Climate4Kids: A Gamified App Teaching about Climate Change

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Abstract: As per Deterding et al. (2011), gamification can be defined as using game design elements in non-game contexts and it is used to increase motivation and engagement. That is why there are already gamified application to change people's behavior when it comes to environmental protection. Climate change is a complex topic which is for younger children aged 6 to 10 years quite often too abstract to understand properly. Therefore, a browser-based app is being developed that aims at teaching basics about renewable energy, mobility, greenhouse effect, soil sealing, heat insulation and the like. Using elements of gamification like points, collecting stars, planting trees digitally, a changing background (depending on the progress made) as well as a narration about the protagonist Mani (a groundhog that is affected by climate change) and his friends encourage the children to use the app not only at school but also at home. By telling stories which introduce the topic, the children get a first understanding of how everybody of us affects the environment and what we can do to prevent effects of climate change. Moreover, instructions for easy hands-on experiments are used to make children experience certain effects and/or consequences of climate change. The app seeks to meet children's emotional needs acknowledging feelings, emphasizing solutions, and encouraging action. The contribution shows how elements of gamification are included in the app to ensure that children are motivated to engage with the topics as well as stay immersed and transfer the learnings into their every-day-life.

Keywords: Digital game-based learning, climate change, gamification, primary school

1. Introduction

Using games for education has got quite a long tradition, dating back to Plato, for example, when he claimed that children needed to play the same games again and again to make sure that society remained stable (D'Angour 2003). Moreover, he stated that children's play was essential for their learning and especially for developing their character (Bergen 2014). In the 16th century, Comenius wrote a paper dealing with the didactic use of games for children. He claimed that playing – apart from the importance of acting out different situations - was an important activity for relaxing and blowing off steam. Especially progressive educational movements at the end of the 19th and beginning of the 20th century like Froebel, Pestalozzi and Montessori stressed playful activities as significant to children's learning (Bergen 2014). Of course, all these people did not talk and write about digital games but about board games, free play and drama. However, they all recognized the significance of playing as learning process. In the 21st century the method of digital game-based learning became more common at schools. Gee (2005) suggested that videogames of good quality also offered quality learning experience. Another approach having become more widespread is gamification. As per Deterding et al. (2011), gamification can be defined as using game design elements in non-game contexts. Gamification is used to increase motivation and engagement (Cheong, Filippou & Cheong 2014). Burke (2014) defines gamification as using game mechanics as well as experience design to digitally engage and motivate people to reach their goals. Although the roots of gamification can be traced back to marketing (Bogost 2014) and the concept has faced substantial criticism, education and training has introduced gamification and gamified elements as well. As Ramirez & Squire (2014) point out, gamification should not be seen as inherently good or bad. There are many techniques that might be used in various contexts to make learning more challenging, motivating or fun, but some are more frequently used over others. As a review of empirical literature by Majuri, Koivisto & Hamari (2018) has shown the top five elements studies had a closer look at are points, leaderboards, badges, challenges, and levels whereas the psychological outcomes studied mostly concentrate on perceptions of use, perceived enjoyment, engagement, motivation and perceived usefulness.

When it comes to using gamification to tackle the effects of climate change, Douglas & Brauer (2021) showed that there already some games and gamified apps around that promote sustainable behaviour. The reason therefore is that gamification "has the potential to engage individuals and various stakeholders towards climate change through interactive, participatory and meaning-making communication" (Rajanen & Rajanen 2019, p. 254). In a systematic review, Galeote et al. (2021) found out that game-based interventions engaging players with climate change issues and research about it have been growing over the last years.

