The role of serious games in communication and education of climate change

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Abstract
Communicating climate change in a manner that spurs engagement and motivates actions among the public is a challenging task, due to its complex nature with many uncertainties. The same problem is evident when communicating climate adaptation where there often are trade-offs made between different needs. Information and communication technology is an area that has been highlighted as a possible form to communicate climate change, especially to youth due to their generally good technological skills. In this study, an application of information and communication technology, a digital serious game, has been studied in the context of communicating and educating about climate adaptation in schools. A total of 96 students and three teachers have been part of the study and the material was analysed using a thematic analysis. The aim of the study was to see how students and teachers reflect on the possibilities and challenges with using games to communicate and educate. In addition, the role of serious gaming in experiential learning was explored, which is a commonly used theory when studying serious games. The results revealed that serious games could play a role in communicating and educating about climate change, where the participants highlighted the game’s focus on local perspectives and solutions. The respondents also found that games could provide a more active learning process allowing the students to make decisions and see the results of their choices, an approach that could open up for discussion and reflection, which are important aspects found in the theory of experiential learning.

Keywords: Climate adaptation, Communication, Experiential learning, Education for Sustainable development, Game-based learning.

List of abbreviations

ICT – Information and Communication Technologies
ESD – Education for Sustainable Development

List of appendices

Appendix 1: Survey to students
Appendix 2: Interview guide
Appendix 3: Explanation of symbols in quotes

1. Introduction
Climate change is posing great challenges for today’s society in particular related to the impact of extreme weather events. The severity of climate change is not known, and it is hard to prioritise between different needs in a society with a growing competition for space. The question is how to choose between these needs and create a society that can cope with the changing climate? Most actions have been targeted at reducing climate change through mitigative actions which are actions aiming at lessening the human impact on the environment. However, the recognition that some changes cannot be halted has led to an uptake of adaptive measures in policies. Measures that aim at adapting to climate change, including actions that protect from extreme weather events caused by climate change. Even if decisions concerning climate adaptation are mostly taken on a local scale the competition
between different needs makes it hard to prioritise. In urban planning there are therefore trade-offs between needs which could be hard to make for people within the field and to understand for the public (Juhola et al. 2013).

It has been frequently discussed in climate communication literature that information given to the public concerning climate change often is hard to grasp. This is a problem due to the importance given to the public when it comes to both their lifestyle choices and their influence on politics (Ballantyne, Wibeck and Neset 2016). Especially youth are highlighted as an important group to reach out to since they have the potential to change their behaviour already at a young age (Ouariachi, Olvera-Lobo and Gutiérrez-Pérez 2017). Moser and Dilling (2004) identifies several reasons for the problem which all concerns the complexity and uncertainty of climate change, since it is hard to understand who will be affected and when. The earlier forms of climate change communication have compared climate change to war and terror. Even if this comparison provides the understanding of climate change as a pressing and urgent issue studies show that it could lead to a sense of that it is already too late to act (Wibeck, Neset and Linnér 2013; Moser and Dilling 2004). Research has shown that in order to spur engagement it is important to focus on local perspectives and concrete actions that focuses more on a personal level which could be easier to relate to (Ballantyne, Wibeck and Neset 2016; Wibeck 2014b; Moser 2010).

Studies show that other forms of communication of climate change to the public can have an important influence on both adaptation and mitigation actions. It is therefore important to further research the area of climate communication and find new and innovative ways of communicating climate change. One such area is information and communication technologies (ICT), which are techniques that visualise climate change through for example movies or games (Ballantyne, Wibeck and Neset 2016; Ouariachi, Olvera-Lobo and Gutiérrez-Pérez 2017; Wibeck, Neset and Linnér 2013). A form where the causes and effects of climate change can be shown visually to the public. ICT is also an area with increasing possibilities due to technological development (Ballantyne, Wibeck and Neset 2016).

ICT could be of particular interest when communicating climate change towards youth, since young people today often are referred to as the interactive generation. One highlighted area within ICT are serious games that could be a possible communication tool used for instance in the school environment. Through the game the player can experience the causes and effects of climate change and learn about solutions. Earlier studies on the subject have evaluated the functionality of selected games but there is a gap when it comes to how the games actually are perceived by the players, concerning for instance the messages communicated in the game (Ouariachi, Olvera-Lobo and Gutiérrez-Pérez 2017; Kapralos et al. 2011).

1.1. Aim and research questions

The aim of this study is to gain insight into high-school students’ and teachers’ perception of the role of serious gaming in communication and education. In this study the case of The Climate Adaptation Game is used to explore this aim. This study is based on surveys with students and interviews with teachers. The research questions of this study are:

- How do students and teachers reflect on the possibilities and challenges of serious gaming as a learning and communication tool?
- What role could serious gaming play in experiential learning?
2. Background

2.1. Climate adaptation

Climate adaptation has historically received less attention than mitigative actions. However, due to the slow progress in the implementation of mitigation actions, climate adaptation is beginning to receive more attention (Palutikof et al. 2013; Juhola et al. 2013). There is also a wide recognition that a dangerous level of climate change will be reached if the threshold of 2 degrees warming is passed (Palutikof et al. 2013). It is however, hard to see that this line will not be crossed since it would require immediate and strong actions. Therefore, we need to prepare for scenarios beyond the 2-degree level and adapt to the climate changes that we failed to prevent. Yet, it is hard to determine what this level actually is due to uncertainties when it comes to countries emission reductions, which also makes it hard to know what level of adaptation that is needed (Palutikof et al. 2013).

Urban areas are central in this debate, both since they have high emissions but also since they are extra vulnerable to extreme weather events, such as heat islands, air pollution and floods. This has several reasons such as rapid urbanisation and dense population and infrastructure with the overarching problem of cities being greatly altered places (Doherty, Klima and Hellmann 2016; Mehrotra et al. 2013; Lee and Hughes 2017; Juhola et al. 2013). Another issue is that many urban areas have a lacking adaptive capacity, which is the capability to adapt to climate change effects. The lacking capacity is connected to the fact that climate change will create new risks but also amplify already existing ones. An example of a risk is that many cities are coastal which will cause increased problems with flooding and water management in the future. Additional problems are social such as how to protect elderly people when the city is hit by a heat wave. It is however possible to adapt to these changes through for instance improved infrastructure, increased amount of green spaces and/or increased flood protection (Lee and Hughes 2017).

Many cities have started to develop plans on how to manage climate risks, work that has shown to be problematic (Mehrotra et al. 2013). One of the identified barriers in this work is that the communication of government decisions often is hard to understand for the public, both concerning needed actions and trade-offs between actors’ interests (Doherty, Klima and Hellmann 2016). Therefore, work is needed to raise awareness and build adaptive capacity in urban areas (Mehrotra et al. 2013; Lee and Hughes 2017). One such approach is to talk in terms of how the local community will be affected, since a localised perspective has shown to be more engaging and easier to relate to for the public than a global (Doherty, Klima and Hellmann 2016; Lee and Hughes 2017).

2.2. Climate communication

Climate change is posing great challenges and requirements of emission reductions and without strong actions and engagement the world as we know it will change. This dilemma has opened up for large communication campaigns towards the public. Campaigns handling how to act as well as the causes behind the changes that we see (Wibeck 2014a). To communicate climate change has however shown to be complicated due to the uncertainties surrounding the issue, where it is hard to say how and when the impacts will be felt (Waschka and Torok 2013; Wibeck 2014b; Moser and Dilling 2004; Ballantyne 2016). It has been shown that this has led to that many in the public see climate change as an equivocal issue.
with many different actors and sides in the debate, which makes it hard for the public to understand climate change due to conflicting information (Wibeck 2014b).

Media is crucial in the communication of science to the public and has shown to shape their understanding. Media, such as television, newspapers, movies and internet, has shown to have a direct effect on understanding and perception (Wibeck 2014a). Studies show that the public is aware of climate change and see it as a grave issue, yet that they see it as a problem distant from them. This could lead to that they see it as less important than other problems with more direct effects on their personal life. In addition, some regard it as a lost cause and feel that it is already too late to act (Wibeck 2014b; Wibeck 2014a; Nicholson-Cole 2005; Moser 2010; Ballantyne 2016). In a study by Wibeck (2014b) a possible cause for this perception is the images of melting ice-caps and polar bears that are frequent in media, showing catastrophic yet distant consequences of climate change. Moser (2010) agrees to this picture stating that it is hard to relate to impacts that are mostly felt in sparsely populated areas such as the Arctic.

In general, it has been shown that the public is aware of the problems but that there exists a gap between knowing and doing called the attitude-behaviour gap. The gap means that even if the public is aware of the problems they are not acting upon it (Wibeck 2014a). It has been shown that the given information needs to be focused on what they as individuals could do to make a difference, providing solutions that the public could engage in and make a difference (Wibeck 2014a; Moser 2010). Waschka and Torok (2013) highlights that the information needs to be directed towards the targeted group so that the information catches their interest and makes them willing to act. Here Wibeck (2014a) and Moser (2010) identified more localised perspectives as a possible solution combined with concrete actions, where the information instead focuses on solutions to the problems.

To visually show the impacts on a local level could be a way to engage the public to take actions. It could also help them in their sensemaking of climate change effects on a more personal level (Nicholson-Cole 2005). One possible area that is highlighted in research is information and communication technology (ICT), where climate change is communicated through, for example, images (Wibeck 2014a; Moser 2010). ICT is an interesting field when it comes to communicating climate change in innovative ways. ICT tries to follow the increasing trend of technology use especially among the youngest in our population. It is believed that since they use technology from such a young age they will also be more susceptible to information given to them through this type of media (Ballantyne, Wibeck and Neset 2016; Ouariachi, Olvera-Lobo and Gutiérrez-Pérez 2017).

Research within this field is increasing, seeing the potential of using ICT to communicate and educate climate change (Ballantyne, Wibeck and Neset 2016). To use visualisation to communicate has received growing attention and it has been used for instance in landscape planning and in environmental decision-making (Nicholson-Cole 2005). One such format is to use games and there is a growing interest in using games to simulate climate change and educate about solutions (Ouariachi, Olvera-Lobo and Gutiérrez-Pérez 2017).

2.3. Serious gaming

Game-based learning refers to the use of games in learning environments to enhance understanding through problem solving (Qian and Clark 2016). Youth today generally have a lot of experience of games and computers, therefore this generation is believed to be highly susceptible to computer-based learning (Girard, Ecalle, and Magnant 2012; de Freitas and
According to Noemi and Máximo (2014) serious games are effective tools to use when teaching or training students in different areas. Serious games could for instance be designed to help building team-work and show the importance of collaboration (Dieleman and Huisingh 2006).

