How a Serious Game Supports Elementary School History Classes in Teaching About the Bombardment of Copenhagen in 1807

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Abstract. This study is intended to support the Danish elementary school history classes in teaching pupils about the Bombardment of Copenhagen in 1807. The study included 22 pupils from two classes. One class with 11 pupils was included in the experimental study, which used a serious game to communicate the learning objectives of the topic. One class with 11 pupils served as the control group and used a more traditional approach with readings from the history textbook. The evaluation was based on a knowledge test with learning objectives from the curriculum. Additionally, the gaming engagement was evaluated in the experimental group through a questionnaire and semi-structured interviews. The game design was focused on intuitiveness, clear goals, and narrative engagement; which was revealed in the findings with the highest score from the gaming-engagement questions. Further, the results revealed higher understanding of specific learning objectives in the experimental gaming group compared to the control group. Previous research has the same findings, but there is a lack of improved suggestions for how to make the perfect match between game content and learning, as well as a lack of improved methods when evaluating games with children or early teens.

Keywords: Serious games · game-based learning · engagement · history · knowledge test · game design · elementary school

1 Introduction

The Bombardment of Copenhagen in 1807 is part of the syllabus in the history subject in the Danish elementary school. In September 1807, the British Navy bombarded Copenhagen, seizing the Danish fleet and assured use of the sea lanes in the North Sea and Baltic Sea for the British merchant fleet. The bombardment included more than 300 rockets, which caused fires. Due to the civilian evacuation, the normal firefighting arrangements were ineffective, and over a thousand buildings in Copenhagen were burned. The attack was implemented against the Danish because of Denmark's forced support of Napoleon's continental blockade. Before this, Denmark was a neutral state for nearly 100 years. The attack was heavily criticized internationally and is regarded as one of the first terror bombardments on a European capital.

History plays a vital role in schools all over the world. Through knowledge of countries' histories, pupils can get an understanding of their own and other societies. However, reading history is a skill with many graduations of proficiency; it involves lots of complexity, and it is not an easy task for pupils aged 13–14 to read the mandatory history literature. The Copenhagen Bombardment is considered a foundation of Danish history. However, the analogue text that forms part of the curriculum is not an easy read. This is partially due its complexity; there were several nations involved, several years and numbers are included, and it draws on old sources and writing styles with reports and eyewitness accounts from the bombardment. Therefore, the aim of this study was to improve pupils' engagement and learning about the Copenhagen Bombardment in 1807 with a serious game. Serious games have been used for various subjects in history [1–5], making it easier to memorize and understand facts, concepts, time, and historical events [1, 2]. The use of serious games in history subjects can also increase interest and make history seem alive [1]. Previous definitions have emphasized that serious games are applications that are not designed exclusively for fun [6] or that are intended to be more than entertainment [7, 8]. However, there are still some unsolved categorical problems regarding what constitutes a game and what "more than entertainment" or "not exclusively for fun" mean. An interesting intersection of history and games is related to one of the early commercialized and popular video games, the historical game *Civilization* (released in 1991). Many other edutainment games with historical content have been released, e.g., *Genghis Khan II: Clan of the Gray Wolf* (1992), *Brothers in Arms: Road to Hill 30* (2005), *Assassin's Creed* (2016), and *Valiant Hearts: The Great War* (2016). These games were not designed with education in mind; rather, they employ a learning experience as authentic gameplay, requiring reflection to make connections between the gameplay and the historical content being taught. In this study, we took inspiration from commercialized historical games but transformed the content into a serious game providing pupils aged 13–14 awareness and historical engagement of the Bombardment of Copenhagen in 1807. The following research question guided the study: Can a serious game be engaging and improve learning outcomes about the history of the Copenhagen Bombardment in 1807 for Danish elementary school pupils in the 7th grade?

A great deal of research exists on various game-design principles linked to the importance of narrative engagement [12–16] in designing successful serious games for learning purposes. However, there are still major challenges involved in measuring whether narrative engagement is beneficial for improved learning within very specific learning objectives. Learning outcomes are often measured by self-reports and knowledge tests [17]. Previous studies have reported positive outcomes in terms of narratives being more engaging than traditional classroom instruction [17–20]. However, the effects of game-based learning on specific knowledge tests are more diverse and inconclusive [17]. The novelty of this study lies in collaborating with the elementary school history teacher to set specific learning questions tied to the curriculum on the Copenhagen Bombardment in 1807 and to observe if there are any learning differences between the experimental (gaming) group and the control (reading) group.

