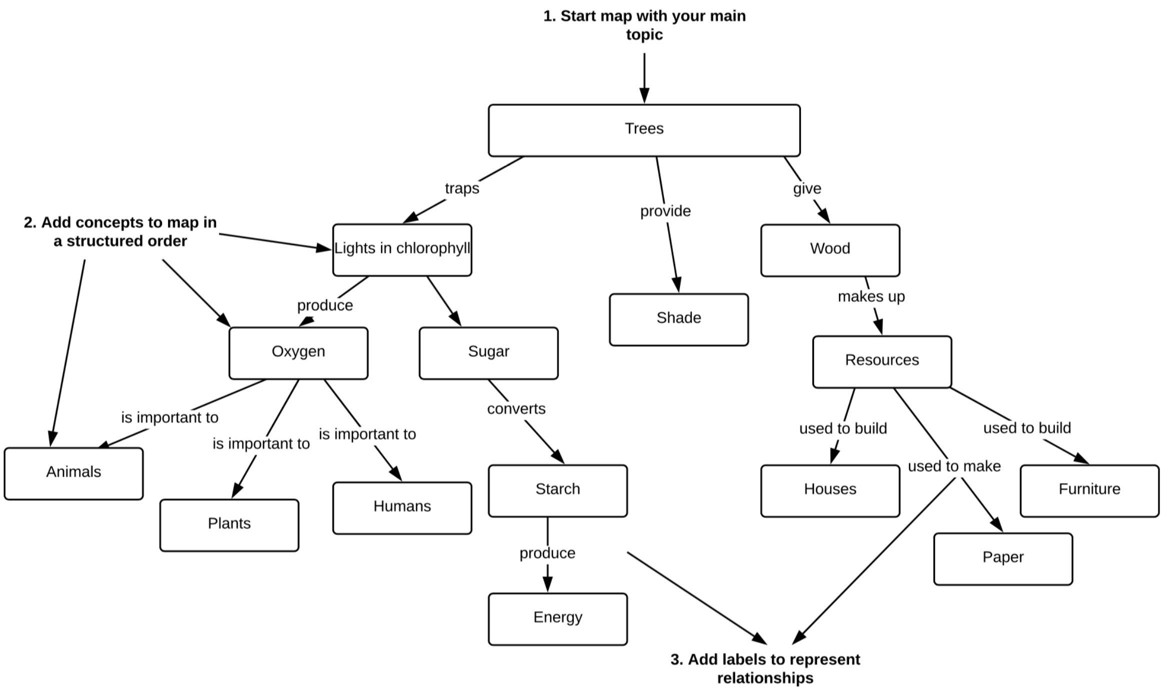
1. Start with a main idea or topic to focus on. The starting point is already given
2. Determine the key concepts: find the key concepts that connect and relate to your main idea and rank them; most general, inclusive concepts come first, then link to smaller, more specific concepts.
3. Connect concepts by creating linking phrases and words: once the basic links between the concepts are created, add cross-links, which connect concepts in different areas of the map, to further illustrate the relationships on the topic
4. Finally, add examples to refine meaning of the concept: since examples do not represent concepts, they are not placed in circles or boxes.

Now you can start the second round of Lemonade Tycoon. Try to get as much profit as possible. During and after playing you have the possibility to create and modify your concept map.
Again, remember that you stop playing at the 15th day.
Notify the researcher if you are ready, then your game score will be noted and the final steps will be explained to you.