Serious games refer to games that are used for training, education and advertising amongst other uses (Kapralos et al. 2011). Serious games aim to be motivating and communicate simulated situations in an educative manner, by supplying an exploration of issues in an environment that allows the students to learn risk-free. The introduction of these amusing ways to learn has led to the concept of “edutainment”, meaning that if the learners have fun whilst learning the interest in the studied subject will increase (Noemi and Máximo 2014). In a game there are certain rules and conditions where one often can take on different roles and get an understanding of why different actors act as they do. In games the players can learn by doing and failing without negative consequences, learning what they should and should not do. This allows them to experiment with different actions and choices seeing the results in the simulated world (Dieleman and Huisingh 2006).

Serious games can visualise scenarios which are not always possible to show the learners in real life. It could be places or scenarios that are not accessible like disaster sites or the ocean floor (Girard, Ecalle, and Magnant 2012; Katsaliaki and Mustafee 2015). A game is often built as a narrative where the learner is exploring different aspects of a subject. It could be a way to teach decision making and negotiation skills while at the same time being entertaining. Several studies show that games have the ability to communicate and teach the players about different issues. Games are therefore suitable for a wide audience ranging from students to professionals (Katsaliaki and Mustafee 2015; Hamari et al. 2016).

Earlier studies have shown that games have positive effects on learning and motivation among students and a well-designed game could give students the possibility to develop their creativity, teamwork skills and their ability to solve problems (Qian and Clark 2016). Currently it is however hard to assess whether games are more effective than traditional learning and there is a need for more comparative studies on the subject. Yet, what one can see is that there is great potential in serious games due to their shown effect on student’s motivation and engagement in their learning. It could therefore, have advantages for students with learning difficulties where traditional learning methods do not work (Girard, Ecalle, and Magnant 2012; Guillén-Nieto and Aleson-Carbonell 2012).

Serious games exist in a vast diversity of areas and forms and several have been developed within the area of climate change and sustainable development (Reckien and Eisenhack 2013; Katsaliaki and Mustafee 2015). The first games on climate change were developed about 30 years ago. These were mostly in the form of board games, but recently also computer games have been developed (Ouariachi, Olvera-Lobo and Gutiérrez-Pérez 2017). Games focusing on climate change often aim at three things: educating about climate change, raising awareness of the challenges and finding solutions to the problems (Reckien and Eisenhack 2013). Dieleman and Huisingh (2006) also highlight that using games to teach sustainability could be an advantage just because they are fun and entertaining, since environmental issues often are seen in negative perspectives and to communicate them through a game could therefore provide positivism to a serious issue.
3. Theory

In this study an analytical framework adapted from Wibeck, Neset and Linnér (2013) is used to analyse the material. This analytical framework was chosen since it is based on climate change communication literature and focuses on the assessment of visualisation tools. Therefore, the framework suits this study’s focus on communication and learning connected to serious gaming. In addition, the experiential learning theory is used to explore the learning potential of the Climate Adaptation Game by looking at the four phases in the theory and how these relates to the responses from students and teachers.

3.1. Analytical framework

The analytical framework draws on the concept proposed in Wibeck, Neset and Linnér (2013), which is based on climate change communication literature. This framework was designed with the purpose of analysing visualisation tools. The framework looks at the elements: content, form, context and relevance of the tool, which in this study were used as a way to assess the teachers and students’ perception of the Climate Adaptation Game. This to identify the possibilities and challenges that they see exist with using serious games in education and communication. The analytical framework was chosen after the material collection and the responses were categorised into the elements. Below the whole analytical framework as it has been used in this study is presented in Table 1 which is adapted from Wibeck, Neset and Linnér (2013).

Table 1: the analytical framework adapted from Wibeck, Neset and Linner (2013)

<table>
<thead>
<tr>
<th>Element</th>
<th>Description of aspects relevant to serious games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>- Storyline and narrative</td>
</tr>
<tr>
<td></td>
<td>- Data and scenarios in the game</td>
</tr>
<tr>
<td>Form</td>
<td>- The form and design of the game</td>
</tr>
<tr>
<td></td>
<td>- The form of the gaming session</td>
</tr>
<tr>
<td>Context</td>
<td>- Knowledge level</td>
</tr>
<tr>
<td></td>
<td>- Match between content and framing and the</td>
</tr>
<tr>
<td></td>
<td>targeted groups knowledge level</td>
</tr>
<tr>
<td></td>
<td>- The games connection to curriculum</td>
</tr>
<tr>
<td></td>
<td>- The games usability in education</td>
</tr>
<tr>
<td>Relevance</td>
<td>- The games relevance for education and</td>
</tr>
<tr>
<td></td>
<td>communication</td>
</tr>
<tr>
<td></td>
<td>- Reflections on if and how they have learned</td>
</tr>
<tr>
<td></td>
<td>something from the game</td>
</tr>
</tbody>
</table>

The analytical framework has been adapted from Wibeck, Neset and Linnér (2013) towards serious games and the parts relevant for this form are further explained in the following section. The first element focuses on the content of the game, what is the focus of the game and how is the content understood by the target group. This has to do with the storytelling were also the timescale and data selection are of importance. The next element called form is
connected to the game and its design. It could be for instance the tasks given in the game, but also interaction and access to the game. Here also the gaming session is assessed by looking at for instance the role play. The context element focuses on the target group and how the game meets their knowledge level, but also their interest and values. These issues are important for the understanding and reception of the game. This element also connects to how the game works with the school curriculum and the context that it is supposed to be used in. The last element, relevance, is connected to the usability of the game. In this case, it concerns both climate change communication and education and how the targeted group reflects on possibilities and barriers with using the game. It also lifts if they reflect on if and how they have learned something from the game.

3.2. Experiential learning

The theory of experiential learning is frequently applied in relation to serious games and their design (Kiili 2005). The main elements of the theory are experience and reflective observation in learning (Kiili 2005). One of the models within this theory was developed by David Kolb in the 1980’s (Kiili 2005; Kolb 2015). Kolb (2015) describes that the experiential learning model focuses on learning as a continuous process meaning that theories are not fixed and could be transformed by experience. Experience could therefore affect previous knowledge and change it. Learning could therefore be seen as a form of re-learning where the students’ knowledge is transformed by experience (Kolb and Kolb 2005). Experience by the learner is seen as the cornerstone for learning since the learner gains a personal meaning of the subject studied, creating a ground for discussion and knowledge sharing since it is easier to communicate our own experiences to each other rather than theories (Kolb 2015).

In Kolb’s learning theory experience is transformed into either abstract or concrete knowledge, and there are two ways of transforming experience: active experimentation or reflective observation. The foundation in the model is experiencing something new. The new experience is followed by data collection and observation about the experience which is called reflective observation. It could be for instance reflections on successes and failures. In the next step the learner creates theories and hypotheses from the experience which is called the stage of abstract conceptualization. The last phase is active experimentation where the learner tries their theories in new settings (Kiili 2005; Kolb 2015). The learning cycle is ideally all four modes in the cycle where the learner first experiences then reflects, thinks and lastly acts (Kolb and Kolb 2005). The four phases of the experiential learning cycle as described by Kolb (2015) are presented below.

- Concrete experiences: be able to experience new things without having a bias.
- Reflective observation: be able to reflect on experiences from different perspectives.
- Abstract conceptualization: be able to build theories from experiences.
- Active experimentation: be able to make decisions from experiences.

The ideal is that the learner touches all four modes in the cycle but in general learners often prefer one of the four modes. Several different learning styles have been identified from the learning model depending on the learners’ preferences. The preference can for instance be affected by life experience, where the learner makes a choice between being concrete or abstract and active or reflective in their learning. Depending on the combination of the four modes the learner will have different preferred ways to learn for instance perhaps a student learns more through fieldwork whilst another learns better from lectures (Kolb and Kolb 2005).
3.2.1. Serious games and experiential learning

According to Kapralos et al. (2011) serious games differ from the traditional teacher-centred learning form since they place learners in the driving position of their own learning. Games allow the students to interact with the virtual world and learn through that experience. The students face problems in the game and get the opportunity to explore and practically try out different options, which provides the ground for experiential learning. With the right design, the game could be a way to achieve a more active learning process (Kapralos et al. 2011).

Dieleman and Huisingh (2006) state that games could be an important piece in all four phases of experiential learning, depending on the type of game. Games makes it possible for a student to gain experience, try out theories, see the results of choices and reflect upon the results. Therefore, addressing all four phases from experiencing, reflecting, thinking and acting. This might lead to revision of their previous theories and knowledge, making it possible for them to make other decisions in the future. It is a process of learning by doing but also learning by trial and error. To combine the game with role-plays has shown to have even better results since they have different roles and need to negotiate and compromise to gain results and make decisions (Dieleman and Huisingh 2006).

Debriefing is another important aspect when it comes to using serious gaming in education, where debriefing means that the players are allowed to reflect on what they have experienced in the game. Debriefing is seen as an essential part of the learning process, allowing for reflections on decisions and happenings in the game (Dieleman and Huisingh 2006; Koivisto et al. 2017; Petranek 2000). Petranek (2000) also highlights the importance of written debriefing since it allows the players to individually and with more time reflect on their own learning experience. Games could according to Koivisto et al. (2017) be seen as providers of virtual experience and also giving the possibility to reflect on our choices. Therefore, reflection and feedback are of outmost importance for the learning process (Koivisto et al. 2017). The players need help to reflect on their experience in the game and how this could be used in reality to learn, which connects to experiential learning and the phase of reflective observation (Dieleman and Huisingh 2006).

Serious gaming is becoming increasingly popular in education but there are important aspects to keep in mind when using them. The game needs to be connected to the school curriculum and the material in the course and it needs to be reality-anchored and user-friendly. The instructions towards both students and teachers need to be clear otherwise it is unlikely that the game will be used in education (Kapralos et al. 2011). Kiili (2005) also highlights that it is important that the game has an appropriate knowledge level that matches the targeted group. The knowledge level should ideally also be raised when the player gets further into the game. Here also the narrative and the storyline are important where the game needs to catch the interest of the players and engage the players in the subject dealt with in the game (Kiili 2005).

