Cloud Computing - An Educational Game on Weather Phenomena

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***Abstract*—We experience weather every day, yet many people do not know how different weather phenomena come about. In this work, we present "Cloud Computing", an educational game that instills a meaningful subset of the according relationships and mechanisms. In the game, weather phenomena are animated based on environmental parameters entered by the user. The user is engaged by "weather quests", for example the task to create a thunderstorm. The user improves his highscore and levels up solving such quests. The challenge of setting the parameters rises with an increasing level, but exuberant difficulty is diligently avoided. Intermittent tests and evaluations involving potential users determined the final design of the game. The available scientific data significantly shaped its basic structure as well as its aesthetics. Cloud Computing was thoroughly evaluated by more than thirty persons in order to ensure its effectiveness—both in terms of engagement and learning targets. The survey is included towards the end of this paper.**

Keywords*— *interactive simulation, educational games, serious games, weather phenomena, clouds

I. Introduction

Weather prediction is of great importance and defines a considerably large domain of research. It is discussed, for example, at the American Meterological Society Conferences [1] and the World Weather Open Science Conference [2]. Only little changes of climate conditions can cause great weather alterations. To interpret these indications properly and to know which weather phenomena will occur, a person has to understand the scientific background of weather formation. Cloud Computing, the educational game presented in this paper, aims at imparting the necessary knowledge. The game's initial idea was influenced by the Pixar short movie "Partly Cloudy" [6]. While watching the movie it appeared that the common belief that clouds shape the weather is widespread. It is a common misconception that clouds are the *cause* for certain weather phenomena [3], whereas their formation is only a visually noticeable side-effect of specific weather phenomena [4]. Cloud Computing highlights this insight and conveys the variables and parameters that can be considered the actual underlying factors. The game is dedicated to and was developed for adults. For scientific research, the level of detail is not appropriate. For children, the presentation of ideas and learning content might be too complex and not appealing.

The game shows islands, which represent different climate zones that correspond to the real world, and the different levels. Each island has an increasing number of quests. This makes each level harder to successfully complete it than the previous level. In the game, the user is encouraged to manipulate certain sliders, e.g. changing the ambient temperature [5], to make animated weather phenomena occur. If the user struggles to create a certain weather phenomenon, hints are available to help him find the right adjustments of the sliders. This paper describes the development of the game as well as the scientific requirements and the background. The research target of this work can be summarised as conveying the influence of different conditions on emergence of certain weather phenomena in the context of an educational game.

The remainder of this paper is structured as follows. In Section II a brief overview of the related work is provided. In Section III, the methodology including the concept idea as well as our agile, user-centred design process are presented. At the end of the paper, the results are discussed in Section IV, the stated claims are supported by means of a user survey, and an outlook to possible future work is given.

II. Related Work

Weather forecasting is a heavily studied research topic. As an example, the Thor Project, founded in 2002, addresses the challenging task of forecasting thunderstorms especially to improve aviation safety [13].

A great number of games already revolve around weather and climatic topics. Yet, only few are based on scientific facts, and, as far as the authors know, there is not a single one that is based on animating weather phenomena. Addressing the animation aspect, however, some titles are similar to the presented approach. In [7], for instance, the weather can be changed and influenced by varying the ambient temperature at the ground and three levels above. According to the settings, the result of the simulation of the precipitation is altered. The simulation differs from Cloud Computing as it does not offer any game mechanics, there are no tasks presented that need solving. Similar to [16] or [17], all weather effects were rendered as particle systems from the Asset Store in Unity3D [15]. A recent discussion of cloud-generation and –rendering, that provides a good survey of this field, is [18]. Another related title is "The Weather Game" [8]. Here, the task is to answer weather-related questions. "The Weather Game" includes no animation and no interaction with weather conditions or phenomena are offered. Computer-based board games like "Wild Weather Adventure" [9] by NASA educate children about weather phenomena and climatic processes, for example by asking questions about components of clouds or prevailing winds in certain regions. The game "Weather Maze" [10] is rather similar to Cloud Computing with respect to solving quests. However, here the user cannot proactively play a role in the emergence of weather phenomena. Furthermore, "Weather Maze" is limited to weather icons instead of animations. In general, there are many games dealing with the topic weather, especially for children. Creating it as an interactive edutainment game with real weather to be animated is a novel approach. The scientific foundation and the distinct target group of our approach differ substantially from other titles in the field. Due to these distinct features, it can be classified as an edutainment game [14].