2. Teaching climate change to primary school pupils

In primary school, subject teaching is responsible for preparing primary school pupils for participation in and shaping an increasingly complex and technological world. Lessons should be designed by teachers in a way that supports learners to explore their immediate and indirect environment in a constructive process, to actively acquire world knowledge and to argue and reflect on their decisions (Greiner et al. 2019). Knowledge and skills should not only be learned and understood by the learners in the individual context, but also classified in contexts and made available under different requirements. Understanding the complex factors that are responsible for climate change is not easy, even for adults. However, understanding how climate change works, what is it caused by, which effects there are on the planet and mankind as well as countermeasures and social options for countering climate change is one of the central issues of our time. This importance is also reflected by including the topic *Climate Action* within the Sustainable Development Goals by the United Nations. The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people can enjoy peace and prosperity (https://sdgs.un.org/goals).

A research project at the University College of Teacher Education Carinthia dealt with the question of how to teach the complex causes and consequences of climate change in primary school. In order to be able to understand the very complex relationships and linking in this context and therefore be able to act in a climate-friendly manner, a step-by-step, relatable knowledge needs to be acquired. This is best done by experience-based development and collection of conceptual knowledge modules for both teachers and students. The focus is on cumulative knowledge building as well as understanding-oriented and concept-related learning. Children are not a blank slate but start every topic with ideas in their heads that are fed by everyday experience. New ideas are thus always formed through the transformation and expansion of these existing ideas. The theoretical background of this question is the theory of conceptual change. Conceptual Change Theory (Vosniadou 2008) understands learning as a constructive and meaningful process that always builds on prior knowledge. According to this theory, new information is placed in relation to existing knowledge, classified and, in the case of incompatibility, is either discarded or initiating a process of reorganizing the existing knowledge. As a rule, this means that the existing knowledge is only changed to the extent that the new information can be integrated into the existing model. Thus, the focus has to be on the question to what extent learning products can influence the development of understanding and the development of key professional insights among learners. Freytag et al. (2021) developed a teaching-learning model to serve teachers as a basis for planning their lessons. As a first step in the above-mentioned project, the participating teachers attended a series of three workshops. In the first workshop, the teachers were presented with a teaching-learning model suitable for competence-oriented teaching. The teachers worked out key professional insights into climate change and made connections to central concepts. In another workshop, the educators dealt with the integration of hands-on experiments in the classroom. The topics of storytelling and gamification were dealt with in a final workshop. The teachers then planned their own competence-oriented lessons using the planning scheme described in the teaching-learning model. For this purpose, the topic of climate change was limited to three essential technical concepts: The concept of conservation: "Nothing is lost in the world", the concept of energy: "You can do a lot with energy" and the concept of interaction: "Factors influencing each other" (Wodzinski 2015). Based on these concepts, the lessons were then implemented in three primary schools. The learning products created during the project implementation formed the basis for the reflective examination of key professional insights and central concepts. They are regarded as the starting point for a cumulative development of understanding of a content or object. In the teaching-learning model, learning products are not understood as final products of learning, but as a central element of the learning and understanding development process. These products make learning progress and gaps in understanding visible and provide starting points for designing lessons (Leisen 2016).

Discussing and reflecting the learning products together with teachers and other learners helps the learners to link the processed content with professional insights and key concepts. The project results have shown that teachers do not see learning products as final products of learning, but as a central element of the learning and understanding development process. The results obtained show that the causes and consequences of climate change should already be dealt with at school with 6- to 10-years old pupils and therefore this project served as the basis for the conception of the Climate4Kids app.

