

Playing Games to Learn – Does it actually work?

C. Seelhammer, H. M. Niegemann

Faculty for Education, Learning and Interactive Media, University of Erfurt, Germany
helmut.niegemann@uni-erfurt.de

Abstract: Although the advantages of digital game based learning are widespread praised empirical evidence is rare. This paper presents a quasi-experimental study (n=79) comparing two groups of high school students, one (experimental group) played a learning adventure game while the other one was presented the learning sessions out of the same game only (control group). Contrary to expectations, the results do not indicate advantages for the gaming group, instead the control group performed better on comprehension and transfer.

Keywords: digital game based learning, empirical study, cognitive load, motivation

Introduction

Several authors have argued for the advantages of learning games as educational tools and in the last few years the use of learning games in the classroom have become increasingly popular (e.g. Prensky 2001). Unfortunately there is lack of up to date empirical evidence to prove learning with dedicated digital games actually works.

Arguments of the “pro-learning-games” advocates generally refer to the motivational and emotional effects (Bryce & Rutter, 2006; De Freitas 2006). Joy of use, fun and interest in the game should foster learning of the embedded subject matter. Although this seems to be plausible in a certain way, empirical support of this assumption is still missing. On the other hand Mayer’s theory of multimedia learning and Sweller’s theory of cognitive load would clearly predict a decline of learning results when additional *extraneous* information is presented to learners (coherence effect, redundancy effect; Sweller 2005a, b; Clark & Mayer, 2003). But neither Mayer nor Sweller discuss possible trade-offs between cognitive load and motivational effects. Therefore it is time to start proofing the conflicting assumptions by experimental studies. The first question one needs to ask is whether it makes a difference to learn a specific topic in the context of a learning game or to learn it separately.

1. Aims and context of the study

Digital Learning Games or “serious games” combine typical features of games (role games, adventure games) with learning material which is more or less integrated in the narrative structure of the game. The German company BrainGames® developed and edited a series of learning adventure games for pupils ages 12 and up covering topics like mathematics (“Mathica”), physics (“Physicus”), history (“Historion”) and music (“Opera Fatal”). Many of the games won awards and the series was commercially successful. All of these games contain a typical adventure cover story.

We decided to use the game “BioLab” which teaches biology (photosynthesis, plant metabolism, genes etc.). The cover story is about a young female scientist who got imprisoned in a bio laboratory and the player’s task is to free her after having accomplished many challenges. Embedded in the story are numerous learning sessions presented in the same graphical style as the adventure.

BrainGames® was ready to cooperate and kindly provided us with two versions, the normal learning adventure and the pure learning sessions without the cover story.

The first research question was whether playing the digital learning game would have a positive effect on learning compared to the learning episodes only.

Hypothesis 1: Students playing the digital learning game show better learning results (comprehension level) than students who are only working with the learning parts of the game.

Hypothesis 2: Students playing the digital learning game show better learning results in the transfer tasks than learning-only students.

A second research question: Does playing the digital learning game enhance the motivation to learn?

Hypothesis 3: Students playing the digital learning game show a higher motivation for learning than students who only work with the learning part only.

2. Method

2.1 Design

The experimental design comprised one experimental group (EG) and one control group (CG). The participating students were randomly assigned to EG or CG.

The EG got the game (one section: botany) and the control group got the learning parts from the same section without any playful elements. In the beginning of the study all subjects had to complete a written pretest (8 items). Following the completion of this test the EG had to play the game whereas the CG worked with the learning part. After they had finished playing and learning, all students had to complete a 28 items post-test which included the 8 items of the pretest.

2.2 Sample

The subjects were $n=79$ 9th grade students (38 male, 41 female) from three classes of a German high school, aging 14 to 15 years and the study took one school day. The first class contained 27 pupils, the second one 29 and the third 28. Every class was divided into two groups (EG and CG), which were almost equal in number.

2.3 Realization

At first every class wrote the pre-test together in one room. Then the class was divided into the CG and EG group and every group went into one of two computer labs, each with 15 single computers that were prepared with the game version or the learning only version. The experiment was conducted successively in three blocks taking 120 minutes each with a 15 minutes break between the blocks.

Every block was structured as followed:

1. Introduction: 30 minutes

2. Pretest: 10 minutes in class and classroom
3. Work with software: 30 minutes in their groups
4. Posttest: 45 minutes in class and classroom

2.4 Material: the game

The learning adventure game “Biolab” starts with a story around a platform where a young researcher lands with her space ship. She gets attacked by some machines on the platform, becomes unconscious and is kidnapped by the machines. The aim of the game is to solve biological puzzles in order to find out what happened on the platform and to rescue the researcher.

The game consists of two components: 1. The playing part (see fig. 1) and 2. the learning part (see fig. 2).

The first one looks like a round platform with different doors (a total of five). Behind one of these doors is the botanic world where the pupils have to answer botanical riddles to continue in this world. In solving these riddles they get closer to finding out what happened on the platform. In the botanical world is it possible to go into a “library” (learning part) where they can get information about botany.

The learning part can be characterized as a kind of library where the 5 topics (botany, zoology, human biology, cellular biology and genetics) are explained in detail from simple to complex facts i.e. the learning content including pictures, graphics, simulations as well as written and spoken texts.

