Escape from Trelleborg – Situated Learning through Augmented Reality

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ABSTRACT
In this paper, we describe the design process behind our augmented reality (AR) learning game for the Viking museum at Trelleborg called *Escape from Trelleborg*. We briefly describe the previous academic work in the field of situated learning, which served as the theoretical foundation for our AR learning game. Then we introduce the design process, during which we used a number of participatory design methods in order to explore the potential design space together with the museum employees and a group of students from a local school. Finally, we describe the evaluation of *Escape from Trelleborg*, which helped us demonstrate that the situated approach to the learning experience had managed to enhance the students' knowledge about the Danish Vikings via two identified learning dimensions – the pragmatic learning dimension and the collaborative learning dimension.

Categories and Subject Descriptors
K.8.0. Personal Computing: General

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Situated learning; augmented reality learning games, educational computer games.

1. INTRODUCTION
Researchers have emphasised the pedagogical importance of situated learning, where the student must venture out into a real-world context, like a forest or a museum, in order to learn about the special practices inside that specific community of practice. To accommodate for the situated learning philosophies, the public school system has for instance introduced the student to the classic field trip, during which students are asked to use the abstract knowledge from the classroom out in the real world. However, the classic field trip could often turn into a tedious experience, since the student might find it too difficult to bridge the abstract knowledge from the classroom with some kind of meaningful activity.

In this article, we introduce the reader to our AR learning game called *Escape from Trelleborg*. The game was created to enrich students with a more immersive as well as engaging learning experience about the Danish Vikings. Therefore, *Escape from Trelleborg* should be understood as a digital alternative to the normal field trip, since students are asked to move around within the studied community of practice while solving mini-games, picking up objects and talking to non-playable characters (NPCs) via their mobile phones.

2. BACKGROUND
2.1 Situated Learning
One important source of inspiration for *Escape from Trelleborg* was the situated learning philosophies, which was developed by different researchers, such as Dewey [2], Schön [15], Piaget [13], Vygotsky [17] and Lave and Wenger [10]. The situated learning philosophies revolve around the assumption that the teacher should attempt to substitute the abstract teaching methods inside the classroom with more concrete learning experiences outside in real-world communities of practice. According to Dewey [2], the student should for instance be encouraged to take part in his own education through the hands-on interaction with the curriculum, since this would make it easier for him or her to establish a mental bridge between the abstract facts from the classroom and their real-world application.

2.2 The Digital Field Trip
Schaffer [12] used the concept of epistemic computer games to capture the manner, in which educational games could help students learn about the routines and rules of a specific community of practice. Designers, such as Hansen et al. [6], Klopfer and Squire [9] as well as Liestøl [11], have therefore tried to reinvent the classic field trip by means of epistemic computer games for hand-held mobile devices, where they augmented existing communities of practice with an extra layer of digital content. *Escape from Trelleborg* is a continuation of these efforts to digitize the field trip, as the game likewise attempts to deliver a situated learning experience to students through a mobile device. Our game combines static learning content, such as historical facts, with ludic elements, like mini-games or puzzles, which are bound to a specific location. Previous epistemic games had primarily been using AR technologies to convey static content in a free-roaming manner. For instance, Liestøl [11] designed a number of situated simulations, which allowed students to experience a digitally reconstructed version of different historical

sites. Thanks to the sensors of the mobile phone, the user could manipulate the visual presentation of the digital content in a natural way by moving around in the physical world.

3. ESCAPE FROM TRELLEBORG

Escape from Trelleborg was realised as an app for the *Apple iPhone 4S*. We created *Escape from Trelleborg* for the Trelleborg Viking museum in Slagelse, which had been built around the remains of an old Danish Viking fortress dating from the year 980. Furthermore, the students from the local schools around Slagelse will several times each semester participate in field trips to the Trelleborg Viking museum, where the teacher will present them with a number of simple questions about the Vikings. But since most of the wooden poles from the Viking fortress have rotted away many years ago, the students could often find it difficult to comprehend the everyday lives of the Danish Vikings in a meaningful way just from walking around in the empty rural landscape. For this reason, we decided that the Trelleborg Viking museum would be the perfect community of practice for our augmented reality game, since it would give us the opportunity to position a digitally reconstructed version of the Viking fortress on top of its real-world remains.

Figure 1. The reconstructed Viking fortress.