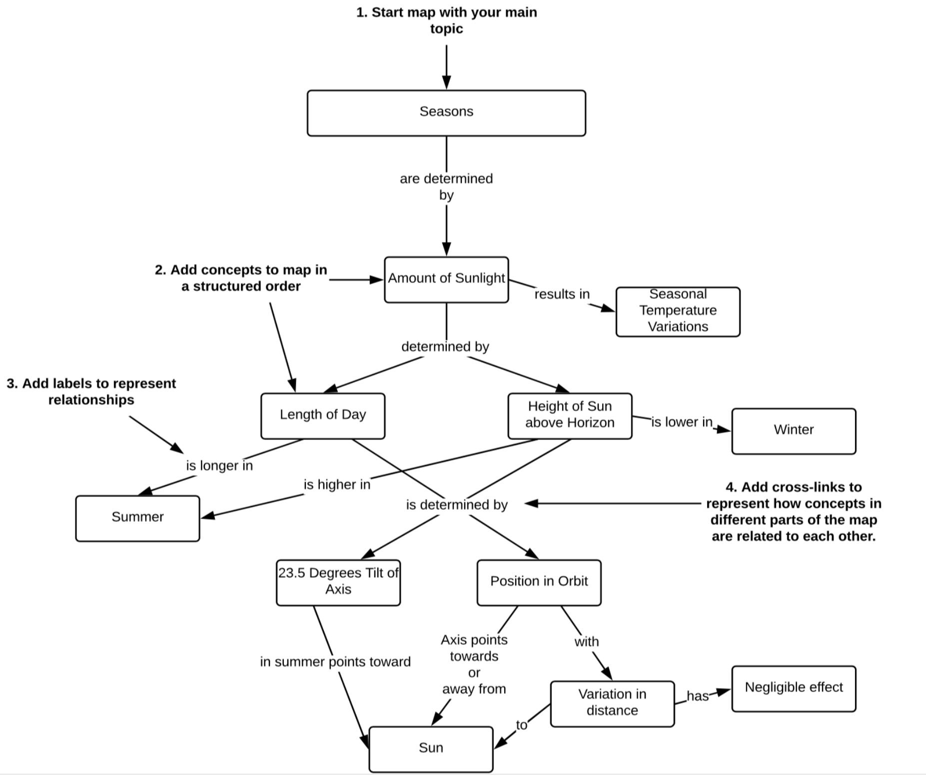
VIII. Concept Mapping Training Materials - Pre-generated Condition

Introduction to concept mapping

Concept mapping is used as a learning and teaching technique, and is a type of graphic organiser to help students organize and represent knowledge of a topic, visually illustrating the relationships between concepts and ideas. Concepts, represented in circles or boxes, are linked by words and phrases that explain the connection between them. Most concepts maps are represented in a hierarchical structure, starting with a main idea or concept and then branch out to show how that main concept can be broken down. The most general concepts are placed at the top, and the more specific, less general concepts are placed below. Additional cross-links represent the relationships between concepts in different areas of the map, this is shown in example II. Examples of a concept map are given below.



Example I - Concept map



Example II - Concept map with cross-links

As part of this research you will carefully read an already made concept map about the game content of Lemonade Tycoon. This concept maps gives you an overview of how to maximise the profit in a lemonade business. Take a few minutes and make sure you read and understand this concept map completely, you may also use this map during the next round of the game.

Now you can start the second round of Lemonade Tycoon. Try to get as much profit as possible. During and after playing you may use the given concept map.
Again, remember that you stop playing at the 15th day. Notify the researcher if you are ready, then your game score will be noted and the final steps will be explained to you.

IX. Game Motivation Questionnaire - Post-test

Participant number: ___

Please rate your current attitude towards the performed task. Choose and mark the number that corresponds to your current attitude best.

	Disagree						Agree
19. I liked playing this kind of strategy games	1	2	3	4	5	6	7
20. I think I was up to the difficulty of this task	1	2	3	4	5	6	7
21. I probably did not manage to complete this task	1	2	3	4	5	6	7
22. While doing this task I liked the role of a lemonade seller who is making as much profit as possible	1	2	3	4	5	6	7
23. I felt under pressure to do this task well	1	2	3	4	5	6	7
24. This task was a real challenge for me	1	2	3	4	5	6	7
25. After playing the game, the task was very interesting to me	1	2	3	4	5	6	7
26. I am eager to see how I performed in the task	1	2	3	4	5	6	7
27. I am afraid I made a fool out of myself	1	2	3	4	5	6	7
28. I am strongly determined that I tried as hard as I could on this task	1	2	3	4	5	6	7
29. For tasks like this I don't need a reward, because they are fun	1	2	3	4	5	6	7
30. It would be embarrassing to fail at this task	1	2	3	4	5	6	7
31. I think everyone could do well on this task	1	2	3	4	5	6	7
32. I think I didn't do well on this task	1	2	3	4	5	6	7
33. I will feel proud of myself	1	2	3	4	5	6	7
34. I feel somewhat concerned	1	2	3	4	5	6	7
35. I would work on this task even in my free time	1	2	3	4	5	6	7
36. I feel nervous by the demands of this task	1	2	3	4	5	6	7

