Adaptive Educational Game

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1 Introduction

The video game industry is huge, and still growing: in 2017 the market will reach 108.9 billion. [7] Educators are interested in meeting this growing demand with products that not only entertain, but educate.

Educational games try to use the intrinsically motivating mechanics of video games while still being useful for learning. Much research is done about the different learning techniques. However, most educational games do not take into account these best learning techniques. Also, these educational games are not tested based on efficiency towards learning. In the next sections there will be an overview of all the important aspects I focused on to make a fun and evidence based educational game that also has a form of adaptation. Later on, in the section of the design and implementation decisions I will incorporate these aspects.

1.1 The spacing effect

An article by Lisa K. Son investigated individual control of spacing strategies during study [9]. She did an experiment in which participants had to study cue-target pairs. The participants were given three choices: study the pair again (massed), study the pair after all other pairs where asked (spaced), or not to study the pair again (done). To explain 'massed learning' and 'spaced learning' a bit further, I will give an example. Massed learning is also known as cramming, which already was mentioned before. Spaced learning however, is studying the to-be-learned items over several repetitions with longer lags.

In her paper she described three possible hypotheses: The spacing hypothesis, the massing hypothesis and the meta-cognitive hypothesis. The spacing hypothesis claims that people choose to space their to-be-learned items to improve long-time memory. However the massing hypothesis suggest that people mass their to-be-learned items to keep their confidence intact. The meta-cognitive hypothesis suggest that it depends on the to-be-learned items which strategy (massing or spacing) they use. Research has found extensively prove that spacing leads to higher performance. However, in this study Lisa K. Son tried to investigate when participants would like to repeat a certain item. "Researchers have said that the efficiency of the expanding practice method is due to the fact that after study, learners wait until the item is effortful to retrieve, but not impossible—which entails massed trials at the beginning of learning when retrieval is still untried and spaced trials later in learning when the item has already been retrieved successfully". This is also what she found after the experiment. Participants spaced pairs when they found the pair relatively easy and massed the pair if they judged them to be hard. People had an

Another paper by Robert A. Bjork and Ted W. Allen took another perspective on the spacing effect. [1] However, they also claim that spacing of repetitions has clear positive effects on the performance. In this study they tried to find out when consolidation is best. They reported how processing difficulty of the activity interpolated between two presentations of an item improves consolidation.

In the paper they describe an experiment in which they differ the difficulty of the activity between two representations of an item. They did an experiment on this where participants where asked to remember trigrams consisting of three common four-letter nouns. After a trigram was shown, digits were shadowed until the participants where cued to recall the trigram or until a new trigram was shown, which on his turn also was shadowed until the participants where cued to recall. 30 subjects participated in this experiment. The shadowing task was either easy or difficult and the intervals between showing trigrams and recalling them was either long or short. They showed that when participants had to recall a trigram after doing a difficult shadowing task improved their performance over doing a easy shadowing task.

1.2 Immediate Feedback

There was some heavy debate about whether immediate or delayed feedback is better for learning. Epstein, Michael L and Lazarus, Amber D and Calvano, Tammy B and Matthews, Kelly A and others claim in their paper that immediate feedback improves learning rather than delayed feedback [3].

They tested this with three studies by having two groups of participants. Both groups were evaluated on a multiple choice test. In two of the studies one group was evaluated by the IF AT (Immediate feedback Assessment Technique) and the other group was evaluated by Scantron answer sheets. This Scantron answer sheets did not provide immediate feedback and where the IF AI provides answering until correct, the Scantron answer sheets did not. Participant, tested with the IF AT, were told that they would discover a start if they correctly answered the question.

After that they had learned using different techniques, they had to do a final exam. On this test there were evaluated by Scantron answer sheets. The final exam took place either one day after the initial learning test or one week after.

All of the three studies showed that there was no difference between the initial test for both groups. However, there were some differences for the groups on the final test. For all of the three studies that are explained in the paper, it appeared that participants that used the IF AT at the initial test performed better on the test than the participants that used the Scantron evaluation technique. This holds for either one day and one week delay. It was even so, that participants that used the IF AT evaluating method performed better than the initial test at day one for all studies. The Scantron group performed equally well or worse on the final test.

Epstein, Michael L and Lazarus, Amber D and Calvano, Tammy B and Matthews, Kelly A and others think that the IF AT method provides better result because participants are prevented from making misconceptions whereas in using the Scantron method the participants could make these because they are not provided with any feedback.