When the student first downloads *Escape from Trelleborg* onto his or hers mobile phone, he or she will be contacted by an old man, who asks the student to solve a complicated murder mystery that took place at the Trelleborg Viking fortress. In the year 980 two children were murdered in the graveyard outside the Viking fortress, and a young thrall by the name of Ogmund would be sentenced to death for the horrible crime. However, the old man believes that Ogmund was innocent, which is why the student must travel back in time and find the real culprit. The old man will install a special time-manipulation program onto the student's mobile phone, with which he should be able to glance into an alternate historical dimension that depicts the everyday life at the Viking fortress. The student must then use the camera in the mobile phone as a magical window into the alternate historical dimension, which he or she can use to explore the digital reconstruction of the old Viking fortress in real-time by moving around within the physical world.

We also decided to incorporate some ludic elements into *Escape from Trelleborg*, such as puzzles, mini-games as well as non-playable characters, which should help create a more engaging learning experience at the Viking museum. The ludic dimension had been cemented around the classic adventure game formula, where the player must move around within the virtual game world while picking up objects, talking to non-playable characters as well as solving puzzles that could help him or her progress in the story. Therefore, the student will throughout *Escape from Trelleborg* be presented with a number of context-sensitive puzzles and mini-games, which should help him or her understand some of the most central aspects of the everyday life at the Viking fortress in a more situated or grounded manner. For instance, the student must move around within the physical world until he or she manages to locate the murder weapon, after which the student should click on it upon the screen of his or her mobile phone in order to pick it up. The student should then move over to the blacksmith workshop next to the museum, where the forging mini-game is launched on the mobile phone in order to learn more about the murder weapon. In the forging mini-game the student must attempt to press the prompted buttons on the screen at the correct time, which will let him or her forge some weapons for the blacksmith NPC. Not until the student has managed to complete all the mini-games and the environmental puzzles, will he or she be able to solve the murder mystery. A full playthrough video [17] as well as a game trailer [18] is available at YouTube.

4. PARTICIPATORY DESIGN METHODS

During the design process, we entered into a close collaboration with the museum employees and a class of students from a local elementary school. In the design process, we carried out some participatory design workshops together with the domain experts from the museum, where we, among other things, asked them to participate in an inspiration card workshop [5] as well as cultural probe packages [3]. During the inspiration card workshop, the domain experts were instructed to combine two types of cards. One type of card, named the domain cards, contained information about the specific areas of the museum. The other type of cards, named the technology cards, had information about different mobile technologies and game mechanics. The domain experts were asked to generate pairs of the domain and the technology cards in order to generate a number of different design concepts that could help us establish a meaningful connection between the learning content and the gameplay mechanics inside *Escape from Trelleborg*.

Figure 2. Inspiration card workshop

We also presented the domain experts with some cultural probe packages, which allowed us to become more familiar with the everyday activities as well as practices at the Viking museum in Trelleborg. Furthermore, we also presented the domain experts with some picture scenarios [12]. By using these participant design methods, it was possible for us to involve the employees in

the design process and integrate their knowledge into the game. For instance, during the design of the dendrochronology mini-game, where the student has to estimate the building year of Trelleborg, the employees provided us with ideas on how to illustrate the basics of dating pieces of word by using their tree rings.

We also involved some sixth grade students from a local school in Slagelse in the design process, and as part of this involvement we asked them to play a design game [4] named *Hit the Gong!*, which we had designed for the occasion. In *Hit the Gong!* the sixth grade students were divided into two teams, where each team took turns drawing a playing card from a large pile. Each card had their own topic connected to the everyday life of the Danish Vikings. Then both groups separately had to name five different artefacts, sounds or feelings, that they off-hand could associate with the drawn topic. When a team had found five artefacts, sounds or feelings their designated runner then had to run to the middle of the classroom to hit a digital gong yielding a point to the team. After playing *Hit the Gong!* each team were then asked to generate game ideas based on the identified artefacts, sounds or feelings for each topic found in the game. Letting the students play *Hit the Gong!* helped us cement *Escape from Trelleborg* around their existing expectations and conceptions towards the Danish Vikings. Finally, yet importantly, we also carried out two participant observations sessions [1], during which we managed to become more familiar with the different students in the class as well as the pedagogical foundation behind their history classes. Based on the students' input, it was ultimately possible for us to balance the content of *Escape from Trelleborg* according to their existing game-playing skills, schooling and historical knowledge.