4. Material and method

In this study a combination of surveys and interviews were used to answer the study objective. The study was conducted as follows: Gaming sessions were performed with high-school students where a moderator steered the game whilst the students had to discuss and negotiate to come to a decision. The students were placed in groups that had different
stakeholder roles in the city. The roles are shortly presented in section 4.4. After the sessions the students filled in a survey about the game. Interviews with the teachers were conducted afterwards to get their view of games as a learning and communication tool.

4.1. Pilot study

Several gaming sessions with different user groups were held during the development of the game. A pilot study was also conducted with one high-school class where surveys were developed and handed out to the students. Assessment of the game and revisions were made to the surveys and the game after the pilot. This material has however only been regarded as a pilot and is not a part of this study’s analysis or result.

4.2. Material

A total of 4 gaming sessions were conducted with high-school students. A total of 96 student surveys were collected and interviews were held with 2 teachers and 1 teacher candidate. The participating students were chosen since their teachers had showed interest in testing the game with their classes. The classes were thus not chosen due to any specific characterises such as field of study.

4.3. The Climate Adaptation Game

The Swedish National Knowledge Centre for Climate Change Adaptation at SMHI has together with Linköping University developed a climate adaptation game. The game was developed for high-school students and practitioners that work on municipal level with climate adaptation. In the game the player takes on the role of a city planner and moves around in a city environment receiving different missions concerning climate adaptation. The game handles the challenges that might arise in an urban setting due to climate change. The players encounter different dilemmas when it comes to the choices that needs to be made to adapt a city in the face of climate change. It could be choices between more housing or securing the water supply from climate events. So, the player needs to make decisions between developing or adapting their city. The game then moves forward in time and shows the effects of the players decisions. The players will receive points for their choices, both in the form of coins and on the Sustainable development goals, this will be further explained later in the section. Figure 1 below show two images from the game.

![Figure 1: Two views of the game](image-url)
The game can be categorised as a serious game since it has been developed with a learning purpose, where the learning objective is to educate about the effects of climate change and show possible climate adaptation measures. The game also aims to show the trade-off between adapting and developing a city. Here economic decision making plays a vital role since not all needs can be met due to limited resources. The game aims to provide the players with an understanding of why these trade-offs are made and the difficulty in making political decisions, addressing the knowledge gap described by Juhola et al. (2013) concerning why trade-offs are needed and made in city planning. The players are allowed to test different possible solutions and also negotiate with different actors in a virtual city. In serious gaming literature such as Dieleman and Huisingh (2006), Katsaliaki and Mustafee (2015) and Hamari et al. (2016) these are aspects that are brought up as important. These studies for instance highlight that games can provide training in negotiation, which has been incorporated in the Climate Adaptation Game through the role-plays. The game also connects to school curriculum which is further explained in section 4.3.1. below.

The players are given six different missions in the city:

1. New residential area (1A) Densify the city (1B) Forest area
2. Climate adapt existing buildings
3. Secure the hospital
4. Climate adapt agriculture
5. New industrial area
6. Save the drinking water

At the start the player needs to explore the fictitious city and find all missions in the city. This since the player will receive a visit-bonus at each new site. In the first period the player is given mission 1-3 then after the first timestep 4-6 are also given. At the site the players are given options A-C or A-B depending on the mission. A is the cheapest with few adaptive measures and C is the most expensive, yet with more adaptive measures and B is a middle option. The player could also choose to do nothing. Now the players must prioritise and choose the actions perceived as most beneficial. The players need to take an economic, social and ecological perspective when making decisions at each mission, meaning that some aspects must be prioritized above others.

The game start at present time, then it moves to 2047 and ends in 2077. This makes it possible for the players to see what their choices results in when it comes to savings, costs, Sustainable Development Goals (SDGs) and human lives saved. Five SDGs are incorporated in the game SGD goal number (3) Good health and well-being, number (6) Clean water and sanitation, number (7) Affordable and clean energy, number (11) Sustainable cities and communities and number (15) Life on land. The players are given points for their choices, either positive or negative depending on their choices. These points will affect how much money they have in each timestep. The effects of their choices are shown after each timestep. During a timestep extreme weather events strike at random and the city could experience heat waves, cloudbursts and droughts, either a small or large event. The events extent and place are shown on a map over the city after each time step. The game ends in 2077 with a summary of all the choices and their effects on human lives, the economy and SDGs.
4.3.1. Curricular connection to the Climate Adaptation Game

In Swedish schools’ sustainable development is a part of the curriculum, stating that schools need to provide their students with an understanding of the links between the social, economic and ecological pillars of sustainable development (Sandahl 2013). The area is called Education for Sustainable Development (ESD) which is recognised by the following criterions as described by Sandahl (2013):

- Be integrated in all subjects
- Be interdisciplinary
- Have a local and global perspective
- Use a variety of pedagogical methods
- Engage the students to develop a critical thinking
- Be based on the values of democracy
- Start in an early stage of school life

ESD aims at making students think about the choices they make in their everyday life and the effect those choices have now and in the future, providing them with the tools needed to make decisions about complex issues. This through not always the traditional ways of learning but through learning that provides the pillar stones for a life-long learning about sustainability. The aim being that they can contribute to sustainable development and create future societies that are sustainable economically, socially and ecologically (Tang 2017). One way of addressing these questions is through climate adaptation, which can be used as a way to open up questions about future societies and how we can create those societies (SMHI n.d.).

4.4. Gaming sessions

In this section the gaming sessions are described and also approximate time for the different steps in the gaming session. The groups of students varied in size from 20-30 students. Each gaming session was conducted in the same manner and took almost 3 hours to conduct. Each gaming session started with a short 10 minutes introduction to climate change, what climate adaptation is and why it is needed and then also an introduction of the Climate Adaptation Game. The students were divided into one of seven roles:

- Big city traders – Represent the traders in the city. Want economic growth yet still regards climate change as a pressing issue.
- Farmers Association Agri – Represent the farmers in the city. Regard climate change as a pressing issue but sees weather variations as the most important due to the effect it has on agriculture.
- The Union of Tenants – Represent the tenants in the city. Regards climate change as an important issue but their main priority is affordable housing.
- Property owners’ association – Represent the property owners in the city. They as owners takes climate change seriously but primarily focuses on their property.
- Pensioners’ organisation – Represents the pensioners in the city and focuses on that their members will have secure declining years.
- Big city nature conservation group – Represents the nature organisations members. They take climate change issues most seriously together with biodiversity.
• The citizen organisation: Do not touch my lifestyle – Represents ordinary people in the city. They are not so sure about the climate change threat but acknowledge that the city has problems with withstanding extreme weather events.

A moderator steered the game and the students were given the tasks in time period 1. They were then allowed to discuss within their assigned group and come to a decision for 10 minutes. This was followed by a negotiation part where the groups negotiated with each other, also 10 minutes. After this the moderator held a vote and the option receiving most votes was chosen (5 minutes). Then it was time for a timestep 30 years into the future. The students were then presented with the events that had occurred during this time. The moderator walked them through the city and showed the effects (all three steps around 10 minutes). The same steps were taken as in time period 1 for the remaining tasks. The last timestep was followed by a summary and reflection where the students could ask questions for about 20-30 minutes. Some time was also devoted for a break and for answering the survey.

4.5. Survey to students

There are several important aspects that need to be considered when using surveys. The questions should be precise with a language that fits the targeted group. There should be a red thread through the survey and the questions may not be leading. Since the survey was handed out after the gaming session there was a possibility for the respondents to ask questions about the content of the survey. It is however, important not to steer the respondents towards any answer (Jakobsson and Westergren 2005; Berntson et al. 2016). The questions were also based on a screening of previous studies within the area which used surveys as evaluation method such as Guillén-Nieto and Aleson-Carbonell (2012) and Carreira et al. (2017), making it to some extent possible to compare with other studies within the area (Dahmström 2011).

A survey was developed and handed out to the students after each gaming session, the students were informed about the aim of the study and were asked if they wanted to participate beforehand. The surveys aimed at providing the students opinion regarding the Climate Adaptation Game and serious gaming (Ejlertsson 2005). The survey had both closed- and open-ended questions to allow for more depth in the answers and to gain a general image of their ideas (Dahmström 2011). This also allows the respondents to describe in their own words their impressions of the game and the session. This approach often generates more information which is in line with the study aim (Jakobsson and Westergren 2005; Berntson et al. 2016). The survey focuses on assessing the game and then on serious gaming and learning. The closed-ended answers range from a full agreement to a full disagreement according to a so-called Likert-scale (Ejlertsson 2005). There are no neutral answers since the students are believed to have opinions on the matter since they just played the game handled in the survey. No personal information was collected in the survey since it was found not to fill any purpose for the study results. The surveys were in Swedish therefore all the quotes have been freely translated into English in the results section. An English version of the survey can be found in Appendix 1.

4.5.1. Coding process and analysis

The response alternatives were coded from 1–4, 1 being a full agreement and 4 being a full disagreement (Dahmström 2011). The quantitative responses in the surveys were analysed using SPSS to develop graphs over the students’ responses which are displayed in the results.
The qualitative answers were coded and analysed using a thematic analysis as described in section 4.7.

4.6. Interviews

Interviews aim at collecting people’s ideas and opinions on different matters, bringing into the discussion the respondents own experiences of the studied topic. In an interview situation it is also possible to probe questions to gain a more detailed response or clarify an answer from the respondent. When performing an interview, the interviewer has a very important role for the validity and reliability of the study. It is important that the interviewer does not reveal their opinion of the posed questions. This could affect the results, since it could make the respondent agree with the interviewer’s opinions, which would give a skewed result. The same applies for leading questions, which also could create unreliable results. Those kinds of questions should therefore be avoided. These problems are called the interviewer effect (Dahmström 2011).

In this study, semi-structured interviews were used which build upon a specific set of questions which have been determined beforehand. This to make sure that certain questions important to the study are brought up in the discussion. However, supplementary questions were also used in order to clarify given answers (Dalen 2015). Semi-structured interviews were held with two teachers and one teacher candidate who had played the game with their students. Therefore, the choice of respondents was a choice-based-on-criteria, as the teachers chosen for the interviews had already shown interest in the study area and participation in the study (Dalen 2015).

Each interview was conducted as follows: the session was held by one interviewer who were following an interview guide. The interviews were audio recorded, and notes were made at each session. The recordings were then transcribed, without repetitions, humming’s etcetera. This since the aim is to understand the perceptions of serious games, so a very detailed transcription was not found to be necessary for the research aim (Dahmström 2011). All interviews were performed in Swedish therefore the quotes presented in the results have been freely translated into English. An English version of the interview guide can be found in Appendix 2.