3. Climate4Kids – a gamified app

Climate change can be seen as the primary threat for our planet (Poushter & Huang 2019). As understanding climate change and counter measures is one of the main issues of our time and needs to be dealt with also at primary school, a multilingual app called *Climate4Kids* was developed to give primary school pupils between the ages of 6 and 10 a better understanding of the subject of climate change. With *Climate4Kids* an age-appropriate introduction to a complex topic that will accompany primary school students throughout their lives will be provided. In order to design the app towards the needs of the target group and to depict the content and graphics as authentically as possible, children and pre-service teachers were involved in a co-constructive development process throughout the development period. The app is based on three pillars: First, picture stories are presented which were written and drawn by pre-service teachers and primary school pupils. These picture stories give a narrational frame to draw users in and to arouse interest in the topic. Using the storytelling method, picture stories were written on relevant topics of climate change. Storytelling is a narrative method that is used to pass on explicit, but above all implicit knowledge in the form of symbols, metaphors, or other means of rhetoric. It is mainly used in digital media, but has a long tradition (Landrum, Brakke & McCarthy, 2019). The audience does not only consume the story by listening, reading, or watching, but can also be actively involved as a prosumer in the implementation. The method is based on the following: A vividly told story attracts the attention and focus of other people more easily than a logical, factual presentation of facts. That is why storytelling has been used for thousands of years to pass on complex knowledge in cultures (Yilmaz & Cigerci, 2019). The story can be based on facts, be fictional, or combine both, fact, and fictional elements. Storytelling generates memories and promotes learning. Kearney (1994) claims that especially difficult topics like climate change can better communicated when wrapped into a story. Secondly, the app provides instructions for simple hands-on experiments, that every child can do at home without requiring any special equipment. The third aspect is a more playful. Pre-service teachers have come up with (non-digital) card and cardboard games about climate change and tested them with pupils. Products of all these three parts - digital picture stories, hands-on experiments, and child-friendly games - were then integrated into the app.

The following sections will describe some of the features of the application in more detail as well as connecting them to the concepts of gamification.

3.1 Background story

The app as a new learning and teaching tool is browser-based and will be available in four languages (German, English, Italian and Slovenian). Based on the knowledge how important storytelling is – especially for children – *Climate4Kids* does not only use storytelling for the picture stories but also for linking the different parts of the app (picture stories, hands-on-experiments, and games). The children are guided through the app by marmot “Mani” (cf. figure 1). Marmots are also severely affected by climate change because their habitat becomes increasingly warmer. Due to the rising temperatures, the marmots often feel too hot for looking for food during the day, which means that they cannot store enough fat reserves for the winter and consequently have to starve. Due to this fact, the marmot was considered an ideal avatar to guide children through the app. Mani is the first non-playable character the children come across – he helps with login to the app, guides through experiments (cf. 3.3) or gives a brief overview what the picture stories (cf. 3.2) are about. The character also slightly changes depending on the section of the app – for example: For the story-section he is depicted reading a book and for the experiment section he is wearing a white laboratory coat. Like in many children stories, Mani acts like a human, explaining, showing emotions, or doing different activities. Users of the app should link the character Mani with *Climate4Kids* at once and children should relate to the marmot.

Figure 1: Mani reading a story

3.2 Picture Stories

Picture stories serve as an introduction to a topic and are intended to spark the pupils' interest in the topic and motivate them to engage and interact. Pupils and/or pre-service teachers wrote picture stories dealing with the following topics (content): mobility, renewable energies, waste, albedo-effect and soil sealing. The pictures and the text were made into a film using professional speakers to tell the stories in different languages. These stories take children in fairy-tale like worlds where animals can speak and act like humans (for example a dog going on skiing holidays) or depict more realistic situations like the story Daisy`s journey around the world in which a girl asks a mother what happens to her rubber duck Daisy after she has been disposed. All the stories aim at teaching a lesson about global warming – such making use of the didactic method of telling stories which became popular in the middle of the 18th century when folk stories were emerging as a genre of children's literature (Lewin, 2020). Most of the stories told in the app have a character who acts in an improper way (out of not knowing better) and is taught how to take countermeasures to global warming. In order to haver longer lasting learning effects, the pupils are asked to answer some questions after having listened to the story. These quizzes consist of single or multiple-choice questions reflecting the lessons learned from the story. Although there are more questions for each picture story (about five for each), there is one central concept the pupils should learn. Therefore, the app already matches the requirements of the new curriculum for primary school (to be introduced in September 2023) which put a focus on competences instead of learning facts by heart.