2   Previous Research

The idea of using serious games to teach history is not new [1–5]. Scholars have described multiple principles for serious games in historical teaching, including the important aspects of learning goals, engagement, realism, feedback, discovery, repetition, guidance, flow, storytelling, social interaction, briefing, and debriefing. Scholars have also emphasized specific aspects of narrative engagement, motivation, and teacher involvement related to making successful serious games with learning purposes.

A) Narrative engagement: Narrative engagement [12] seems important within a serious game focused on historical engagement because of its relation to the story experienced while playing the game [13]. Thus, it may result in imaginative immersion [14], narrative involvement [15], or narrative immersion [16]. The desire to know how the story of the Bombardment of Copenhagen unfolds evokes curiosity, suspense, and narrative engagement, making pupils want to continue playing [13]. Characters in the game may support narrative engagement, as well, when a player begins to involve themselves in their character and as the other characters develop in the narrative [13].

B) Motivation: Engaging in reading for history classes, both in serious games and in other media (analogue included), requires the reader to be motivated [21]. This involves, for example, grasping important elements within the text's content, comprehending the text's overall meaning, gaining new knowledge, and engaging in social interactions (with the teacher and other pupils) using knowledge and/or lessons learned from the text [21, 22]. Furthermore, to design a motivating experience in a serious game, scholars have already emphasized aspects of intrinsic motivation, such as individual curiosity, a desire for challenge, and involvement [9, 23]. It is assumed that the experiences of flow [24] and enjoyment [25] are crucial in this process. When players have mastered specific challenges, they develop a greater level of skill that can be used and improved with more complex challenges in other levels or games [11, 26]; this can have a positive influence on intrinsic motivation in serious games. Serious games in a traditional learning context, as in this study, have the advantage of possible extrinsic motivation from a teacher or learning progression. However, this means that serious games' learning content needs to invoke motivation at various levels for pupils and teachers.

C) Teacher involvement: A very important aspect of a successful serious game promoting historical engagement for a group of pupils aged 13–14 is to include the teacher. Scholars have argued that teachers are key to the success of serious games for educational purposes [27, 28] as a tool to motivate pupils and promote deep learning. Thus, it is important to provide teachers the necessary gaming knowledge and skills to allow them to integrate game-based learning effectively and efficiently in their classes [27, 28]. If a teacher does not find game-based learning useful, they will not provide it to pupils, as the teacher is the crucial gatekeeper. The teacher also provides important instructions for the game in a pedagogical approach, and they can include game-based learning in their teaching progression as well as the content of the game in specific in-class discussions and learning. An important aspect when designing serious games for improved learning in history is to include teachers at an early stage. A teacher can provide valuable evaluative information, such as insight

regarding the pupils, specific learning outcomes, and content, and they can serve as the pupils' gatekeeper for access to information.

3 Methods

3.1 Participants

The participants in this study were pupils from a Danish elementary school aged 13 or 14. One class functioned as a control group for the evaluation, being provided the history textbook and evaluation criteria instead of playing the game (only reading the analogue textbook). The control group consisted of 11 pupils (six male and five female). The other class (experimental group) also consisted of 11 pupils (four male and seven female). Both classes are from the same school, with the same curriculum, but had each a different history teacher. All participants gave informed consent and were informed that they could withdraw from the study at any time and that their participation would not influence their grade. Additionally, all participants were given anonymized ID numbers, and all data were labeled with these IDs. We applied special considerations when recruiting teenagers in accordance with Danish data law, the international code of conduct, and ethical approval from the elementary school.

3.2 Procedure

An important focus of this study was to create a game that fit the curriculum on the Bombardment of Copenhagen, as this would make the game broadly applicable to history classes in all Danish elementary schools. To ensure the game followed the curriculum, a history teacher was involved early in the process. The teacher ensured that the material presented in the game was useful and in accordance with the curriculum throughout the game development.

The data collection consisted of a questionnaire, a knowledge test, and interviews. The questionnaire was inspired by the user-engagement scale (UES) short form [29] and consisted of eight items on a 5-point Likert scale. The questionnaire covered three themes: attention, perceived usability, and aesthetic appeal. Only the experimental (gaming) group answered the questionnaire, as it targeted elements specific to game engagement. The knowledge test was made in collaboration with the teacher and had six questions. Both groups were provided the same knowledge-test questions immediately after playing the game (experimental group) or reading from the analogue textbook (control group).