4.7. Thematic analysis

The transcriptions and the surveys were analysed using thematic analysis, which is used to find and analyse patterns in material. It is a suitable method when the aim is to find common threads in the material. The method also provides a detailed picture of attitudes towards a subject. A theme is described as something that catches important aspects that can be related to the research questions (Vaismoradi, Turunen and Bondas 2013). A thematization of the material also enables the identification of the areas given most weight by the respondents. Which is of importance since it gives insight into general ideas. Areas that are not brought up as often could however also be important since it could be critical voices towards the studied phenomena (Dalen 2015).

The transcript and the answers to the surveys were read through several times, then themes were searched for with the theoretical framework in mind, i.e. the elements’ content, form, context and relevance. Each sub-theme was given a description in the developed thematic map (Ryan and Bernard 2003). A thematic map is a presentation and description of all the
themes found in the analysis. This includes a description of when it is used, when it should not be used and an example quote. The thematic map was developed in order to gain transparency and reliability in the analysis and enable reviews of themes during the process (Vaismorad, Turunen and Bondas 2013).

When using a thematic analysis, the first thing to remember is that there are not a defined number of themes. Themes are interpretations and there are many ways to look at a material. To enhance the trustworthiness of the study, choices and valuations should be clear and visible (Ryan and Bernard 2003). Since it is not always possible or fruitful to crosscheck thematicizations it is important to have transparency in the study, meaning that it should be possible to gain insight into how the analysis was performed. Therefore, a thematic map was created to provide insights into the analysis (Vaismorad, Turunen and Bondas 2013).

4.8. Delimitations

In this study, material was collected from four different gaming sessions which has resulted in a broad material. In the analysis this material is however handled as one since it provides the possibility to find the common threads in the students’ and teachers’ reflections. A choice was also made not to handle the student groups as four individual, this since the aim is to gain a general perception, not to find patterns and disparities between different student groups. It is recognized that both these choices could result in loss of patterns within and between the individual groups of material. The reason behind these choices lies in the intention to study the possibilities and challenges that exist according to both students and teachers.

In this study, themes were identified using a thematic analysis, here a delimitation has been done presenting only the themes that answer the purpose of this study. Meaning that some themes has been excluded from the analysis due to irrelevance to the study aim. It is also recognized that the size of the material only can provide a first insight into the perception of the game. Therefore, further assessments would be required to be able to draw certain conclusions. Additional material in the form of notes and recordings from the gaming sessions were also collected. This material has however, not been used in this study due to the focus on understanding the perception of the role serious games could play in education and communication. This additional material rather focuses on the evaluation of the Climate Adaptation Game which was out of the scope of this study’s aim. The material has therefore not been analysed in this study.

4.9. Ethical concerns

When studying people's ideas and opinions it is important to follow clear ethical guidelines. In general, it is important that the members do not feel compelled to answer questions, to prevent them from going home with a feeling of having said too much or answered incorrectly (Wibeck 2010). To keep an ethically correct study the following steps were taken as described by Wibeck (2010), Bryman (2002) and Dalen (2015):

- Each participant was given information beforehand about the subject of the session.
- All information about the participants was handled confidentially.
- Participants were given the possibility to withdraw from the study at any time.
- The teachers and students gave written consent to the recordings.
An ethical aspect in this study is that the targeted group of students are minors. However, since the students are between 15 and 18 years old they can on their own decide if they want to participate in the study or not. In this case permission from their parents is therefore not required. This is according to Swedish law concerning ethical considerations in research (SFS 2003:460). Therefore, consent forms and information letters were given to the students. They were also given the same information orally in the beginning of the gaming session. They were also given information about the surveys orally. The students were asked to sign a consent form where they allowed recordings and usage of these within the project group. They were also informed about the possibility to withdraw from the study at any time. Also, the interviewed teachers were given consent forms before the interview. In this study nor name, school or programme will be mentioned in the thesis (Wibeck 2010; Bryman 2002; Dalen 2015; Vetenskapsrådet n.d.).

5. Results and analysis

In the following section the survey responses and the interviews are presented. First the quantitative responses are presented to provide an initial idea of the students’ responses.

5.1. Students’ quantitative assessment of the game

The first question given to the students concerned how motivating the game was. Below the responses are presented in Figure 2.

![Figure 2: Graph showing the responses to statement concerning motivation (n = 95)](image)

In Figure 2 it can be seen that the majority of the students did agree to that the game motivated them to learn more about climate adaptation. When adding the responses 81 percent of the respondents did strongly agree or partly agree to the statement while 18 percent partly or strongly disagreed. There were also 1 percent who did not answer the question. The responses to the second question are presented below in Figure 3.
Figure 3: Graph showing the responses to the statement on level of knowledge (n = 96)

Figure 3 shows that 65 percent did strongly agree to that the texts had an appropriate knowledge level and 29 percent did partly agree. Whilst only about 6 percent disagreed either partly or strongly to the statement. The responses to the next question are presented in Figure 4.

Figure 4. Responses concerning the given feedback in the game (n = 96)
In Figure 4, one can see that the majority either strongly agreed or partly agreed to the statement concerning feedback, 87 percent. There are about 13 percent not agreeing to the statement concerning feedback. Below the responses to the following two statements concerning learning is presented in Figure 5 and Figure 6.

![Graphs showing responses to statements](image)

**Figure 5 and 6: Responses concerning the students pre-understanding (n = 96) and if the students learned something from the game (n = 95)**

Figure 5 shows that the majority of the students had some previous knowledge of climate adaptation, 86 percent, whilst 14 percent partly disagreed or strongly disagreed to having previous knowledge. Figure 6 shows that the majority of the students felt that they had learned something about climate adaptation from the game, as 46 percent strongly agreed, and 42 percent partly agreed, whilst 9 percent partly disagreed, and 2 percent strongly disagreed to have learned something from the game. There were also 1 percent that did not answer the question. The responses to the next statement are presented in Figure 7 below.
Figure 7: Responses concerning if they have learned about trade-offs (n = 91)

Figure 7 shows that the majority of the students felt that they had learned about trade-offs through the game, where 44 percent strongly agreed, and 44 percent partly agreed. Around 6 percent partly disagreed, and 1 percent felt that they had not learned from the game and strongly disagreed. There were also 5 percent who did not answer the question. Finally, the responses to the last statement is presented in Figure 8.

Figure 8: Responses to the statement on the game’s value in ESD (n = 95)

Figure 8 shows that the majority 58 percent strongly agreed, and 29 percent partly agreed to the statement that the game is valuable in Education for Sustainable Development. There were
9 percent who partly disagreed, yet none did strongly disagree with the statement. There were also some, 3 percent, who did not answer the question.

5.2. Students’ and teachers’ reflections on the game

In following section, the students’ qualitative responses are presented according to the four main elements: content, form, context and relevance. In addition, the teachers’ responses are also presented in accordance with the elements and the sub-themes. The material has been treated as one in the following analysis to be able to find common themes among the students’ and the teachers’ responses.

5.2.1. Content

In the following section the responses concerning the content of the Climate Adaptation Game is presented. As described earlier, content relates to the storyline, narrative and the data and/or scenarios used in the game. The sub-themes identified in the material are: storyline and narrative, the game’s connection to reality, communicating climate change and missing aspects.

Storyline and narrative

Many of the students provided general comments on the game’s content stating that it was interesting and concerned a relevant topic and the following are two examples of such comments:

“It was fun, interesting and educational.”

“It provides a good perspective to see it from.”

When the students reflected on the content, they expressed that the game provide perspectives on climate adaptation and city planning in a fun way. Also, the teachers brought up that the game provides new perspectives to the students, and a new way of thinking of climate change as one of the teachers described it:

Yeah, but I think it could be interesting to talk from another perspective about climate adaptation, no but as the students also said that you think that this happens like in poor countries. You don’t think about that we need to think forward here as well, things will happen. I think this question needs to be lifted even more actually. […]

The teacher brought up that the game focuses more on a Swedish perspective, that shows the students’ that also Sweden will be affected by climate change. Also, the students referred to different perspectives and how the game helped them in their understanding and expressed that:

It showed how ordinary cities can be affected by climate change in a clear way and how you can prioritize between climate-smart choices to avoid catastrophic consequences.

The student here focuses on ordinary cities and how these might be affected. Showing that the content in the game could be helpful in showing local effects and perspectives. The students also reflected on the feedback given in the game and many of them found the feedback to be enough and one student wrote that:
This student found it good that the changes both were shown visually and explained by the moderator. A couple of more students also highlighted that it was good that the city in the game also changed in accordance with the choices that the students made. Also, one teacher stated that it was good that the students received feedback quickly after they made decisions.

The game’s connection to reality

The interviewed teachers raised in particular the game’s connection to reality. They thought that it was important to have examples taken from reality so that the students got more than just the virtual experience of the problems. One of the teachers raised this as one of the challenges with using the game compared to other forms of learning and took excursions as an example and said that:

[...] It is a bit more difficult when talking games where it becomes very digital then it is a question, well, but can the students relate to the things that happen digitally or is it just a game within quotation marks? So, I think, well, but this ability to relate to the situation and create some form of feeling for it I think it is hard to reach with games. Compared to if you’re out experiencing, how are the cows doing actually? If you are depending on what you are going to talk about within sustainable development like this you can look at a farm it is a bit harder to see in a game – yes, the cow looks sad well how should I relate to that?

Two of the teachers raised that the connection to reality is important and that practical examples are important for the storyline and the engagement by the students. One teacher also raised that it could be hard as an individual teacher to cover all the aspects in the game and talks about collaborations between teachers as a possible way to catch all perspectives from natural science and social science. The teachers argued that more practical examples would provide more context to the game and a more reality-based experience for the students. One teacher stated that the connection to reality is something that the students need help with and said that:

[...] Yes, and above all that they will need help to draw these parallels between the game and reality since they won’t draw these parallels on their own. Even if some do, not all of them will [...] 

The same teacher also asked for a manual with different examples from real life situations that could be used in education. From the students’ perspective they did not raise this issue as much yet there was one student who raised the connection to reality and different perspectives and wrote that:

"Would have been good if the game more clearly connected to a real city. “

This student raised what the teachers also brought up, to make the game more tied to reality. Another perspective that was brought up by the students concerned the decision-making in city planning and how the game captures these aspects and one student expressed that:

"The game mirrors the reality in taking political decision where compromises are a big and important part"
Several of the students expressed that this was something that they were able to experience from the game the reality of taking political decisions and the pitfalls that exists. So, it seems as if the game captures the aspects of decision-making, but that the connection to reality could be further strengthened, in line with the given reflections.