1.3 The four pillars

A framework that was offered by Hirsh-Pasek et al described 'the four pillars' that are important for effective learning educational apps for children. Active learning, Engagement, Meaningful learning and Social interaction are the four pillars to guide researchers, educators, and designers in evidence-based app development."Active, engaged, meaningful, and socially interactive experiences support learning, and if these concepts are harnessed within apps, the potential benefit for learning in early childhood is significant." [5]

According to Hirsh-Pasek et al. children need to play an active role in their own learning. They are not simply observers. However, there is a distinction between being mentally and physically active that is important for making a good educational app. We are especially interested in trying to engage the player into being mentally active. The distinction between physically and mentally active is made by looking at the terms 'minds-on' and 'minds-off'. When a certain child is playing a game and reacts to certain changes on the screen, it could be possible that the child is actively learning, however, giving a response to certain changes on the screen takes little effort, and is therefore 'minds-off'. In contradiction, trying to figure out how to make a puzzle does require some effort, is 'minds-on'. In the paper of Hirsh-Pasek et al. they describe that students are learning better if they have to teach certain topics to other student and therefore having a 'minds-on' mind-set. Active learning also entails that the student is not only absorbing the information about a certain topic, but is trying to learn the topic actively by for example writing certain things down, explaining why something is true to others etc. "Active manipulation appears to be key for supporting minds-on learning, even for infants. " [5]

Engagement is the second pillar of the framework of Hirsh-Pasek et al. They claim that engagement is essential for learning. "Distraction is becoming a key area of research in the study of engagement, as children's normal environments seem to require constant multitasking" [5]. Children learnt fewer novels and facts from pop-up books than from unenhanced storybooks. "The danger of distraction is apparent throughout childhood and adulthood. When college students multitasked on a laptop during a lecture, not only did they score lower on a test, but so did others in direct view of that laptop (Sana, Weston, & Cepeda, 2013)" [5]. It is therefore important to support children's engagement in the learning process by avoiding distractions in the game. Distractions could be sound effects and for example extraneous animations.

Furthermore, 'meaningful learning' is also one of the pillars that should be integrated in an educational game. Meaningful learning can take many forms. Learning with a purpose is for example meaningful. It is important that the child knows why it should learn for example concepts.

Another important form of meaningful learning is linking new learning to already existing knowledge. This is in contrast with rote learning, in which new information does not fit into an existing framework. Children are better able to remember concepts when they link that information to knowledge that they already know. The new information fits in the old framework and is therefore easier to remember. Also according to Hirsh-Pasek et al. students are able to keep concepts for a longer period of time in memory when they learned 'meaningful' than when they crammmed the information.

Another form of meaningful learning is putting the information that should be learned into a context that is familiar to the student. This also is in agreement with linking new learning to already existing knowledge. Also Hirsh-Pasek et al claim that students are able to stay engaged to learning when the information they should learn is in a rich context. Students get less bored and continued learning more easily.

The last pillar according to Hirsh-Pasek et al. is 'social interactions'. Hirsh-Pasek et al claim that social interaction itself enables learning. Children are learning much from their peers, which is sometimes even more important than from formal schooling. In the paper of Hirsh-Pasek et al. is described that children observe and imitate their familiy and with respect to that are learning how the world works. They claim that social interaction is essential to learning. Also in school social interaction improves learning. Hirsh-Pasek et al. describe that social interaction teach children the essential skill of critical thinking. Children are trying to understand certain train of thoughts of other peers and therefore provides critical thinking. Not only listening and trying to understand other peers improves learning but also trying to explain certain topics to your fellow peer. What already is mentioned here is that children learn better when they think they have to teach or explain a particular task to another peer. In that case, children are putting more time in learning because they feel responsible. The children then are also engaged in active learning. Social interactions could be integrated in games in various ways. The first option could be to make a multi-player game. In this way children are engaged in the game in a group, which improves social interactions. This could be managed by using programs like Skype or other screen sharing apps. Another option could be to integrate social interactions through having on-screen characters which could interact with the player.

1.4 Intrinsic motivation

To make a game attractive to a player it should be intrinsically motivating. "The concept of intrinsic motivation lies at the heart of the user engagement created by digital games." [4] M. P. Jacob Habgood & Shaaron E. Ainsworth want to test the concept of intrinsic integration to improve the relationship between educational games and its learning content.