Pupils from the experimental group were interviewed about the same themes from the user-engagement questionnaire (attention, perceived usability, and aesthetic appeal) but with the possibility to ask different questions and follow up on the pupils' replies. The interviews, following a semi-structured interview guide [30], took place after the game play in the classroom. Pupils raised their hands if they wanted to answer the questions from the researchers. The teacher was also present, also for the participants of this age group to feel more comfortable. It took between 10 min and 15 min for the pupils to play the game. Only very few pupils needed help to progress in the game. The pupils in the control group were asked to read the chapter in the analogue textbook regarding the

topic (which consisted of six pages), and it took between 15 to 20 min for the pupils to read through.

3.3 Data Analysis

We analyzed the user-engagement questionnaire using cumulative frequency, following a mean and standard deviation for each question. The knowledge tests were also analyzed by cumulative frequency, and we compared the number of correct answers between experimental and control groups. All the interviews were analyzed via traditional coding [31] following four steps: organizing, recognizing, coding, and interpretation. Researchers transcribed the interviews and organized and prepared them for data. The codes in each interview were labelled with five predefined themes, allowing the possibility for additional themes. The data were analyzed via content analysis [31]. The interview data were transcribed and showcased through a content analysis exploring the frequency of positive and negative statements within each theme.

4 Game Design

The game was developed in the Unity Engine version 2021, utilizing asset packs from the Unity Store for the majority of the included 3D models. The game takes place in the city of Copenhagen (Fig. 1), as close to as possible to various elements such as canals, bridges, harbors, buildings, and an important church tower (which functioned as point of aim).
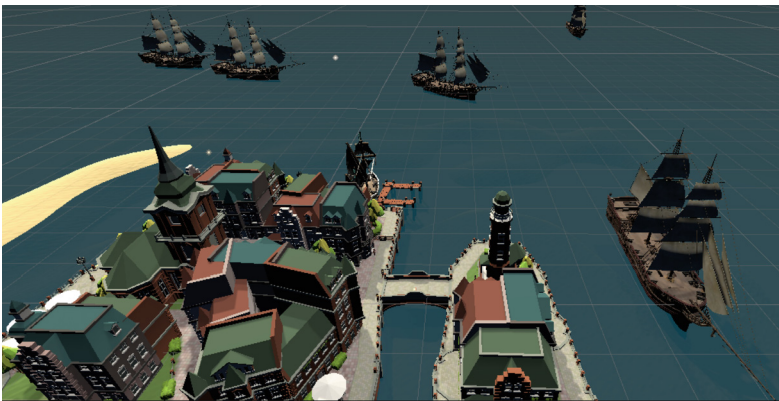
Fig. 1. The game takes place in the city of Copenhagen, with canals, bridges, harbors, buildings, and an important church tower.

The narrative was of high importance, as it needed to correspond with the history of the Bombardment of Copenhagen and with the learning objectives outlined in the curriculum. The players were to follow guidance from the implemented interactable non-player characters (NPCs). The player was able to run/walk around in the city environment, but to progress in the story and get the necessary historical information (through

notes), they needed to follow the NPCs' guidance (Fig. 2). The notes are with the exact same texts pieces as in analogue textbook used by the control group. To get the entire story in the game, the players needed to collect and read four notes. The players were visually provided with feedback on how many notes (out of four) they had collected (Fig. 3). The game narrative goes like this:

1. First, the player is spawned into the world in front of two NPCs, one of whom is interactable (Fig. 2).
2. The first NPC asks the player to pick up a note left on a bridge nearby (Fig. 3). There is included feedback of how many notes the player had collected.
3. After the note is picked up, the NPC gives the player some information about the war, and then tells them to see the guard who is guarding the bridge.
4. By interacting with the guard, the player is provided some information about the war, and the guard tells the player to cross the bridge and enter the first house.
5. After the player enters the first house, another NPC is standing close to the entrance, and that NPC gives the player information regarding the war and tells the player to go to the NPC in the middle of the city.
6. The player then goes to the last NPC and interacts with him. The last NPC provides the remaining information, and the player is free to walk around and explore the city afterwards.


Fig. 2. Interactive NPCs are guiding the players with tasks.

5   Findings

5.1   Knowledge Test

The findings from the knowledge test revealed that the experimental group who played the game answered questions correctly to a much higher degree (Table 1).