Communicating climate change

The teachers also discussed different strategies to discuss climate change with their students and they expressed that scare tactics and doomsday logic rarely have the wanted effect and one of them stated that:

Yes but (.) it is such a great risk that you present it as if all is lost […] you cannot communicate it like that since then no youth will embrace it. That’s an advantage I guess that (.) even if you don’t play Minecraft it is still in an environment that they feel is theirs. That alone, well, makes them feel as if they own the question in some way. […]

The teachers all agreed that discussing climate change in the classroom is problematic and that it always is a balancing act. Not illustrating that “all is lost”, yet still communicating the challenges that exists, providing both challenges but also possible solutions. The teacher felt that the game could be one way to discuss climate change and open up for discussion, but still highlighted the importance of talking about the issue in many different ways. This is also something that the other teachers brought up as important. The same teacher discussed climate communication further and said the following:

[…] to talk in terms of how much it would cost to do nothing and what consequences that would give in monetary terms, that I also believe could be a way to discuss it. That it would be extremely costly for us to adapt the environment and just that we might have either the alternative to curb the emissions or just adapt and see that we might need to combine them and what it costs in one end we might gain in one end if we save in the other […]

The teacher stated that the economic aspect seems to be of importance since it provides something to compare it to, when putting the consequences into economic terms instead of only narratives in the form of what effects it will have on a particular group. The teacher had seen this in earlier communication efforts and took the example of “don’t drink and drive”. The students had been more engaged in the issue when talking about the actual cost of accidents involving alcohol.

The students did not reflect on the form of communication but rather reflected on how the content in the game helped them in their understanding, yet one can still see that some aspects that they brought up can be related to what the teachers discussed concerning the focus on consequences and solutions to climate change. Two students for instance expressed that:

“You had to think about the economy so it wasn’t always the best you could do”

“You get motivated to climate adapt more since it in the game was about how many lives you saved and it weighted more than how much money you could save”
The economic aspect is highlighted as one of the things that the students brought with them from the game as well as the loss of lives that could be caused by extreme weather events. Even if it is important to show the consequences that might come the teachers highlighted that it is important to focus also on solutions and that it is possible to make a difference through our actions. One of the teachers discussed that the game focuses much on possible solutions to the issues and the consequences that might appear when not acting at all. The game provides an insight into that there are possible solutions and if we act now it might not be so bad. This form is according to the teacher better than focusing on scare tactics in the communication. In the students’ reflections on the games connection to ESD education one student highlighted just that:

”To show that it is possible to do things for a sustainable development”

The student highlighted different solutions as one of the positive aspects of the game and its value for ESD. The most important thing according to the teachers seems to be to avoid communicating in a way that makes the students feel as if everything is lost and that it is too late to act, and instead focus on what you actually can do to make a difference.

**Missing aspects**

The students brought up that even if the game provided several solutions that could be implemented, it did not provide them with ideas on how they as individuals might act to help and asked for more actions and effects on a personal level. The teachers raised two things that they felt were missing: energy aspects and lifestyle choices. The latter could be connected to what the student felt about missing the effects it has on their own life and one of the teachers expressed the following:

[...] What would be a bit interesting could be [...] well if you live in a sustainable way or if you could insert some perspective such as if I do like this, these choices effect the climate in the city in some way? [...]  

This can be connected to what some of students felt about the content in the game, that it did not provide them with ideas on how they as individuals might act to help. In addition, the students did highlight several different aspects that they would like to see in the game. One general comment that many students raised was that it was unclear why things happened, and the students expressed that:

”A bit more about each choice significance in the end would have been good. Not only the bigger picture. “

”We received too little information about the city and what it was that cost things and how things looked like today.”

”I wanted to know more about what our choice did.”

These comments concern the feedback system in the game and it is clear that the students felt that it could be improved and further clarified. When talking with the teachers also they identified some things that could be improved with the feedback system and one of them expressed that:

[...] perhaps one could have like well between these it could have been with your choices. But you ended up on the better scale or what you could say. I
don’t know *it could be* something so that they see like well but if you had really bad luck this could have happened with the choices that you made. Since you don’t know if you made good or bad choices.

This clearly connects to the comments left by the students on better explanations on why things happened. This also connects to the points given for different actions, since some students felt that they did not understand why they received or did not receive SDG points or coins for their actions. Some students felt that the connection between their actions and the climate events was hard to understand and that it could be improved. This was also raised by one of the teachers who also felt that the calculations in the game needs to be more explained so that the students can understand it better. And also, it needs to be highlighted that there are real climate models behind the calculations and effects so that the students can relate to that these events actually are something that could happen in the future. This is a perspective that is connected to the data in the game, both in scenarios but also the calculations behind lives saved, the SDG points and the coins received or lost. This is an important aspect that was brought up concerning the content in the game by both students and teachers, since it has a great effect on the understanding of climate adaptation.

5.2.2. Form

The form element relates to the form of the game, which in this case is comments on the game itself and the gaming session. The sub-themes identified in this element are: the form of learning, challenges concerning the format of the gaming session and more play than learning.

The form of learning

The general comment among the students was that the game was fun and interesting to play. Some of the students also expressed that they did get more engaged and interested in climate adaptation. The students expressed that:

“It aroused interest in a different but interesting way”

” By visualising different connections through the game climate adaptation becomes an easier subject to understand and therefore more interesting”

“An idea to make new people interested in this and understand the seriousness of it!”

“Fun, relaxed, exciting, you do not just sit with a book. Discussions are good.”

The students found that the game created an interest in climate adaptation and also made it easier to understand through the visualisation. Many of the students also said that it is good with new ways to learn that are different from traditional ways of teaching, where they are allowed to try out a new way of learning.

The teachers thought that the gaming session worked well and that the students seemed to have had a good time while playing. Some of the teachers even expressed that they were surprised by the engagement showed by the students while playing and one teacher expressed that:

[…] they were so motivated so that surprised me I thought that it would be more of them who just waited for the time to go by […] But now it seemed as if all of them were on and wanted to be part of the horse-trading and they
wanted to find a solution they wanted in some way to win […] or like pursue their cause. It surprised me that they engaged so much in it.

Several of the teachers also expressed the potential to motivate their students with a new way of learning. The motivational aspect was something that the teachers raised that it could be a way to motivate students that might not think that ordinary learning forms are as giving. In addition, that it could motivate students that might not be as study-motivated and one of the teachers stated:

[…] There are motivation opportunities like to motivate students who might not feel that it is so fun, but they can get to perform a task that allows them to be the drivers.

So, all three teachers saw potential in the game and were positive towards using it in their education. Also, that the students here get the opportunity to on their own be the driver of their learning process since they in their engagement in the game and the role play drive the game forwards. The students also reflected on the way of learning and talked about the suitability for the target group and some of the students expressed that:

“It is a much more fun way to teach. It raises an interest among young people”

“Nuanced and suitable for the target group”

Some of the students expressed that the form is good for the target group since they are used to technology and games which could be a motivator for them. However, there were also some students that stated that even if the game was fun they felt that they learn more from ordinary forms of learning and one student expressed that:

”Personally it is probably easier to understand traditional education. But the game probably also works if you are used to work like that.”

The comment raised by the students and the teachers lifts the importance of using several methods to engage and teach in the school environment. Since some persons learn better through traditional learning forms and some benefit from other more active kinds of learning as one of the teachers discussed. The teacher here reflected on that animations and visualisation can be used as a complement to the traditional forms of learning. The teacher highlighted that both traditional and new way of learning have their possibilities and challenges and that a combination of different forms of learning might be a good way to go. The teacher also reflected on the difference between using a game and other learning forms, where students are more active in this form of learning than the traditional. Allowing the students to test something on their own. Where student activity is important in order to keep the students active in their learning as stated by one teacher:

[…] student activity is good - when the students are allowed to actively do something during the lesson not just sit and listen but when they get to do something and get involved and then I think that motivates many also when they feel that well now I am doing something, and I can see the results directly. If you for example use a game where you receive feedback quite directly on your choices.

The teacher brought up that the students are more active and can interact with the game. This was also something that the students stated that the way of learning was good since they got the opportunity to practically test something and expressed that:
“It is a good way for students to get involved by being allowed to practically test”

“It gets more fun to do something than just sit and listen”

Some of the students also expressed that it was positive that it was something that they could be active in and felt positive towards trying something new. So, one of the possibilities with using the game in education seems to be that the students are allowed to be more active in their learning. All teachers stated that it is always good to find new ways to educate and that the variation is good for the students learning, which also some of the students felt.

**Challenges concerning the format of the gaming session**

The main thing that the students brought up was that the game was hard to follow sometimes and that the instructions could be improved. Some students felt that it went too fast and/or that the instructions and rules of the game were confusing. Some expressed that:

- “Needs to be better instructions or explanations to how the game works”
- “Hard to follow”
- “It went too fast sometimes and/or it was a bit unclear”

These are some of the challenges that were brought up by the students concerning the gaming session. Concerning the feedback some students saw it as problematic and raised the same comments as before that it went too fast and requested more clarity about why some things happened in the city. One of the teachers also saw that the visual feedback could be improved in order to make it easier to understand what happened in the game. The teacher asked for some form of further visualisation that showed what had actually happened in the city during the time-step. A more general reflection from both students and teachers was hence that the feedback mechanisms in the game as well as the instructions would require improvement so that both students and teachers would find it easier to follow.

There were also more specific comments on the game and the gaming session. All three teachers raised that time could be a constraint, since in these gaming sessions the students played for almost 3 hours and one of the teachers said that:

[…] But when it becomes a learning purpose the it is really hard to remove well that the students’ needs to learn something. This learning what is it called like the pressure, the stress that lies on the students that they still need to learn something so that I believe is a contributing factor which also makes the time aspect very long.