X. Knowledge Test

Participant number: ___

Please answer the following questions about the game

1. Name three reasons for customers to be unsatisfied
    - ○ ____
    - ○ ____
    - ○ ____

2. What is meant with lost sales?

   ____

   ____

3. Except the supplies for making lemonade, please name three possible expenses for running the business:
    - ○ ____
    - ○ ____
    - ○ ____

4. Explain why the umbrella upgrade influences customer satisfaction

   ____

   ____

5. Indicate whether the following statement is true or false:
   Popularity represents the percentage of people who come to your stand.

   ○ True ○ False

6. Name three things that have to be considered when buying stock.
    - ○ ____
    - ○ ____
    - ○ ____

7. When the weather is over 30°C (85°F), you decide to put 5 ice cubes in the lemonade. How many lemons and sugar would you add to meet customers' satisfaction?
   ___ lemons and ___ sugar cubes

8. Which statement is true about moving your stand
   - ○ When moving the stand, satisfaction and popularity change with the location.
   - ○ When moving the stand, satisfaction and popularity depend on your stand.
   - ○ When moving the stand, popularity changes with the location and satisfaction depends on your stand.
   - ○ When moving the stand, satisfaction changes with the location and popularity depends on your stand.

9. Describe three situations when you would or when you would not run a marketing campaign.
   - ○ ____
   - ○ ____
   - ○ ____

10. Visits and service time are two concepts influencing sales. Name for each concept four actions you can do to increase the amount of sales.
    Visits:
    - ○ ____
    - ○ ____
    - ○ ____
    - ○ ____

    Service time:
    - ○ ____
    - ○ ____
    - ○ ____
    - ○ ____

11. Which of these actions is better to attract more customers? Please explain your answer
    - ○ Investing more money in advertising.
    - ○ Purchase an upgrade that increases popularity.

because: ____
____

12. Which of these actions is better when your customers are complaining about the long waiting time? Please explain your answer.
    - ○ Lower the cost on advertising.
    - ○ Move the stand to a place with fewer customers

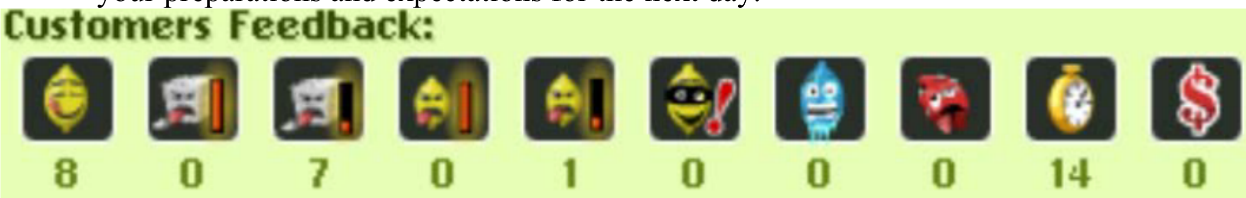
    because: ____
____

13. Which of these actions is better when buying ingredients early game? Please explain your answer
    - ○ Buy ingredients in small amounts so that there will be no leftover stock at the end of the day.
    - ○ Buy ingredients (except ice cubes) in large quantities to save money.

    because: ____
____

The next questions describe possible game situations.

14. After a business day you receive the feedback below. You sold 40 of 60 cups. Describe your preparations and expectations for the next day.



Please describe which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason

15. You start with your stand in the Bronx. The lemonade price is set to $1.50. Your recipe is 8 lemons, 3 sugar, and 2 ice cubes. The weather forecast is sunny and around 25°C (75°F). Your customers complain about the waiting time. You had 30 cups and went out of stock before evening.