The difference in correct answers is particularly clear for Q1, Q5, and Q6; the experimental group had eight, seven, and six more answers correct, respectively, and therefore
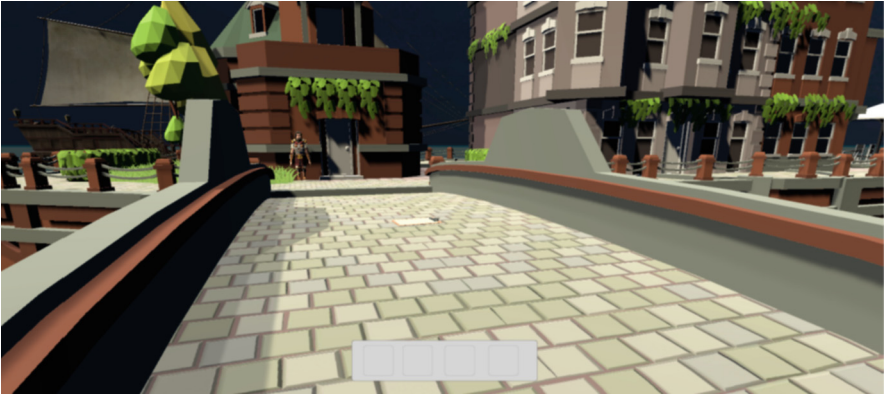
Fig. 3. A left note on the bridge to be found and read.

Table 1. Findings from the knowledge test tied to the curriculum. Exp = experimental (game) group and Con = control (analogue reading) group.

Learning Questions	Group	n	No. Right answers	% right answers	Diff in %
Q1: Which of the European countries had the strongest fleet in 1807?	Exp	11	9	82	73
	Con	11	1	9	
Q2: Why did Crown Prince Frederik withdraw from the Second League of Armed Neutrality?	Exp	10	0	0	−20
	Con	10	2	20	
Q3: How long did it take the British to take over the Danish fleet and sail away with it?	Exp	10	5	50	20
	Con	10	3	30	
Q4: Why did the Russian Tsar feel he had to ally with France?	Exp	10	3	30	0
	Con	10	3	30	
Q5: Why did the Danish state go bankrupt in 1813?	Exp	10	9	90	70
	Con	10	2	20	
Q6: When did Crown Prince Frederik make peace with Great Britain?	Exp	10	6	60	60
	Con	10	0	0	

answered these questions correctly 73%, 70%, and 60% more often than the control group. There was only one question (Q2) for which the control group answered correct to a higher degree than the gaming group. This could indicate that the information for

Q2 was not explained or exposed well enough in the game. The information needed to answer Q2 was in the game given only through a voiceover, whereas the other questions were given as written information in for example a note. To convey information using only audio seems in this context not to be the optimal solution. Q4 had an equal number of correct answers between the groups.

5.2 Gaming Engagement

The findings from the user-engagement questionnaire revealed positive and negative feedback on game engagement (Table 2).

Table 2. Findings from the gaming engagement

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	1	2	3	4	5	n	SD	Mean
1. Focused Attention								
Q1.1: I had a hard time concentrating when playing the game	0	3	5	3	0	11	0,775	3
Q1.2: I understood what the purpose of the game was	0	1	5	4	1	11	0,820	3,45
2. Perceived Usability								
Q2.1: I felt the game was challenging	1	2	6	2	0	11	0,874	2,82
Q2.2: The game was intuitive and it was clear what to do	0	0	4	2	4	10	0,943	4
Q2.3: The narrative was clear	0	2	3	2	3	10	1,174	3,6
3. Aesthetic Appeal								
Q3.1: I felt engrossed in the game	4	4	1	0	1	10	1,247	2
Q3.2: I enjoyed playing the game	1	4	2	2	0	9	1,014	2,56
Q3.3: The visuals provided an enjoyable game experience	0	2	4	3	1	10	0,949	3,3

The highest mean score was in Q2.2 (Mean: 4.00, SD: 0.943), addressing the game's perceived intuitiveness and clarity. Additionally, Q2.3 (Mean: 3.60, SD: 1.174) showed

pupils' positive perceptions of clarity in the game's narrative. The purpose of the game (Q1.2) seemed to be relatively clear (Mean: 3.45, SD: 0.820). However, the findings also revealed potential challenges concerning the pupils being engrossed (Q3.1, Mean: 2.00, SD: 1.247) and enjoying the game (Q3.2, Mean: 2.56, SD: 1.014). These challenges most likely come from balancing between having clear goals (with the intent of always knowing what to do in the game) versus discoverability and difficulty. The game never gets difficult which can create boredom and ruin the player flow.

5.3 Qualitative findings

The qualitative data is derived from the interviews conducted with the pupils (in class) after they had played the game. The themes are founded based on the coded interviews. The feedback, immersion, teaching, and motivation themes revealed mainly positive perceptions of the game (Table 3).