2.5 Pretest

The pre-test first asked for some personal data of the subjects (i.e. age, gender, school, computer knowledge, knowledge of the game used) to describe the sample. These questions were followed by a block of 8 items, 4 to assess the prior knowledge and 4 to assess the ability to transfer the knowledge. The items were either open or multiple choices. Subjects could reach a maximum of 23 points.

2.6 Post-test

The post-test assessed the students’ knowledge after they had worked with the gaming or the learning-only parts of the game. The test consisted of 28 questions. It included a block of open and multiple choice questions for understanding (35 points) and another block for transfer (29 points). Subsequently there were some questions concerning the motivation using a scale of 1-7 (apply – not apply).

Both tests were created on the basis of the subject matter of the game with the help of biology teachers.

3. Data analysis and results

There was no difference between both groups in the pre-test concerning the prior knowledge in botany. All students had some knowledge about this topic.

While observing the students working with their materials, it became clear that some in the EG had problems with the playing part. There was the impression that some had difficulties to orient themselves in the botany world. They didn't know what to do and the riddles seemed to be too complex for them. They often contacted the researchers or other students around them.

The CG had sufficient time to get through the whole instruction of the botany learning section and had no orientation problems. In addition it was noted that they got through the section several times, demonstrating that the time span of 30 minutes was enough for the presented material.

After working with the software all subjects had to pass the same post-test. The analysis of the 18 items for comprehension shows that the EG had an average of 10.42 points and the CG 15.59 points from the maximum of 35 points which nobody reached.

Using the prior knowledge scores as covariates an ANCOVA was calculated. The results showed a significant difference between the groups ($p=.000$). The effect sizes (partial eta-square) of the prior knowledge were 0.204 and for the treatment groups 0.397, which is a rather high ES score. Obviously both the treatment and the prior knowledge had an influence on the learning outcomes. A 2-factor ANOVA showed no statistical interaction but a main effect between the groups and the prior knowledge. Subjects benefited more from the learning materials if they had a higher prior knowledge, but the treatment also made a considerable difference. Hypothesis 1 was not affirmed as the EG group who played the learning game (including learning content) hadn't answered more comprehension questions correctly than the group who only worked with the learning part. Moreover the CG reached better results. The results indicate that people seem to learn better from good structured learning materials without playful elements than from a game with integrated learning sessions.

The analysis of the 10 transfer items showed that the EG had an average of 7.71 points and the CG 9.21 points. The maximum score of 29 points couldn't be reached by either group; however, one student from the EG got 0 points. Again an ANCOVA was calculated using the prior transfer knowledge from the pre-test as a covariate.

Results of this calculation showed a $p = .000$ for the influence of the covariate and for the treatment a $p = .013$. The effect sizes (ES, partial eta-square) for the prior-knowledge were 0.239 and for the treatment 0.078.

The 2-factor-ANOVA (treatment and prior knowledge) showed a significant result but no interaction between them for both factors. Students with high prior knowledge profited more from the learning materials than those with low prior knowledge. The treatment also made a difference in the transfer tasks. Therefore the hypothesis 2 can also to be discarded. Students who played the game weren't better in answering transfer questions as the ones who only worked with the learning part. The students who played the game had worst results in transfer questions than the learning-only group.

Finally the questions concerning the motivation were analysed. Here results of the groups didn't differ and therefore hypothesis 3 had also to be rejected. Subjects who played the learning game did not show a higher motivation while playing this game for learning as the ones who only worked with the learning content. The gaming elements seemed not to foster learning motivation.

4. Discussion

The presented study could not confirm widespread assumption on the benefits of digital game based learning; however, this does not mean that serious games are generally useless. Only one game was studied, which was a rather prototypical one amongst the “learning adventure games”.

In the case of the chosen learning game, the gamers experienced some disorientation in the game, which was irritating for some of them. Some of the experimental design problems were the time constraint as well as the large time discrepancy between completing the game versus the learning section only. Both groups did poorly in answering the transfer items. In general transfer is almost never high without explicit instruction or exercise, which was missing in the games’ learning sessions.

As for the motivation, all students seemed to be curious and interested in dealing with the game, but became disappointed in both groups. De-motivation probably increased with the lack of success while playing and too much negative feedback during learning.

A main problem of digital learning games is the missing integration of the learning tasks into the game story. We found that there was no learning adventure to actually integrate the learning tasks into the story. True integration would mean that the adventures, proofs and tasks of the game could only be passed after successful learning and application of the new learned subject matters. There is no doubt that this would be a big design challenge; however, if the narration of the game and the learning parts are not integrated, learners would rather separate playing games and learning.

Obviously just blending gaming and learning is no reasonable way to foster learning. Serious games must be thoroughly designed in cooperation with game designers, instructional designers and subject matter experts. There are also unanswered questions concerning the functions of the stories which are constitutive for adventure (learning) games and the interactivity of the games.

More research should be done on the long-term effects of serious games. Besides motivation there are also variables like “emotions” and “mood” whose influence on learning in the context of serious games is not at all studied. Empirical research on the effects of digital game based learning is in its beginning stages.

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