5. EVALUATING ESCAPE FROM TRELLEBORG

In order to investigate whether or not *Escape from Trelleborg* had enriched the students with a more elaborate and reflective understanding about the Danish Vikings, we decided to conduct a number of user-testing sessions of the game together with some sixth grade students. Some days prior to the user-testing sessions, we conducted a small workshop together with the students, during which we asked them to create some picture-collages about the Danish Vikings. The workshop helped us determine how much the students already knew about the Danish Vikings before the subsequent user-testing sessions. Next, we divided the students into a number of small groups, who were instructed to play through *Escape from Trelleborg*. The students were asked to verbalise their thoughts on *Escape from Trelleborg* by means of the think-aloud method, and we documented the user-testing sessions with pictures, notes and video recordings. Each user-testing session lasted around 30 – 60 minutes, after which we conducted some semi-structured interviews that helped us evaluate the overall playing experience in collaboration with the students.

In the wake of the user-testing sessions, we asked the students to participate in a second workshop, where they once again should create some picture collages about the Danish Vikings. Therefore, we could begin to examine the differences between the picture-collages from the first workshop and the picture-collages from the second workshop, which helped us determine whether or not *Escape from Trelleborg* had succeeded in enriching the students with a more nuanced understanding about the Danish Vikings at Trelleborg. While interpreting both the students' picture-collages as well as the data from the user-testing sessions, we observed a number of interesting themes or learning dimensions that could begin to indicate some of the educational possibilities behind *Escape from Trelleborg*.

5.1 The Pragmatic Learning Dimension

First and foremost, we discovered that the situated or grounded approach to the learning experience had enriched the students with a more elaborate and reflective understanding about the Danish Vikings. The user-testing sessions of *Escape from Trelleborg* had helped the students bridge the abstract facts from the history lessons with different kinds of pragmatic experiences from the Viking museum. During the first picture-collage workshop the students could experience some difficulties externalising their existing knowledge about the Danish Vikings through the pictures. Even though the students had participated in several field trips to the Trelleborg Viking museum, most of them were nevertheless still unable to remember basic facts about the everyday lives of the Danish Vikings. For instance, a student that had chosen to create a picture-collage about the different weapons from the Viking Age, was only able to remember that the weapons were made of steel as well as that the Vikings used the weapons in the battles against their enemies. In another example, a student explained to us that Harold Bluetooth had built the Viking fortress at Trelleborg back in the year 980. But when we asked the student a number of clarifying questions about his picture-collage, such as why Harald Bluetooth constructed the fortress in the first place as well as how the archaeologists had been able to date the remains of the long-houses, he just shrugged his shoulders and said "I don't know. I just remember that Harold Bluetooth built the fortress in that year […] I have no idea about the other stuff." One could therefore argue that the picture-collages from the first workshop revolved around a somewhat superficial or shallow understanding about the Danish Vikings, since most of the students were unable to reflect upon the memorised facts from the field trips to the Trelleborg Viking museum.

Figure 3. The picture collage workshops.

At the second picture-collage workshop, we discovered that the students found it much easier as well as more entertaining to create the picture-collages the second time around, now that they were able to bridge their pragmatic experiences inside the virtual game world with the abstract facts about the Danish Vikings. During the second workshop some students for instance pointed out that Harold Bluetooth had built more than 30 long-houses around the Viking fortress, since they had been counting all the digitally reconstructed buildings inside the virtual game world. The students also noted that each long-house had been more than 30 meters long, which was why several Viking families often

lived under the same roof. We therefore asked the students to tell us where they had obtained the different facts about the long-houses, to which one boy replied that "[…] we counted the length of one of the long-houses with the phone. I mean, we walked along the house with the phone, and counted our footsteps." Another group of students decided to create a picture-collage about Trelleborg, on which they once again wrote that Harold Bluetooth had constructed the Viking fortress back in the year 980. But the students had also plastered some screenshots of the dendrochronological mini-game onto their picture-collage the second time around, which they used to explain that the archaeologists from the National Museum in Copenhagen had used the dendrochronological research method in order to date the wooden poles from the Viking fortress. The grounded or situated learning theories highlighted the importance of the students' pragmatic experiences outside in the studied communities of practice. And the picture-collages from the user-testing sessions of *Escape from Trelleborg* likewise demonstrated that the students had learned to process the more abstract historical facts about the Danish Vikings through their first-hand experiences inside the virtual game world.