Please describe which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason

16. You moved to the central station. After one day at the new location the popularity is 80%. The weather forecast is rainy and around 23°C (71°F). The recipe is set to 9 lemons, 3 sugar, and 3 ice cubes. You already purchased the upgrades radio and customer reward card. Yesterday you sold all cups.

Please describe which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason

17. Your popularity with a stand in the park is 30%. The news report states: "*Children think lemonade is not 'cool'."* The weather forecast indicates rainy weather with around 15°C (60°F). Your recipe is set to 8 lemons, 3 sugar, and 3 ice cubes and the price is set to $2.25. Many customers say it is too expensive.

Please describe which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason

When you are finished with the questionnaire, please hand it in to the researcher.
Thank you for participating in this study!

XI. Knowledge Test - Answers and Scoring

Please answer the following questions about the game

CONCEPTS

1. Name three reasons for customers to be unsatisfied:
    a. *Bad recipe*
    b. *Long waiting time*
    c. *High price*

    0.5 points per correct answer, with a maximum of 1.5 points.

2. What is meant with lost sales?
    People who come to the stand and leave without buying anything
    1 point for the correct answer.
    0,5 point for the sales that could have been done during the day

3. Except the supplies for making lemonade, please name three possible expenses for running the business:
    a. *Advertising*
    b. *Upgrades*
    c. *Rent location*
    d. *Hiring staff*

    0.5 points per correct answer, with a maximum of 1.5 points.

4. Explain why the umbrella upgrade influences customer satisfaction
    It keeps the customers dry on rainy days and cool on hot days, it influences customer satisfaction because of the service provided.
    1 point for the correct answer, 0.5 point for partially correct answer

5. Indicate whether the following statement is true or false:
    Popularity represents the percentage of people who come to your stand.

    ○ True ○ False

    True
    1 point for the correct answer.

PRINCIPLES

6. Name three things that have to be considered when buying stock.
    a. *Buy enough stock for the next day*
    b. *Estimate number of customers to make sure not to get out of stock*
    c. *Buying supplies at once is cheaper*
    d. *Stock gets spoiled after a certain amount of time*
    e. *Leftovers from last day*
    f. *Capacity of the current lemonade stand*

    0.5 points per correct answer, with a maximum of 1.5 points.

7. When the weather is over 30°C (85°F), you decide to put 5 ice cubes in the lemonade. How many lemons and sugar would you add to meet customers' satisfaction?

___ lemons and ___ sugar cubes
7/8 lemons and 3/4 sugar cubes
0,5 point per the correct answer, with a maximum of 1 point.

8. Which statement is true about moving your stand
    a. When moving the stand, satisfaction and popularity change with the location.
    b. When moving the stand, satisfaction and popularity depend on your stand.
    c. When moving the stand, popularity changes with the location and satisfaction depends on your stand.
    d. When moving the stand, satisfaction changes with the location and popularity depends on your stand.

    C is the correct.
    1 point for the correct answer

9. Describe three situations when you would or when you would not run a marketing campaign
    a. *Related to growth*
    b. *Related to popularity*
    c. *Related to weather*
    d. *Related to revenues, not enough cash available*

    0.5 points per correct answer, with a maximum of 1.5 points.

10. Visits and service time are two concepts influencing sales. Name for each concept four actions you can do to increase the amount of sales.
    - Visits
        - *Increasing popularity*
        - *Improving visibility*
        - *Increasing marketing*
        - *Improving location*
    - Service time
        - *Training staff*
        - *Upgrading the stand*
        - *Purchasing an additional stand*
        - *Purchasing the calculator upgrade*

    0.5 points per correct answer, with a maximum of 4 points.

11. Which of these actions is better to attract more customers? Please explain your answer
    a. Investing more money in advertising.
    b. Purchase an upgrade that increases popularity.