Table 3. Qualitative findings, example of pupils' statements within five themes

Themes	Category	Frequency	Examples
Feedback	Positive	8	"The NPCs in the game were easy to interact with"
	Negative	3	"It was a bit difficult to control the game because the mouse sensitivity was high"
Immersion	Positive	6	"I was very immersed, and it was easy to see the objective of the game"
	Negative	5	"It took a while to figure out what to do in the beginning of the game"
Teaching	Positive	8	"It was more fun than the traditional teaching in history class"
	Negative	3	"The game was overloaded a bit with information so it was hard to remember"
Learning Outcome	Positive	5	"The questions were easy to answer"
	Negative	6	"I missed the traditional way of reading and answering questions"
Motivation	Positive	5	"It was nice that I had to interact with the characters in the game"
	Negative	2	"It would have been nice with a list of tasks to look at when playing"

One of the themes with the highest number of coded positive statements was for the teaching. Several pupils found the game as a more fun way to learn, as seen in the positive teaching example quote: "It was more fun than the traditional teaching in history class." However, this perception seemed to come at a cost, as multiple pupils found the learning outcome from the game to be less effective than their usual learning outcomes from the

traditional format of reading the history book. There are also elements for improvements within the game design, including more emphasis on minimizing cognitive overload ("The game was overloaded with information"), as well as the purpose ("It took a while to figure out") needs to be clearer in the beginning og the game.

6 Discussion and Future Works

Existing literature [32, 33] includes various examples of how to evaluate serious games. However, when performing evaluations in specific contexts with real users—in this case, with pupils aged 13–14 in elementary school—it can be very difficult to conduct a perfect research evaluation. Logistics, time constraints, gatekeepers, legislation, lack of a proper post-test, technical issues, and resources can be barriers to perfect evaluations. Game evaluation with early teens is difficult but should also raise further questions about how we evaluate serious games with children and teenagers. A major limitation for this study is whether the early teens understood the questions asked and could cope cognitively with a 5-point Likert scale. In addition, randomization is often impractical for evaluating serious games in a fieldwork context. It could also be unethical to randomize pupils in the same class, with some playing the game and some not; this setup should also be avoided because of the potential learning effects.

Like this study, there are several other studies comparing digital computer games and analogue text reading within the same learning objectives [20, 34]. However, one should be careful in interpreting findings of the research on pupil's learnings from such comparison. It might be that we in the game design highlighted and emphasized specific elements of the learning objectives. Further, computer games might also interfere with learning if they are not directly related to the story. This study did not take into account individual variation in responses to the computer game. It cold be that not all pupils are uniformly susceptible to the game or the quality of the educational input from the game.

In research, there remains much more attention towards how to evaluate serious game targeting children and adolescent. There are still some important challenges in how to increase the validity and reliability when evaluating serious games when children and adolescents are the users. Participants, including the teachers, should be motivated and want to participate – also in the evaluation part. Further, which method should be used, and how to ask the right type of questions, aligned with the child's capacity for being reflective (or not) in relation to his or her behavior and habits. Future work is needed to generate significant evidence and insights regarding pupils' learning of history via serious gaming. First, a much higher number of participants is needed, and baseline and control groups should be included in the research design. Second, further details on the identification of the participants are needed (e.g., their confidence in serious gaming and game genre preferences, current knowledge in history, motivation, expectations, and technology acceptance). It is important to emphasize that there is no established taxonomy of serious gaming, and serious games are still diverse in their outcomes and certainly understudied to provide knowledge about history. It would also be interesting to create different options in the game design to make the game more personalized with the inclusion of the participants' own knowledge and motivation.

7 Conclusion

In this study, we taught pupils about the Bombardment of Copenhagen in history classes (elementary school) using a serious game approach. The results revealed higher understanding of specific learning objectives in the experimental gaming group compared to the control group, who engaged in analogue textbook reading. The game was developed intuitively and clearly, and the narrative was perceived positively. There is an interesting result from the learning question Q2, which was conveyed only through a voiceover in the game. The result indicated that exclusively using voiceover to convey learning in the game was not optimal. Based on previous research [35, 36], and a more solid theoretical framework, we should have included more emphasis on improved learning questions. This could be with an improved multimedia learning framework, as there is reason to expect that the target group within this study will learn more effectively from combinations of both words, voiceover, a narrative, sound effects.

The interviews supported positive attitudes toward learning through a serious game as an alternative to traditional textbook readings. That serious games can be used as a supplement to traditional textbook readings is already well established in the literature [19, 20]. One of the main takeaways from this study is the importance of a teacher's involvement and collaboration to fulfill specific learning objectives in a curriculum, thereby developing a successful serious game that engages pupils and teachers. These objectives need to be very clear from the beginning during the research design and game design processes. It is vital to know what the game is intended to achieve and, specifically, how it can supplement the analogue text reading.

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