The teacher here reflected on the time aspect and that it could be hard for the students to be concentrated and focused on learning for such a long time. Also, the students said that the time was a constraint since it took a long time to play the game and that it is hard to concentrate for such a long time and stated that:

- “Takes some time but otherwise it can show the event in a very simplistic way”
- ” It takes a long time for little knowledge, I would have liked it to go faster or contain much more facts”
The challenges brought up did also focus on the teacher’s abilities and pre-understanding. All teachers raised that the technical aspect could be a challenge for teachers, since using the game in education does require technical knowledge. This is something not all teachers feel secure about and could provide an obstacle for using the game in education. One of the teachers expressed it this way:

Unfortunately, I do. I am not one of those who have played computer games. So, I feel a bit unsure in the navigation [...]. I feel a bit insecure with it and I am wondering how long it would take for me. [...] But that I see as like the biggest obstacle that I am not used to playing video-games or computer games and it is hard to navigate. So that I am not completely out there not finding the tasks. [...]  

All three teachers brought up the technical aspect as something that could be a challenge and that it would require good instructions. The teachers also raised some concern regarding the kind of computer needed to use the game since the Minecraft platform require more capacity than the students’ computers currently have.

**More play than learning**

When using a game as a learning form there is always a risk of ending up in a situation where there is more play and less learning. This was an area brought up by both students and teachers and some of the student expressed that:

“More focus on competition than on climate adaptation”

“Since people do not usually take it seriously since it is a game”

There were some more similar responses from the students were the competition part seems to have been too much in focus. It should however be mentioned that there also were students who expressed that they found the competition part as something that made it fun and interesting. Also, the teachers reflected on this and one teacher said the following:

[...] But as always with games I believe that there is a risk that you play to beat a score or win or so that you might not always reflect on what you are actually doing what it is. And there I think the teacher comes in that a teacher needs to help them to reflect on what they actually have done. (.) And I think that it is like the same thing as giving them a computer they won’t get better just because of that it is how. But if the computer can spark discussion or spark a possibility well then we have gotten somewhere. I think that’s the risk with games that it might be too fun sometimes, but perhaps it can be fun as long as it leads to a good discussion after [...]  

Here one important aspect is brought up concerning discussion and reflection and its connection to learning. It is stated that games or educational forms are allowed to be fun if they lead to a good discussion afterwards. The teachers also highlighted the importance of allowing the students to reflect on what they have experienced, since it enhances learning. One teacher also focused on the importance of discussions to avoid a situation with more play than learning, which the teacher felt would be lost if the students are playing one-by-one. The teacher however felt that the same situation could occur also in other situations and takes discussions as an example. To change the gaming sessions and allow the students to play one-
by one neither of the teachers found to be better than the role-plays, since they found the loss of discussions as a loss of learning for the students. Even if there were some students who felt that they would have found it more fun and better for their understanding to play one-by-one, the majority expressed that they had enjoyed the role-play. All three teachers did highlight the importance of having a discussion after and allowing the students to reflect on their experiences from the game to avoid a too big focus on the competition part.

5.2.3. Context

The context element handles the knowledge level in the game and the targeted groups pre-understanding. The identified sub-themes are: pre-understanding, knowledge level in the game and connection to the curriculum and reflections on learning.

Pre-understanding

The students were also asked to reflect on their pre-understanding of climate adaptation. For this set of responses, it was hard to see a general trend in the answers. Many of the students had knowledge within one area such as agriculture or water management, but there were also students that had some knowledge in all areas and students without any pre-understanding in the area. When talking to the teachers they felt that the students probably had little previous knowledge about climate adaptation and one of them said that:

[…] I feel that they probably are not so familiar with just climate adaptation what it is. So that is probably something you need to talk about before. So that they like feel that they are comfortable. […]

The teacher brought up the students’ pre-understanding as a possible challenge and that it would be good to have more introduction to the subject before playing the game. Another teacher also talked about their pre-understanding yet focusing on the different roles and that it would have been good to have given them more time before the gaming session to read in on the different roles. The teacher believed that this would provide more depth to the discussion which then also gives a deeper learning for the students. There was also some of the students who asked for more explanations on the roles especially on what they in the group should prioritise. The teacher also talked about the challenge of keeping the students interested in the area during the whole gaming session. They felt that it would require the teachers to study the area more thoroughly so that they have enough pre-understanding to help the students for instance with anecdotes as discussed earlier.

Knowledge level in the game

The students also reflected on the knowledge level in the game and here the majority of the students regarded the level as fitting for the targeted group. One of the students expressed that:

” I think that there are good words that you should know at this level of school but there is always something new with certain things which is very good.”

However, there were also some students who stated that the game was too hard and that they did not understand the terms and concepts in the game. They asked for more introduction to the concepts to understand it better and some of the students stated that:

“Some concepts were difficult explanations would have been good”
“Could not follow. Did not understand what you were talking about. You could have given us more background before you started with the game.”

This connects to the preunderstanding, as one of the teachers noted, and that it would require some more background on the subject. But there were also a few of the students who expressed that the game could have been harder and one student for instance expressed that:

“It was definitely not too hard, I think that it could have been more technical terms etc. I had probably learned more then.”

This is also evident in some of the answers concerning the games relevance in ESD education where some students expressed that the game was suitable for the target group whilst some students expressed that it was probably more suitable for a younger target group. So, there is a mix in the perception of the knowledge level in the game which is most likely linked to the varying preunderstanding amongst the students.

**Connection to the curriculum and reflections on learning**

The teachers were asked to reflect on how the game could be used in education and all the teachers were positive to the usage of the game and thought that it could be usable in their education and one teacher expressed that:

” […] Yes, but there are clear links to what is written in like (...) our central content […]”

The teacher connected the theme of the game to the subject that the teacher teaches and the central content of the course. The teachers also reflected on how the game could be a part of the education and one of them said that:

[…] Perhaps you have talked about sustainable development perhaps you talk more climate adaptation then you say that well now we are going to look at how it might be done. How you could think and so. So, that, well, as a part of a project about sustainable development I think that you think that it is a part. That you can test a new way to work with this. To initiate some discussions which I think is good.

All three teachers thought that the game could be used as an element in their education and some of the teachers talked about a specific theme week where the game could be a part. The teachers also highlighted once again both the possibilities with using new methods to learn and the importance of discussions in education. Another comment was left by one of the teachers who said that:

Well, the possibilities are that you create something that they are not used seeing, that creates variation. Since, it is easy that a lot of education is that the teacher talks and then we discuss a bit and then they work on their own. It is rewarding when you can do something different to like do a break off. But I think if it is going to be good you need to follow it up. I think that’s the key […]

Here the teacher talked about the possibilities with using the game and that variation and new ways to teach are important in education. These new ways to learn was also something that the students raised as positive. Two students expressed that:
Fun, new way to learn

It is always good to find new ways to learn. “

Several students highlighted new ways of learning and that it is positive to be allowed to try something different. The teachers however highlighted that the game needs to be followed by something more to be educative, an assignment were the students are allowed to reflect upon what they have experienced in the game. The teachers brought up how one could engage the students even further and help them in their understanding through reflection and discussion. One of the teachers stated that follow-ups is an essential part in all education, which will according to the teacher help them deepen their learning from the game, one of the teacher expressed it like this:

[…] Though many things like this I think it is easy that you get stuck and that it becomes a happening, like it becomes a funny thing that you did and then you don’t follow up. […]

This was also raised by one student when reflecting on the game’s value in ESD education. The student felt that it could be valuable if it is more connected to a task and expressed that:

“If you can connect it to a specific task so yes”

In line with these comments, the students along with the teachers felt that the game would be more giving if it is followed by assignments and more discussion. Several of the students also highlighted that they found the discussions as giving, yet that they as mentioned in an earlier section felt that they would have wanted more explanations to what happened in the game. This could be connected to the teachers’ discussion on pre- and post-assignments.

5.2.4. Relevance

The last element concerns how and if they have learned something from the game. The identified sub-themes within this element are: learning experience and Education for Sustainable Development.

Learning experience

The general comment from the students about their learning was that they had learned about the consequences of climate change, and the different methods that exist to climate adapt a city. Two students expressed that:

“I have learned about how our choices change the society in a positive and negative way”

”Think from another perspective and then gained more knowledge and understanding”

The specific things that the students mentioned that they had learned from the game concerned how flooding and heat waves can cause negative effects and what could be done to adapt to these events. There was however, some students who asked for more deep explanations in the game and one student wrote that that even if the person learned about flood protection more explanations would have been good and stated that:
“About flood protection for instance. Would have learned more if you had gotten more information but there were actually not so deep explanations.”

This student amongst some others expressed that the information could have been deeper in order to enhance the learning from the game. This could also connect to what the teachers said about pre-assignments and follow-ups in order to help students learn from the game.

The students also mentioned that they had learned more about the different perspectives that exist in a city and one of the students puts it this way:

“You got to know how it is discussed from different perspectives and that there are many things you need to consider”

These were general comments that the students connected to the roleplay and the discussion with the other groups. That it is necessary to compromise due to all different needs in the city and with a tight budget that needs to be kept. In their learning experience the roleplay seems to have played a vital role and both students and teachers highlighted them as an important part and all teachers felt that the students enjoyed the roleplay as one teacher stated:

[…] something that I noticed was that they (?) thought it was fun to negotiate with the other groups. So that got them going what I noticed that well now we get to, when are we allowed to go and negotiate with them and when can we do that and really horse-trade or what you say. When you walked around and listened to them it was one group who said when they were going to make another decision they said that now we need to talk to them as we talked about when we took this decision we want to win them over to this and so on. So, it was clear that they went in for it and thought it was fun.”

The teacher highlighted that the students enjoyed the roleplay and the discussions and that they seem to have been engaged in the decision-making process. They thought through what their group would have wanted and what the other groups stands for. This was also something that the students highlighted. Some students expressed the following concerning what and how they learned something from the gaming session:

“Because you needed to take on a role and think like they would have done. And that was interesting how different you think from the different perspectives you work for.”

”You don’t get as bored as you get at some briefings and you are allowed to share your opinion with others.”

”You needed to reason and compromise which lead to that you got more perspectives.”

These students expressed that they have learned that there are a lot of different perspectives to take into account when making decisions on how a city is being developed. One student also highlighted that the discussions had made the experience more fun. So, through the discussions it seems like as if the students brought with them different perspectives and the central role of negotiation and compromises between needs in city-planning. So, in line with these reflections it seems as if the role play connected to the game provides information about different perspectives and how compromises and trade-offs are made in city development.
Education for Sustainable Development

The students were asked to develop their thoughts on if the game was valuable for Education for Sustainable Development. Here the students highlighted several things that they had learned from the game and some students expressed that:

“You got another perspective on how you work in society and how you work to create sustainable development.”