Figure 2: Pupils with their hand-made drawings

3.3 Hands-on experiments

Working on the topics requires a multidisciplinary approach; understanding climate change requires scientific knowledge, but also practical knowledge, as well as sociological and economic knowledge. It is therefore of great importance that pupils experience haptic elements for lasting understanding. This is ensured by offering instructions for hands-on experiments within the app. The decision against a computer-generated simulation was made because as Hufer (2017) puts it learning sometimes needs to be non-digital. Hands-on experiments are primarily intended to increase the motivation of the pupils to deal with the topic of climate. The experiments should be simple, astonish the pupils, but also make them question processes and events and therefore stimulate discussions. Using *Climate4Kids*, the teacher now has the opportunity to have pupils rediscover apparently quite simple effects or to try to simplify relationships that seem to be quite complex. By working on the experiments on their own, the pupil can proceed in an action-oriented manner and make his own experiences (learning by doing). This ensures sustainable education. The simplicity of most experiments allows a wide variety of variations of how to implement them.

Figure 3: Mani carries out the finger warmer experiment according to the instructions on the right

The hands-on experiments, which require little material, nearly no preparation and can be done quickly, should pupils engage and make them curious about and interested in the topics. The experiments are easy to understand and can be used in classroom teaching as a supplement, introduction, or summary of the topic. What is more, the experiments should draw pupils' interest to research, as the hands-on experiments can also be tried out alone at home.

3.4 Games

Pre-service teacher students at the University of Klagenfurt have designed non-digital games for the target group that are intended to successfully connect the digital with the analogue. A deck of cards on the subject of soil sealing, for example, can be printed out and played using the app. Because only by playfully dealing with a topic can the full potential of the children be tapped (Hüther & Quarch 2016).

3.5 Gamification Elements

In order to connect all the above-mentioned parts of *Climate4Kids* and to make sure players can really engage with the app in a playful way, some more elements of gamification have been introduced. In 3.1, we have already discussed the use of a background story to immerse the target group more in the environment of the app. As the objective of the app is that children have a look at all the parts (especially listen to / read the picture stories, do the quizzes afterwards and do the hands-on-experiments), a reward system was integrated: When the quiz questions have been answered correctly, players can earn trees which will be planted at the start screen of the app (this screen is also used to choose the topic the learners want to deal with and are the direct way of choosing a picture story). Figure 4 shows what the start screen looks like when players have planted two trees (which means they have answered two questions correctly) and what it looks like when 21 trees have already been

planted (meaning in summary 21 questions have been answered correctly). Therefore, advancement in the game can be seen at a quick glance at the start screen.

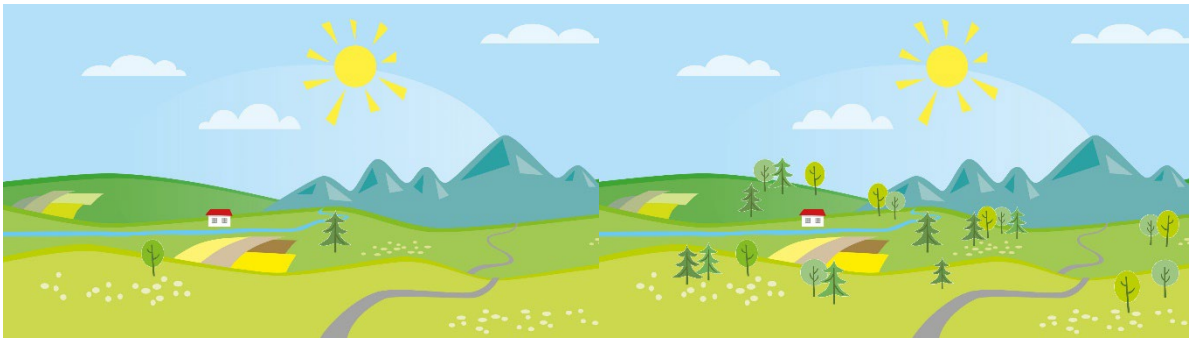

Figure 4: The more activities the player completes, the more trees will be planted

Instead of a traditional progress bar, the app uses the face of the planet getting happier and happier depending on how many trees have already been planted. This way, planting of the trees shall also be associated with the healthiness of our planet by the players. The face of the planet will change throughout the game. Additionally, there will also be a health bar showing players how many trees they need to plant to reach the next level (or face) of the planet.