5.2 The Collaborative Learning Dimension

Also, we discovered that location-based augmented reality games for hand-held mobile devices in fact could turn into social playing experiences, since the students spontaneously would begin to collaborate with each other along the way. Khaled et al. [8] had already pointed out that their *StoryTrek* platform could enrich the users with some kind of shared reading experience, where [...] it is possible for readers to jointly experience stories and harness the sharing of one device as an opportunity for discussion and reflection of the stories being experienced [...]". During the user-testing sessions at the Viking museum we also discovered that the physical constraints of the *Apple iPhone 4S*, such as the small screen as well as the awkward placement of the microphone, in fact helped us establish a more social playing experience around *Escape from Trelleborg*. One example of this could be the ship mini-game, where the students needed to navigate a small wooden ship across a creek without hitting any of the obstacles along the way. However, most students would find it difficult both to blow into the microphone of the mobile phone as well as steer the wooden ship past the obstacles on the screen at the same time, which was why they invented different collaborative playing techniques that helped them overcome this challenge. While one student blew into the microphone, the other student from the group would instead attempt to steer the wooden ship with the navigational arrows on the screen while shouting out a number of guiding commands, such as 'stop' 'go right' or 'go left'. Another example that captures the collaborative learning dimension behind *Escape from Trelleborg* could be the sneaking mini-game, during which the students should attempt to sneak past an enemy inside the virtual game world by holding the mobile phone in a perfect 90-degree angle in front of them. Therefore, some students decided to invent another collaborative playing technique for the sneaking mini-game, where one student would walk behind the student that was holding the mobile phone while stabilising his movement with the hands on his hips.

The physical constraints surrounding the *Apple iPhone 4S* had therefore helped us establish a social playing experience that transgressed the normal boundaries of the magic circle, since the students invented collaborative techniques out in the real world that should help them solve the mini-games as well as puzzles inside the virtual game world. The game scholar Huizinga [7] used the concept of the magic circle to encapsulate the manner, in which "[…] play […] proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner.". However, location-based augmented reality games for hand-held mobile devices could often begin to transgress the boundaries between the virtual game world and its surrounding sociocultural environment, since the students are asked to walk around within the studied community of practice while interacting with different artefacts from the real world. Most people think of mobile gaming as an isolating activity, where the physical constraints surrounding the modern generation of smartphones will prevent more than one player from interacting with the small screen at the same time. However, the transgression between the virtual game world and its surrounding sociocultural environment can potentially afford for some highly social playing experiences, which is why the teacher could begin to use *Escape from Trelleborg* in order to teach the students something about different group work practices.

Figure 4. The collaborative learning dimension.

6. CONCLUSION

According to the situated or grounded learning philosophies, the educational content will always be embedded within a particular sociocultural context. Therefore the teacher must attempt to substitute the abstract teaching methods inside the classroom with more concrete experiences outside in the studied communities of practice. For this reason, we decided to create *Escape from Trelleborg* as an example of a pedagogical tool that could help the teachers situate or ground the normal history lessons outside in the real world. Epistemic computer games for hand-held mobile devices have throughout the last decade been trying to digitalise the classic field trip. In a similar manner, *Escape from Trelleborg* allows teachers to augment the existing community of practice at Trelleborg with digital content, such as links, sounds, non-playable characters as well as mini-games. Based on our analysis of the data from the user-testing sessions, we managed to identify two overarching learning dimensions, called the pragmatic learning dimension and the collaborative learning dimension, which we encourage other designers to explore further in relation to their own educational computer games.

Since this study, we have, in collaboration with the teachers at Trelleborg Friskole, begun to develop two additional epistemic computer games based on *Escape from Trelleborg*, which should enrich the students with a more situated or grounded understanding about Christiansborg Palace and Kronborg Castle. Also, the teachers at Trelleborg Friskole have agreed to make the

Escape from Trelleborg a mandatory part of the sixth-grade history classes at the school during the next semester, and this should allow us to study some of the more long-term learning effects behind such a digitisation of the classic field.

So to conclude, we firmly believe that location-based augmented reality games for hand-held mobile devices, such as *Escape from Trelleborg*, could revolutionise the pedagogical practices inside the school system in the future, since the teachers suddenly will be able to situate the students' learning experiences outside in real-world communities of practice. While exploring the physical landscape at the studied community of practice, the student will be asked to complete a number of puzzles or mini-games on his mobile phone that could teach him about the different topics within the curriculum in a more situated as well as grounded manner. Therefore, we encourage other designers to build further upon our pragmatic experiences from the design process behind *Escape from Trelleborg*, so that the schools can begin to understand the unique educational potential behind such a digitalisation of the classic field trip.

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