“You notice that everything you do has consequences or helps the environment - even the little things”

The students’ highlighted that they had learned more about the work towards sustainable development and the effects our choices today have in the future. The teachers also reflected on if the game could help the students to train their competence to act and their holistic view. Two important pieces in Education for Sustainable development. One teacher said the following:

Yeah but this with action alternatives here you really get to choose which alternative that you would like to do and then you also see what kind of consequences this action alternative leads to, right? And then of course also depends on what happens in the game itself but action alternatives seem like a really good way to explain also that concept. Since it is not always so easy what an action alternative is and they almost always ask about what that is. Make a decision and that becomes something, you can clearly show that here I think. So that I think is good. And sustainable development exists all the times but it is not so clear just in what way perhaps in the game so I think that action alternatives is what I want to highlight here.

This teacher highlighted action alternatives as one thing that the students get to train through the game. It does exist different ways to handle a problem and that it will lead to different outcomes, which is the case for climate change issues since there are different scenarios that do depend on how we choose to act today. This can be connected to the following comments given by students:

“Yes, since we need to make important decisions concerning the future “

“I understand the consequences of decisions”

The first student highlighted that the game is valuable since we need to make decisions now on how we want our future to look like. The other answered understanding of outcomes when asked about the learning from the game. Both perspectives could be connected to what the teacher said about action alternatives. Another teacher highlighted competence to act as something the students train through the game and said that:

[…] They have to cooperate and that [...] is probably some kind of competence to act to train cooperation. And just this ability to talk for their own cause and get others to listen. That is a really important knowledge to have regardless if it handles environment or whatever it is about this kind of ability to speak for a cause. But if they then move on and act I don’t know. […]

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Here the teacher also talked about that the students learn to speak for their cause, which is of importance in all subjects not only for environmental issues. This is also something that a few of the students brought up when reflecting on the value of the game in ESD education, that they were allowed to train argumentation. The same teacher however considered that it is hard to say anything about how and if they will act in reality and what they have learned in the long term. Since this is not something that is shown so fast and the teacher felt that it is something that will show further on. Lastly, one teacher also highlighted the holistic view as something the students are allowed to train through the game and said that:

Yes absolutely I think that it creates, well, but it creates this holistic view and the students are allowed to make decisions that they then see the results of directly. […] Since you can talk like very theoretical about well do you take this decision it will lead to or it can lead to this if we do like this. So I absolutely think that the game is a good tool for visualising these well these decisions that the students are allowed to take. And Education for Sustainable Development is so important right now how are we going to motivate our students to become sustainable individuals for our […] future?

Something that also relates to what the students highlighted as valuable for ESD that you understand consequences and how the work for sustainable development functions. In relation to the teachers’ perspective, the game could be a helpful tool to use in education for sustainable development and work as a positive contribution to their education.

6. Discussion

6.1. Possibilities and challenges with serious games

One of the biggest challenges is how to communicate climate change in a way that will engage and motivate, there is a need for forms of communication that engage the targeted group, making them willing to act (Waschka and Torok 2013). It has in general been problematic to raise this motivation among the public and new ways to communicate is asked for, one such format being ICT (Wibeck 2014a). In this study one such format, serious games have been studied in the context of communication of climate change in education. Using games to communicate complex issues is especially highlighted when the targeted group is youth (de Freitas and Oliver 2006; Ouariachi, Olvera-Lobo and Gutiérrez-Perez 2017). A generation where ICT media could be a suiting communication format since this generation in general is very familiar with technology. This was also something that was raised in this study by both students and teachers, that games could be a possibility since it is a form that the students are familiar with. In this study the majority of students felt that the usage of the game was suitable for the targeted group and that it creates an interest in climate adaptation.

The dilemma of communicating climate change is according to Waschka and Torok (2013), Wibeck (2014b) and Moser and Dilling (2004) much connected to the uncertainties and the complexity around climate change issues, where it is difficult to give certain responses to where the effects will be felt. Perspectives that also are something that was brought up by the participating teachers in this study, where they reflected on the dilemmas in communication of climate change issues in general. It is hard to communicate in a way that shows that climate change is an urgent issue but still give the students hope for the future, motivating them to act. The teachers also related to climate change communication and the usage of scare-tactics, which the teachers felt would not make the students engage in climate change issues if
communicated as if all is lost. These are comments that are in line with earlier literature on the subject such as Wibeck (2014b) and Nicholson-Cole (2005) concerning the view of climate change among the public. Where also Wibeck, Neset and Linnér (2013) and Moser and Dilling (2004) in their studies see that when climate change is compared to war and terror it could lead to a sense of it being too late to act or hopelessness. The teachers instead expressed the importance of keeping a positive tone; stating that even if it is hard there are still things to do to make a difference.

Several studies exist that highlight different possible communication strategies where solution orientated, localised and personalised seems to be the foci (Ballantyne, Wibeck and Neset 2016; Wibeck 2014a; Moser 2010). When assessing the reflections on the content in the game the highlights are in line with this literature, where both students and teacher reflect on the localised perspective and the focus on solutions in the game. The students highlighted in general that they had gotten perspectives on consequences and solutions when it comes to climate adaptation in cities. Both the participating teachers and students found that the game provided hope and solutions that showed them that it is still possible to do something for the climate. One of the participating teachers also felt that the game showed the students that things also will happen in Sweden which the teacher highlighted as an important thing that should be lifted more. A comment that can be connected to earlier studies on climate communication such as Wibeck (2014b), Nicholson-Cole (2005) and Moser (2010) that showed that many regard climate change as a distant problem with little connection to their own lives. A perspective that could be connected to the usage of images of climate change effects in for instance the Arctic regions.

The use of games to communicate climate change was something that the students and the teachers participating in this study in general were positive towards, highlighting that it is good to use new ways to communicate the issue. In general, the students found the game motivating and a fun way to learn, which also has been shown in serious gaming studies on the topic such as Guillén-Nieto and Aleson-Carbonell (2012) study of serious games potential in university education. One thing that was highlighted by the respondents in this study was that games are a more active way to learn and teach, since the students are the drivers behind what happens in the game. They need to make decisions on their own and see the consequences of these decisions. An aspect that also some of the students brought up in their reflection that they were allowed to practically test different options. Dieleman and Huisingh (2006) also highlights that games are a learning form that allows the students to be more active than the traditional form of learning. Another raised possibility with using games was that it could function as a motivator. The students are allowed to be the drivers of their learning and experiment in the game which could make them more motivated in their learning. The motivational aspect was also something that the teachers saw could help students with learning difficulties which is supported by literature such as Girard, Ecalle and Magnant (2012) and Guillén-Nieto and Aleson-Carbonell (2012).

An important aspect that was brought up by some students as well as teachers was the importance of variations in education and communication, using several formats and strategies when talking climate change. This study indicates that combinations of different learning forms are good since they complement each other. Also, that combinations are good since different learning forms have their possibilities and challenges as expressed by one participating teacher in this study. This also connects to the literature on experiential learning where Kolb and Kolb (2005) states that there are many different learning types that benefit
from different forms of education. One student might find lectures better than games and vice versa. This further strengthens the idea of combinations and variation in education as brought up in this study.

A possible obstacle for using the game in education identified by the participating teachers was that it could be hard for the students to connect what happens in the game to reality. An aspect that is also highlighted in serious gaming literature such as Kapralos et al. (2011) who highlights that the game needs to be reality-anchored. The participating teachers in this study highlighted that it would be good to tie the game even more to real cases, making the game more reality-anchored. The students can then see consequences in a more localised perspective by providing examples of what has actually happened in Sweden already, which could further motivate the students. A perspective that is in line with literature on climate change communication where for instance Waschka and Torok (2013) identify showing personal effects as a possible motivator for the targeted group. This could also increase the understanding of local consequences and show the importance of climate adaptation actions on a local scale. It would therefore be good to provide the teachers with material that they can use as inspiration with examples that provide context to the different tasks that are presented in the game, which was also asked for by one of the teachers. Even if it is not possible to tie the storyline in the game towards a real city, since the games focuses on effects that could occur in Swedish cities in general, more practical examples could be inserted in the storyline to provide the feeling of a more reality-anchored storyline in the game.

Another thing that the students felt was missing is how they as individuals might act to help. An aspect that also one of the teachers felt was missing in the game and stated that it could give another dimension to the game making the students engage even more. This is in line with earlier studies such as Wibeck (2014a) and Waschka and Torok (2013) who highlight this as important for engagement and motivation in climate change issues. The individual level is however not brought up in the Climate Adaptation Game. In the game the students are provided with a localised and solutions orientated perspective of climate adaptation, yet not with action that they as individuals could take. The learning objective of the game is focused on understanding decision-making and the trade-offs between different needs in city planning. An aim that many of the students felt was reached, stating that they had learned about decision-making and trade-offs. They also felt that the game provided them with the insight that it still is possible to do something about climate change. This does however not prevent addressing the individual perspective in follow-up assignments or in discussions, tying the game more directly to the personal level and how they as individuals can act to make a difference.

Another challenge that was brought up in connection to using games was that it could be more fun than a learning experience. Both students and teachers stated that it could be a problem since some might not take games as serious as traditional learning forms. The teachers that were interviewed in this study highlighted that this could be counteracted by reflections and discussions in the gaming sessions, which they identified as a great potential with using games that it could be used to spur discussions on the subject. Also, that the students in this game are allowed to see many different perspectives of the issue. Both students and teachers expressed that more reflections would have been good, allowing students to reflect on what they have experienced. Here the interviewed teachers also highlighted the usage of role-plays as an important part of the learning experience from the game. This is in accordance with earlier studies such as Dieleman and Huisingh (2006) who saw that the usage of role-plays
where the players needed to discuss and negotiate were positive for their learning experience from the game. The roleplays also open up for the students to practice team-work and argumentation skills, an aspect that also was something that the teachers highlighted as important for ESD education.

6.2. The role of serious games in experiential learning

Serious games have been highlighted as a learning form that fits into the learning theory of experiential learning by for instance Kiili (2005) and Dieleman and Huisingh (2006). Games can provide the students with experiences from a virtual world, where they are allowed to trial and error different choices and see the results in the game. This learning by doing is what provides the ground for experiential learning (Kapralos et al. 2011).