Figure 5: The more trees are planted, the happier the planet will get

Visualizing the progress in the way shown should fulfil different purposes: First of all, pupils should be encouraged to answer the questions in the quizzes correctly to be able to plant more trees and try quizzes more often until they get all the answers correctly. To encourage redoing the quizzes, the full number of points (and trees) can only be reached when all the questions have been answered correctly three times. This way, the number of repetitions is raised which also makes lasting learning effects more probable. If a question is answered incorrectly, pupils will not be presented with the correct answer but will be referred back to the picture story (or the experiment). Second, pupils can only collect all the trees if they not only listen to / read the picture stories but also do the hands-on experiments as quiz questions will address both areas. This way, the rewards should help to tackle all the areas of the app and not only concentrate on one or two topics or not doing the hands-on experiments at all. However, the app will only present questions to picture stories / experiments that have at least been opened once by the player. Third, various player types according to Bartle (1996) shall be addressed: Achievers want to collect all the trees as fast as possible and reach the last level – the healthy earth face. Explorers will love the back story and the picture stories as well as Mani as the character guiding them through. As the app does not provide a multiplayer mode, those players belonging to the group of Socializers need to be catered for outside the game by talking about it in classroom and exchanging game experiences. The last type, Killers, could have easily been targeted by integrating a high score board. However, as the topic of the application does not agree with competition, this element was not used.

4. Conclusion and outlook

The app *Climate4Kids* aims at showing primary school children which effects of climate change there are and – even more important – what everybody can do to take countermeasures. By tackling the complex topics in a playful way, the project team hopes to give teachers a tool which can be used versatile. However, the intention is that the children and young people do not only use the app in classroom settings, but also at home. This way, parents can also get informed about the topic of climate change and can talk with their children about the themes depicted in the app and find solutions on an individual level how to take small steps to improve life for nature and mankind. Since the content is developed in a playful way and users can make their own haptic experiences through the hands-on experiments, a lasting effect is guaranteed. In order to find out if the app

really works in primary school contexts, playtesting and evaluation of the app is planned for the fall of 2022 when pupils of some chosen schools will be introduced to the app and use it in classroom teaching. As not only children but also primary school teachers belong to the target groups, both groups will be asked about their experiences using qualitative and quantitative approaches. The results of this evaluation will be used for adapting and improving *Climate4Kids*.

The elements discussed in this paper were developed in a first step. In follow-up projects, the use of the Climate4Kids app will be expanded and more topics and elements will be integrated to make playing and learning experience even better. Modern methods of digitization, such as gamification, digital picture stories, storytelling, games and freehand experiments are to be expanded with other didactic methods. The application in its current form introduces primary school children between the ages of 6 and 10 to the topic of environmental protection and climate change. In a next development step, the Climate4Kids app is to be further developed so that it can also be used by children between the ages of 10 and 14. In terms of content, it is planned that the concept of the circular economy, such as the sustainable consumption of electrical appliances, will be incorporated into the app. The general goal of this follow-up project is to bring the issues of climate change, environmental protection, and the circular economy more into the focus of the younger generation, to work out the need for ethical action through an understanding of the scientific background and to motivate players to take specific steps. Sustainability is particularly evident in the use of the project results, which are not only available free of charge to a small group of people involved in the project, but to all pupils who want to use this app. The app as a new learning and teaching tool will be used internationally and will be available in five languages (German, English, Spanish, Italian and Slovenian). To ensure that the new versions of the Climate4Kids application developed in this project will be used in classroom teaching of primary schools, further training courses for teachers (train the trainer) on the topics dealt within the application, such as the sustainable use of electronic devices, will be developed at the University of Teacher Education in Carinthia. These training courses can then be offered regionally, nationally and internationally for teachers.

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