III. Methodology

In this section, the methodology of developing the game Cloud Computing with the game engine Unity3D [15] is decribed.

A. *Overview of the Game Mechanics*

This section gives a brief introduction of the game. We describe what the user sees first and what he is supposed to do at which stage. First in the game, the start menu is loaded. This menu contains the two buttons “Start Game“ and “Introduction“. In the introduction the description of the game and an explanation of the basic functionalities are provided.

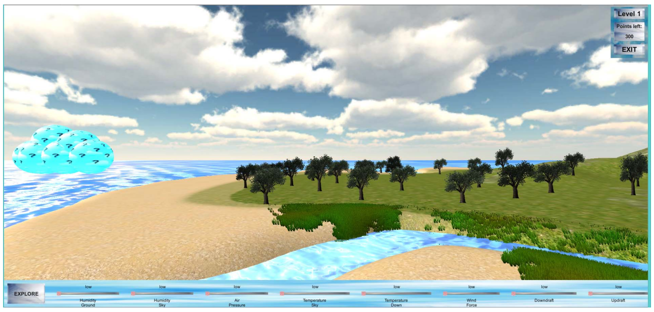

Fig. 1. The main screen of Cloud Computing.

After starting the game, the first level is loaded and the GUI for user interaction is displayed, as can be seen in Fig. 1. A 3D island is shown to the user. It is a closed environment with a few quests represented by 3D cloud icons. The user can decide whether he wants to solve these quests or explore by himself setting sliders and clicking the “Explore” button. The sliders on the bottom represent the changeable weather conditions and are always visible to allow for self-guided learning via the “Explore” button, as displayed in Fig. 4. The sliders each have three levels (low, medium and high), regulating the humidity of the air, air pressure, temperature, the wind force, as well as the up- and downdraftThe other permanent GUI element is in the top right corner of Fig. 1 and shown in detail in Fig. 2b). By clicking on the “Level” button, the next level is loaded, if all quests on an island have been solved successfully and the reward for the quest has been added to the user’s score. In order to quit the game, an “Exit” button is included to this GUI. The player clicks on one of the cloud icons to start a quest. The quest details are displayed in a pop-up window. Compared to [19], Cloud Computing does not allow the user to adjust settings of one phenomenon in different manifestations, but of different phenomena altogether. To further exploit this learning opportunity, a quest starts by asking for the proper names of a visualized phenomenon, or vice versa. Afterwards, the user can work through the presented phenomena one after the other.

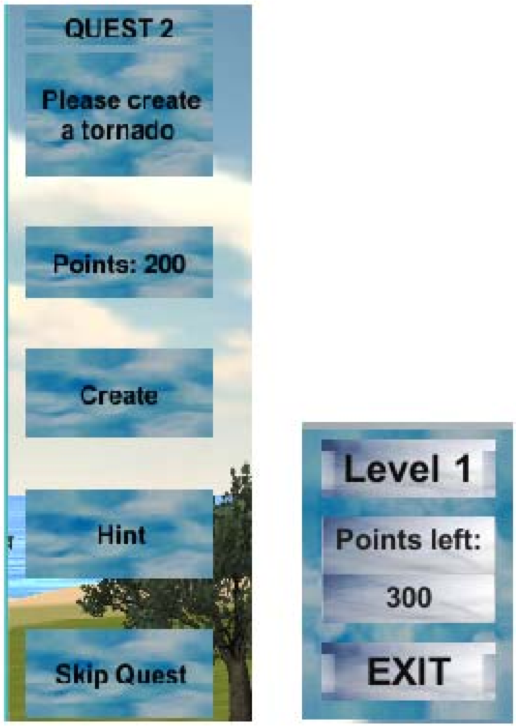

Fig. 2. a) Interaction bar during solving quests (left)
b) GUI element is in the top right corner (right)