    Action *b*, because: *It is a lifetime investment that constantly increases popularity*
    1 point for the correct answer

12. Which of these actions is better when your customers are complaining about the long waiting time? Please explain your answer.
    a. Lower the cost on advertising.

  b. Move the stand to a place with fewer customers

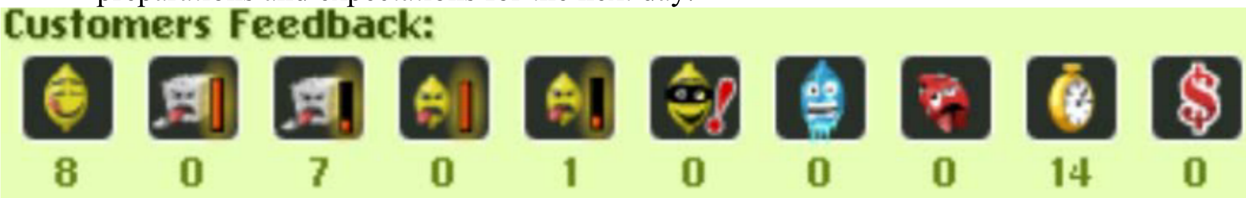
Action a, because: *This way you have less expenses, and keep popularity*
1 point for the correct answer

13. Which of these actions is better when buying ingredients early game? Please explain your answer
    a. Buy ingredients in small amounts so that there will be no leftover stock at the end of the day.
    b. Buy ingredients (except ice cubes) in large quantities to save money.

    Action a, because: Otherwise a lot of ingredients get spoiled.
    1 point for the correct answer

The next questions describe possible game situations.
HEURISTICS

14. After a business day you receive the feedback below. You sold 30 cups. Describe your preparations and expectations for the next day.



Please describe in a detailed way which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason
Adjust recipe	*More sugar needed*
Buy an upgrade	*To shorten waiting time*
Increase advertising	*Increase popularity*
Increase price	*Nobody complained about price*

0.5 points per correct answer, with a maximum of 4 points.

15. You start with your stand in the Bronx. The lemonade price is set to \$1.50. Your recipe is 8 lemons, 3 sugar, and 2 ice cubes. The weather forecast is sunny and around 25°C (75°F). Your customers complain about the waiting time. You had 30 cups and went out of stock before evening.

Please describe in a detailed way which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason
Adjust recipe with more ice	*Weather gets hot*

Buy more cups	*Out of stock, could sell more*
Increase price	*More profit, hot weather people want lemonade.*
Buy an upgrade	*Reduce waiting time*
Lower marketing	*Reduce waiting time*

0.5 points per correct answer, with a maximum of 4 points.

16. You moved to the central station. After one day at the new location the popularity is 80%. The weather forecast is rainy and around 23°C (71°F). The recipe is set to 9 lemons, 3 sugar, and 3 ice cubes. You already purchased the upgrades *radio* and c*ustomer reward card*. Yesterday you sold all 60 cups.

Please describe in a detailed way which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason
Adjust recipe with less lemon	*Bad ratio of recipe*
Increase price	*Sold all, could sell more*
Do not change anything (1 point)	*You sold everything (1 point)*
Buy more cups	*You sold everything*
Lower the price	*Rainy day*

0.5 points per correct answer (except exception), with a maximum of 4 points.

17. Your popularity with a stand in the park is 30%. The news report states: "*Children think lemonade is not 'cool'."* The weather forecast indicates rainy weather with around 15°C (60°F). Your recipe is set to 8 lemons, 3 sugar, and 3 ice cubes and the price is set to $2.25. Many customers say it is too expensive.

Please describe in a detailed way which actions you are going to do to prepare for the next day and provide a reason for each action.

Actions	Reason
Buy not too much stock	*Less customers, children do not like lemonade*
Adjust recipe with less ice	*Because cold and rainy weather*
Buy calculator upgrade or cash register upgrade	*Reduce waiting time*

Buy umbrella	*Against rain*
Advertise	*To make it 'cooler'*
Reduce price	*Because of bad weather*
Move stand	*To a dry location*

0.5 points per correct answer, with a maximum of 4 points.