Many educational games use 'sugar coating' for making the game fun. This means that the player is rewarded with game-play for completing the educational content. This is also known as extrinsic motivation. Extrinsic motivation has as disadvantages that it disrupts the flow of the game; the player has to regularly switch to non-flow-inducing activity. This has as effect that the user is less engaged in the game. Intrinsically motivational games, however, maintain this flow, which leads to engagement. The paper describes the two central components of intrinsic integration:

1. "Intrinsically integrated games deliver learning material through the parts of the game that are the most fun to play, riding on the back of the ow experience produced by the game and not interrupting or diminishing its impact."

2. "Intrinsically integrated games embody the learning material within the structure of the gaming world and the player's interactions with it, providing an external representation of the learning content that is explored through the core mechanics of the gameplay." [4]

To test whether intrinsic integration into a game improves learning and is more fun, M. P. Jacob Habgood & Shaaron E. Ainsworth did an experiment. They described a study in which participant had to play an educational mathematics's game. The game had three different variations: an intrinsic, an extrinsic and a control version. The intrinsic variations integrated mathematical 'questions' into combats; the extrinsic variations had non-mathematical combats but rather asked mathematical questions between combats; The control version had no mathematical content at all. It appeared that the participant that played the intrinsic version of the game had a higher score at the game than the participants that played the extrinsic or the control version of the game. The intrinsic version of the game produced greater learning gains. On a different study, it also appeared that participants also spent more time playing the intrinsic version. Intrinsic motivation is thus favored over extrinsic motivation.

1.5 Distinction between learning and fun

Although the experiment of M. P. Jacob Habgood & Shaaron E. Ainsworth shows off that intrinsic integration improves learning rather than extrinsic integration, Matthew Kam, Aishvarya Agarwal, Anuj Kumar, Siddhartha Lal, Akhil Mathur, Anuj Tewari and John Canny disagree on this. [6] They think that it is in some extent important to keep a distinction between the learning part and the gameplay. They designed two games and evaluated these games between iterations of the game. They discovered that some animations could work confusing which distracts children from the learning task. Also they found out that the learning goals are less obvious to children when gameplay and learning tasks are too well integrated. They also think that their lessons could apply to other educational domains than that they used.

1.6 The four principles

The four pillars of Hirsh-Pasek et al. already described four important aspects that an educational game should have. Schwartz, Bennett L and Son, Lisa K and Kornell, Nate and Finn and Bridgid, however, also described four important aspects that are important for a game to be educational and fun [8]. Process material actively, practice retrieval, distributed practice and using metamemory are also known as these 'four principles'. Each of these four principles will be shortly described.

According to Schwartz, Bennett L and Son, Lisa K and Kornell, Nate and Finn and Bridgid, processing material actively improves learning rather than passively processing. This is somewhat related to the first pillar of Hirsh-Pasek et al; play an active role in your own learning [5]. Some student will perhaps say that they already are processing information deeply when reading, however, greater learning gains are provided when these student are actively processing the information by for example explaining the information to others.

The second principle is based on retrieving the information. This is somewhat different from re-studying. You could for example, read your to-be-learned concept over and over again. In this case you are not retrieving the information because you are not trying to remember the information yourself. Research proved that retrieving practice improves learning over the long term rather than restudying. Some could say that it is harmful for the player to test on something one has not started to learn. This is because incorrect answers would have harmful effects. However, research indicates that even unsuccessful retrieval attempts are more effective than studying without testing. It must however, be said, that this is only the case if the player gets useful feedback.

The third principle entails distributive learning. This is also known as spacing the to-be-learned items. The spacing effect is already discussed in short periods of time. However, in this paper, distributive learning is mostly focusing on long periods of time. This means that the to-be-learned items should be spread over several days. Distributive learning is known to be more efficient than massed learning (in this context, all to-be-learned items at for example the same day).

The last principle entails using metamemory. Metamemory refers to the awareness of our memory process and knowledge. Students should be able to monitor their knowledge while studying. This could be provided by retrieving information through tests. Metamemory also entails the strategy for learning.