As Dieleman and Huisingh (2006) stated in their study games could be relevant for all four stages of Kolbs learning cycle from concrete experience to active experimentation. But perhaps especially for the fourth phase active experimentation, since it is here the players are allowed to test their knowledge within an area and practically test theories. The students are also allowed to be more active in their learning and be the drivers behind their learning process (Kapralos et al. 2011). This was also something that was raised in the reflections from both students and teachers, that this form of learning allows the students to trial and error and learn from this experience. These reflections connect to the phase of active experimentation, since this is the phase where the students are allowed to test their knowledge and see the consequences of their decisions (Dieleman and Huisingh 2006).

This experimentation phase also provides the students with new experience which leads to the first phase of concrete experience as stated by Dieleman and Huisingh (2006). Since the students might experience things in the game that transform their previous understanding. This form of active learning was something that both the participating students and the teachers highlighted. The students also expressed in the survey that they found it fun to be allowed to practically test something through the game. This is also something that is highlighted in earlier studies such as Dieleman and Huisingh (2006) and Kapralos et al. (2011) as one of the strengths with games in connection to experiential learning. In the participating students’ reflections, they also highlighted that they were allowed to experience and then gain understanding especially on the trade-offs in city planning and between different actors in the city. This connects to the phase of concrete experience, where the students gain experiences from the game. Experiences that can transform the students previous understanding as stated by Dieleman and Huisingh (2006).

Something that was highlighted over and over by both the participating students and teachers was the importance of reflection and discussions. The students should be allowed to reflect on and discuss what they have experienced. The teachers stated that if the game should be usable in education there needs to be more time for both reflection and discussions. These comments clearly connect to the importance of debriefing which is highlighted in serious gaming literature such as Dielman and Husingh (2006), Koivisto et al. (2017) and Petranek (2000). The studies highlight the importance of allowing the players to reflect on what they have learned as a part in their understanding and knowledge gain. Debriefing can also be connected to the theory of experiential learning and the phase of reflective observation. The phase where the player learns from observing others or when allowed to reflect on their experience (Kolb 2015). As one of the teacher stated there is a risk that the game ends up being just a happening that is not followed up. Therefore, it would be important to have follow-up assignment after
the game where the students can reflect on their experience, which also is highlighted by Petranek (2000) study on the importance of written debriefing. It could also be a possibility to make the game more reality based by connecting these assignment to cases from the real world such as flooding events that has occurred in Sweden already. The teachers in this study also highlighted that the students would need help to reflect on what they have learned and that it is the teacher’s responsibility to help them. This is an aspect that also is brought up by Dieleman and Huisingh (2006) who express the importance of aiding the players in their understanding of the game. So, to provide the students with both pre-assignments and follow-up assignments could be a way to help the students in their learning process from the game.

Debriefing could also help the students to move into the third phase of the cycle where they move from reflection into the thinking phase where they build different theories from their experience, the phase of abstract conceptualization (Kolb 2015). This phase is however, hard to assess since it concerns the students long-term learning. Assessing this phase would require studies on what the students has learned in the long-term after being allowed to reflect on their experience from the game. An aspect that also connect to what one of the participating teachers expressed when asked about what the students learned in connection to ESD and competence to act. The teacher found it hard to reflect on this since it concerns their long-term understanding of climate adaptation, meaning that this phase in the experiential learning cycle would require further follow ups on the participants in this study to gain an understanding of what they learned from the game in a longer time perspective.

Even if there are several possibilities with using games in experiential learning there are also challenges that have been identified by teachers as well as students participating in this study. One challenge that was evident concerns the design of the game which of course is of great importance for the usability of the game as identified by for instance Kiili (2005). In this particular game the feedback system and instructions were highlighted as potential obstacles for the usage of the game. The students and teachers felt that they did not always follow the feedback given and some student expressed that the game was confusing and that they did not understand why things happened. This shows that both feedback and instructions need to be improved in order for the game to be usable in education, since as stated in Kapralos et al (2011) it is unlikely that teachers will choose to use a game if the instructions are found to be insufficient. Problems with the feedback system could also provide obstacles for the debriefing phase where the players are supposed to reflect on the game and the given feedback. Here one of the teachers highlighted that it was hard to know whether one had made good or bad choices. An uncertainty that could be an obstacle for the students’ reflection and learning from the game, since it is important that the players understand the events occurring in the game in order to learn. So, improved instructions and feedback is evidently an improvement potential in this particular game and also an important part of the reflective phase in the experiential learning cycle.

This also connects to the teachers pre-understanding since something that all teachers raised was the technology barrier. The teachers here highlighted that all teachers are not as used to technology as their students which could create a barrier if the teacher feel that the game is too hard to understand and use. In the interviews, all teachers requested improved instructions and guidance for the teachers. This is a general obstacle that is raised when it comes to using serious gaming and the aspect is brought up in the study by Kapralos et al. (2011) who stated that the instructions need to be clear. Of course, also the students’ pre-understanding is important since the game needs to be at an adequate level of knowledge in order to be usable
as highlighted by for instance Kiili (2005). It was however, hard to see any general trend in the students’ responses concerning their pre-understanding, since their responses ranged from too easy, fitting to too hard level. The teachers here felt that Climate Adaptation Game’s content probably was new to the students’ and that having a good introduction and a pre-assignment could be helpful for the students understanding. This could also help in the sense that it levels the playground since then all students have received the same introduction and assignment. So that none of the student will have zero pre-understanding of climate adaptation when entering the gaming session.

7. Concluding remarks

From this study of the Climate Adaptation Game and the reflections from teachers and students a number of possibilities and challenges have been identified with using the Climate Adaptation Game in teaching and communication. All teachers stated that they would like to use this game in teaching, and the majority of the students felt that the game was valuable in Education for Sustainable Development. The Climate Adaptation Game could be used as a motivator for learning providing variations in teaching methods. There are however also identified challenges that need to be addressed in order for this game to function in education and communication. The greatest challenges with using serious gaming seems to be connected to the design of the game, since in this case, the overarching challenge concerns the design of the Climate Adaptation Game: its content, the feedback and the usability of the game.

This study has also shown that serious games could play a role in experiential learning since it provides the students with possibilities to gain virtual experiences. Because they can practically trial and error different actions alternatives and see the consequences of these in the virtual world. This could help their understanding of climate adaptation by visually showing the students what could happen providing a reality-anchored experience. This could show the students the difficulties in taking political decisions and the trade-offs that exists between different needs. This could help them to better understand political decisions in the future. The biggest challenge brought up in these gaming sessions concerns debriefing, which was something that the respondents felt was missing in the gaming sessions in this study. This could however be counteracted with more pre-assignments and follow-up assignments.

These are results that in general are in line with earlier studies of serious games and the connections to Kolb’s experiential learning model. This study indicates that the Climate Adaptation Game could play a role in education and communication of climate adaptation. There is however, a need for further studies on the area in order to gain a deeper insight in the role of serious games. It would be beneficial with studies with another target group such as students at another age or people working within the field to gain a broader perspective on the issue. Another aspect would be to further explore the learning experience from serious games within the area, to gain a better understanding of the students learning process from games compared to other forms of learning.
8. Acknowledgement

First of all, I would like to thank my supervisor Tina Neset for her invaluable support and guidance during this process. I would also like to thank her and Lotta Andersson at SMHI for allowing me to be a part of this project. I also want to thank my family and friends, I would never have made it without your support and helping hands during this semester.
9. References


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1 The reference system used in this thesis is based on the system used in Climatic Change (Springer, 2018)


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Appendix 1: Survey to students

Here the full survey to the students is presented, which has been translated into English.

The Climate Adaptation Game

Here is a survey about the gaming session today. The questions have four answer options – circle the one that suits you best. After each question, we also ask you to develop your answers. Thank you!

1. The game motivated me to learn more about climate adaptation
   
   Strongly agree           Partly agree          Partly disagree             Strongly disagree

   Why, why not?

2. The texts in the game have an appropriate level of knowledge for me
   
   Strongly agree           Partly agree          Partly disagree             Strongly disagree

   Where there any words that were too simplistic/difficult?

3. The feedback after each step was clear and I understood what happened and why
   
   Strongly agree           Partly agree          Partly disagree             Strongly disagree

   Why, why not? Is there anything that could be improved?

4. I had knowledge of climate adaptation before the game
   
   Strongly agree           Partly agree          Partly disagree             Strongly disagree

   What areas would you say you had knowledge in?
5. I have learned more about climate adaptation through the game
   Strongly agree   Partly agree   Partly disagree   Strongly disagree
   
   If you agree, what have you learned?

6. The game helped me to deepen my knowledge of how different decisions are made and the compromises that need to be made between different needs.
   Strongly agree   Partly agree   Partly disagree   Strongly disagree
   
   If you agree, in what way?

7. I think the game is valuable in Education for Sustainable Development
   Strongly agree   Partly agree   Partly disagree   Strongly disagree
   
   Why, why not?

8. Do you have other comments/feedback on the game?

Thank you for your participation!
Appendix 2: Interview guide

Here the interview guide used in the interviews with the teachers is presented, which has been translated into English

Interview guide

1. Could you shortly tell me who you are and which class you played with?

2. How do you think that the gaming session with your class worked?
   - What worked well, less good (and why)?
   - Lessons learned?
   - Surprising?
   - Reactions from your students?

3. How do you think that the Climate Adaptation Game could be used in education?
   - What role could it play?

4. Do you see any possibilities and/or challenges with using the game in education? (Now that you played it with your class?)

5. Within the area of Education for Sustainable Development one part is to train the students competence to act and their holistic view. Do you think that the game could be a tool to achieve this?

6. Research suggest that there is a need for new ways to communicate climate change issues. What do you think about that statement? Do you agree and how should these new ways be designed?

7. Games are said to be one such communication form. How would you assess games compared to other ways to convey knowledge?
   - Differences and similarities?
   - Possibilities and challenges?

8. Do you have any suggestions on how the game could be further developed/used?

9. Finally: Would you like to add something?

10. Can I come back to you if I have any further questions?
Appendix 3: Explanation of symbols in quotes

*Short explanations of the symbols within some of the quotes*

<table>
<thead>
<tr>
<th><strong>Italics</strong></th>
<th>The person is doing something while speaking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bold</strong></td>
<td>Emphasis</td>
</tr>
<tr>
<td>Asterisk (*)</td>
<td>The person who speaks has laughter in their voice</td>
</tr>
<tr>
<td>Question mark in brackets (?)</td>
<td>One word is inaudible</td>
</tr>
<tr>
<td>Point in brackets (.)</td>
<td>Short break</td>
</tr>
<tr>
<td>[…]</td>
<td>Parts of the quotes has been removed</td>
</tr>
</tbody>
</table>