It could for example be a better strategy to learn easy items first, because these items should be easier to retrieve from memory than harder ones. If the student used a different strategy and focuses more on the hard ones, it could be possible that on the test the student is not able to retrieve the hard ones (more difficult to retrieve) and therefore does not know any answers (the easy ones where not mastered).

1.7 Research Question

In this project I try to answer the following research question:

"Will a game teaching chemistry (molecule structure and names) with an adaptive learning algorithm improve learning compared to the same game without an adaptive learning algorithm?"

To answer this question, I built an game that teaches chemistry. The game has two versions. One version makes use of an adaptive algorithm that adjust difficulty of both game dynamic and content to improve learning and the other version is not. My expectations are that the game with an adaptive learning algorithm improves learning compared to the same game without that adaptive algorithm.

2 Materials

To make the educational game I made use of the language JavaScript with the free open-source Phaser game framework combined with HTML and CSS. To test my results I used statistical packages in python.

3 Chemistry game implementation

To answer my research question, I developed a chemistry game for children of high school. The game focuses on the aspects already discussed. In this section the game will be described and all important aspects will be explained.

3.1 Basic design of the game

The basic design of the game consists out of two parts: the story line and the game play (how to play the game) itself. In this section, these two parts will be described and explained.

3.1.1 Story

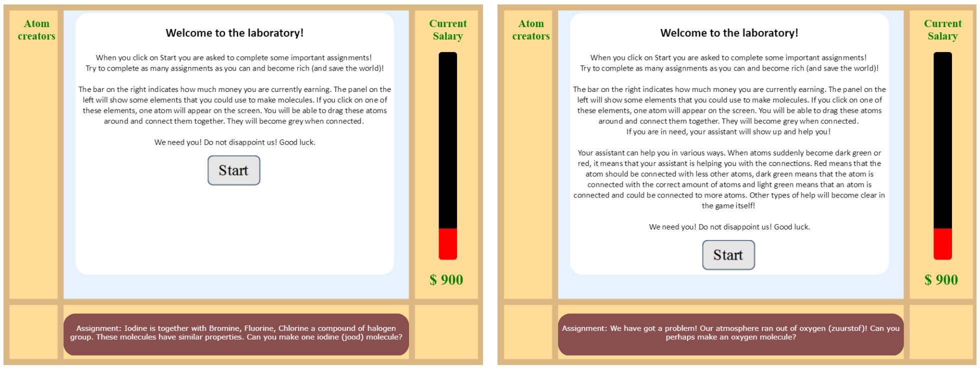
As is already described, the game teaches molecular structures and names. Players are working in a laboratory. Their goal is to get an as high monthly salary as possible. They are able to get more money by trying to combine elements to make the right molecular structures. If they get the molecule right, their salary increases, otherwise it decreases. Every assignment is a new challenge in which the player has to make a certain molecule structure for a certain purpose. In Figure is given an overview of all the assignments.

The design of this game is such that learning objectives are kept visible. Each challenge is also a learning objective. This is in agreement with the paper of Matthew Kam et al [6]. However, this game should also be intrinsically motivating to evoke engagement [4]. Trying to accomplish this, the challenges are the educational parts itself. The most fun part to play should be trying the accomplish the assignment. Making the molecular structures is like trying to finish a puzzle. Which parts should be combined to make the right puzzle? In this way, the game play is directly integrated with the educational part. Also, constructing the right 'puzzle' is a "minds-on" activity [8]. The player should not be able to make a right molecule unless he or she is putting some effort in it. Therefore this story also provides active learning which is one of the four pillars described by Hirsh-Pasek et al. and one of the four principles described by Schwartz et al.

3.1.2 Game play

To get a grip on how the game should be played, we need examine the game play. When the game starts, the player is provided with an explanation of the game and is made familiar with the story line. In Figure 1 below the start of the game is shown for both versions.

The player can press the "Start" button in the explanation panel. This indicates that the game starts. All the buttons will appear and the first assignment is printed at the bottom of the screen. This is shown in Figure 2. The player can press buttons on the left side of the game. These buttons create



(a) Random (b) Adaptive

Figure 1: Start page of chemistry game

atoms at a random place on the screen. Buttons create the element indicated at the button. The player could make as many atoms as he/she likes. Later on this will be described in more detail. Atoms in the screen can be dragged around. When atoms are near other atoms, they 'snap' together. This means that they form a connection. In this way a player is able to connect atoms together to create the needed molecule. It could be possible that the player creates by mistake too many atoms. To solve this problem, there is a trash can in the lower left corner. The player can delete an atom by dragging it to the trash can.

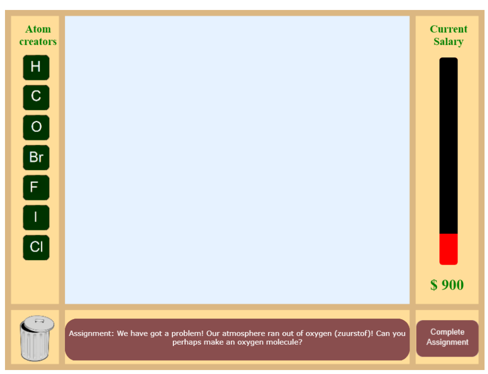


Figure 2: Game Design

When the player thinks he has made the molecule needed for this assignment, he or she could press the 'Complete Assignment' button. The program evaluates the answer and gives feedback. The feedback is situated in different components. One component is the text that is written on the screen. When the player presses the 'Complete Assignment' button, feedback is given. The other component of feedback is situated in the progress bar on the right. The progress bar will fill or will become emptier depending on the answer given.

After that the player is not able to change the particular molecule and has to press 'Next Assignment' which is situated in the left bottom corner. When the player presses this "Next Assignment" button, the next question will be generated. This loop will endure until all questions are asked. A pop-up with text will appear. The text displays how well you did on the assignments by showing your month salary at that particular moment. Also feedback of the last question is shown.

3.2 Baseline Algorithm

In order to answer the research question, two versions of the game should be compared. Therefore one should be adaptive and one should not be adaptive. The baseline algorithm is a version of the game that does not take into account the order in which questions are asked. Also it will show a lack in other adaptation additions. In this view, the order of questions can make a game adaptive, therefore this version computes a random question every time another question is completed. This random strategy is based on learning by using flashcards. In schools flashcard have been used for a long time for a variety of purposes. Also in the domain of chemistry it appeared that flashcards could be a useful tool to learn for example chemistry vocabulary [2]. The baseline algorithm does not concern about the order in which questions are asked. However, when a certain question is answered wrong, the questions is directly answered again. This is in contrast with the version of the game that also has an adaptive element. In order to compare these two versions, it seems best to have no spacing of repetitions whatsoever in the baseline version of the game. Later on the exact adaptive parts of the 'adaptive' version will be discussed.

3.3 Evaluating questions

In both versions of the game, questions are evaluated based on four aspects: the amount of atoms being used (`rightAmount`), the connections that are made (`rightConnections`, the type of elements that are used (`rightUnique`) and the amount of specific element types that are used (`rightType`).

In order to make a good evaluation of the answer, I considered these four aspects. When a molecule is not made correctly, the player still could 'get' some points (more accurately: lose less money). The bigger the mistakes, the more money a player loses. Also the feedback that is given is based on what you did wrong. The adaptive version of the game also takes into account the score that you had for the question. This will be discussed later.

3.3.1 Four aspects of evaluation

These values are being evaluated true as such:

- The boolean `rightAmount` is true when the amount of atoms being used is equal to the amount of atoms used for the correct answer.
- The boolean `rightType` is true only if the amount for each specific element that should be used is correct.
- The boolean `rightUnique` is evaluated to be true whenever all types of elements that should be used for the assignments are used, not taking into account the amount of atoms.
- The boolean `rightConnections` is evaluated true, whenever all connections that should be used are used. This means that this boolean also is true whenever there are more connections than needed.

In total there are seven combinations that are valid to examine. Players get highest score if the molecule is correct, which means all Boolean values are true. In Table 1 below there is a overview of the scores that could be established by integrating these booleans. Why there is only one value higher than zero is explained later.

Score	rightAmount	rightType	rightUnique	rightConnections
1	True	True	True	True
0	True	True	True	False
-0.2	False	False	True	True
-0.4	True	False	True	False
-0.6	False	False	True	False
-0.8	True	False	False	False
-1	False	False	False	False

Table 1: Evaluation to scores

3.4 Determining difficulty of question

Questions that are being asked should be labeled with a difficulty. To determine whether a particular question is difficult, I took into account three aspects: the amount of atoms, the amount of unique atoms and the familiarity of the molecule. The familiarity of the molecule is determined manually where water has a higher familiarity than for example dibroomchloormethane. A molecule could be very infamiliar (familiarity = 0), relatively familiar (familiarity = 1), or familiar (familiarity = 2). The difficulty of a question is determined by means of this equation:

$$Difficulty = amountOfAtoms + amountOfUniqueAtoms - familiarity$$

3.5 Feedback

After the evaluation of each question, the player gets immediate feedback [3]. The feedback entails the information about if the answer is right, but also explains which aspect of the molecule should be changed or/and which aspects are right. The feedback, however, does not drop the exact answer, so the player is forced to read the feedback as carefully as possible. However, after four indirect answers, the formula of the structure is given. Later on this will be discussed in more detail.

3.6 Adaptive Algorithm

Now that we have discussed the basic design of the game, how the difficulty of a question is determined and how answer are evaluated, we can go in depth. The game needs to be adaptive, so I made an algorithm that considers the next question and its properties based on previous answers of the player. I needed to make certain consideration in making this algorithm:

1. The player has to make all the questions in order to finish the game.

2. The player has to answer the most difficult questions correctly to finish the game.

3.6.1 All questions

If it is the case that the player has to make all the question in order to finish the game, the adaptive algorithm should be implemented with a different purpose then when the second item is true. Let me explain this further.

When it is necessary to answer all the questions in order to complete the game, then it is not possible to skip certain questions. This seems very logical, but this has a very important implication. When it is not possible to skip a certain question, it is also not possible to determine the next question based on the answers of the player. I will explain this on the basis of this example. Imagine we have the questions A, B and C, with in order the difficulties 1, 1 and 2. If the player gets the question A right, it should consider the next question to be more difficult, namely C. This means that question B is skipped. The only way that the statement: "The player has to make all the questions in order to finish the game" remains true, is by showing this question at the very end. This is, however, quite striking, because then it would mean that after correctly answering the question C, the next question is easier! This is not very adaptive.

There is, however, another way to make the game adaptive. When the player gets question A right, it would still show B as next question. However, it makes it more difficult for the player by for example showing more elements that could be made. In this situation questions will be asked in increasing difficulty order, but are still adaptive.

I also considered this option. However, I found out, that this is perhaps also not fair. Because this is a chemistry game it is hard to estimate which elements a particular player knows. It could be possible that the player does not know the answer to question A, but does know the answer to question B. However, the difficulty of these questions is the same.

3.6.2 Most difficult questions

When considering the other statement to be true: "The player has to answer the most difficult questions correctly to finish the game", the adaptive algorithm has to be implemented very differently. It means that question B can be skipped, when answering question A correctly. Important to note is, that when answering question A correctly it could be the case that question B is asked later. This could be the case when question C is answered wrong. However, with this approach there are also some disadvantages. It could be the case that questions are asked twice. Now, this could be a problem because it would spoil the idea of being a game. Also it is perhaps boring for the player to answer the question twice. Another problem with the statement being true is that, all questions that are asked in the game, could be part of an exam of the student. This means that if one question is skipped, the algorithm kind of assumes that the player knows this particular question. This could hold when it was a mathematical educational game, but it would not hold for this chemistry game in which all elements should be learned.

3.6.3 All questions with repetitions

Taking all of the above knowledge into account, I agreed to make an adaptive version like such. The order of the questions is basically from easy to hard taking into account that easy problems should be learned first using a strategy that is considered to be effective [8] and is part of using meta-memory.

When the player answers a question incorrect, the question is repeated. However, the question is not repeated directly. As was already explained, it is important to space out the questions for better learning effect [9]. Therefore when the question is repeated depends on the answer the player had given. If the answer was very wrong (-1) the player would get this same question again after two other questions. The better the question was answered, the longer it would take to repeat the question. In Figure 2 is shown when particular questions are repeated. In this way the question were spaced out over the game considering the difficulty of the question according to the player. The player still had to make all questions, but I would not become boring as the same question is not asked directly after being answered incorrectly. Questions that are more difficult, which in this case is established by looking at how good a player answers a particular question, are repeated earlier than easier ones. This is in consensus with the research of Robert A Bjork and Ted W Allen. They found out that if players could choose when to repeat a question, difficult questions were massed (repeated in a short time) and easy questions were spaced

Score	Amount of questions asked before repetition
1	no repetition
0	5
-0.4/-0.2	4
-0.8/-0.6	3
-1	2

Table 2: Repetition of questions

(repeated after a long time) [1].

3.6.4 Adaptive feedback and hints

The game is adaptive at determining the order based on the answers of the player. Certain other features also provide adaptation to the knowledge of the player. When a particular question is answered incorrectly, the player gets immediate feedback on the question [3]. This feedback is based on what aspects of the assignment the player did wrong. Not only this feedback is adaptive, but when a particular question is repeated, the player gets help with the part that they did wrong. The player gets help of an assistant. In Table 3 is shown which kind of help is offered to the player. The "x" in the table means that this variable could be either `True` or `False`.

Assistant's aid	rightConnections	rightAmount	rightUnique	rightType
"Your assistant is going to help you with the connections"	False	True	True	True
"Your assistant thinks you need to use these elements"	x	x	False	False
"Your are not able to make any more elements than necessary"	x	False	x	x
"Your are not able to make any more elements than necessary"	x	True	True	False

Table 3: Hints from assistant

This assistant helps the player getting more questions right. However, the assistant won't help with the parts that the player got right. This knowledge should be actively retrieved from memory when the player is repeating the question. Retrieval improves learning rather than restudying [8], which in this case should be, that the participant gets the answer directly after doing the question wrong. In that case the player tries to remember the answer by reading or in this case looking at the correct answer.

3.7 Progress bar

The goal of the game is to have a as high salary as possible. The salary that also is show in Figure 2, is also projected on the progress bar. This progress bar gives players an indication of how well a question answered and therefore stimulates their meta-memory [8]. This progress bar also fits the story that is being told and therefore should evoke players to be engaged to the game [5].

The bar fills or becomes emptier not only depending on the answer being given by the player, but also depending on the determined difficulty of the question. The harder the question was, the higher the 'degree of change' in the bar will be. This means that, when a difficult question is answered completely wrong, the bar will become more empty than when an easy question is answered completely wrong. In this way the error is higher for difficult questions, which also reflects reality; making mistakes on more important matters, is worse than on less important matters. The reverse is also true; correctly answering a difficult question, allows the bar to become more filled than correctly answering a easy question. In the subsection 'Degree of change' will explain how scores and difficulty of a questions are integrated to determine the change of degree.

Furthermore, the bar also changes color. In the beginning the bar is red, which indicates that your salary is not that high. If the bar is completely filled, the colour of the bar will be green. Intermediate colours are: orange, yellow and light green. This is shown in

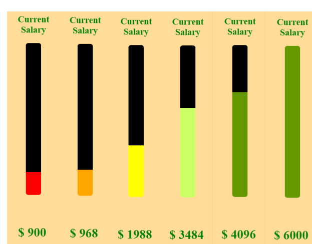


Figure 3: Colour change of progress bar

3.7.1 Degree of change

To determine the degree of change, it is important to notice that the bar should be filled completely, when all questions are answered correctly. If it is the case that certain questions are repeated, it should not be possible to get the maximum score or even a higher total score than when answering all questions correctly. Therefore I made the design decision to only fill the bar if the question is answered correctly. All other scores for questions are negative or zero. Furthermore, the only other way to get a completely filled bar is by get the score 0 for a certain question and get the question right at the first repetition (score = 1).

4 Methods

4.1 Participants

30 Participants enrolled in this research. All of the participants were invited to participate by social media. Participants were randomly divided over the two versions of the game.

4.2 Design and Procedure

Two versions of the game were tested during this research. Participants were instructed to play the game and to answer a questionnaire at the end of the game. Participants were not allowed to make use of the internet, also participants were instructed to read the feedback carefully.

4.3 Instruments

4.4 Questionnaire

5 Results

Table 4: T-tests on group

	Mean_adap	Mean_rand	t	p
adapt	3.56	2.36	-2.92	0.01
like	3.39	3.21	-0.42	0.68
hint	3.67	2.79	-1.80	0.08
learn	3.72	3.21	-1.30	0.20
order	3.83	2.93	-2.56	0.02
mean_time	30.93	25.36	-1.16	0.25
mean_score	0.43	-0.01	-2.62	0.01
salary	3809.50	1993.14	-2.68	0.01
unclear	2.56	2.14	-0.93	0.36
easy	2.44	1.86	-1.50	0.14

6 Conclusion

7 Discussion

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