Fig. 3. Task after clicking on a quest cloud: Select right cloud formation according to the weather phenomena

At that point, a hint may be given to continue. After this task was solved successfully, the sliders have to be set to the right positions in order to start the animation of the weather phenomenon. When solving the quest, a GUI bar appears to the left (see Fig. 2a): It contains interactive and non-interactive elements. The first three labels from the top inform the user about the quest to be solved, including the points that can be achieved. The three buttons below have the following functions: By clicking “Create”, the weather phenomenon is animated if the sliders were adjusted correctly. . If only one slider has the wrong settings, the desired weather phenomenon is not animated. An example is depicted in Fig. 5, where a tornado is created, Fig. 4 shows the correct settings for the tornado. Other weather phenomena are thunderstorms, winter storms, rain, hail, fog, tornados, and snow. By clicking the button ”Hint”, further explanations and instructions are shown. “Skip” abandons the currently active quest.

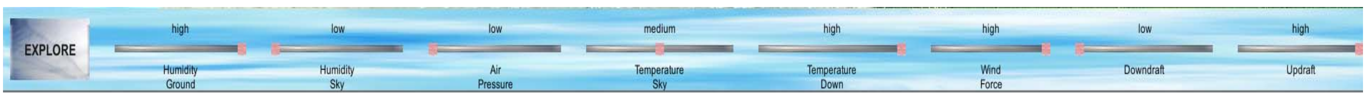

Fig. 4. The slider bar with settings of a tornado

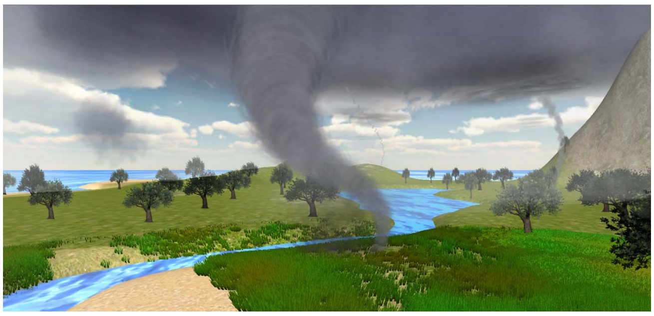

Fig. 5. The triggered weather phenomenon – a Tornado – is animated

After the weather animation, level and score are updated. The actual simulation model of Cloud Computing is based on a comprehensive database (derived from [12]), comprised of several rules that link the adjustable weather parameters to (a) certain changes in the parameter settings themselves, (b) changes in the weather, and (c) emerging weather phenomena as a whole.

B. *Concept User Experience*

While the player levels over time, his knowledge grows. He receives feedback after testing the slider adjustments if he is either solving a specific task or experimenting on his own agenda. The feedback is served as an animation of the effected weather. The game consists of different levels, which aims at an increase of complexity over time and provides guidance for the user. The camera movement is restricted in order to focus the user's attention on the important parts of the game. There is no movement of the camera while the user is adjusting the sliders or clicking buttons. Zooming in and out to see details of the level scenario and the animations is allowed for the user's comfort and it is possible to rotate the camera. The "Explore" button emphasizes the autonomy of the user, wheras the combination of questions about cloud types, the interaction with weather conditions, and animated weather phenomena ensure the immersion into the targeted educational domain.

IV. Results and Discussion

The edutainment game Cloud Computing instills the underlying mechanisms of the formation of various weather phenomena. In the following paragraphs, the complexity and elaboration of the finished game are elucidated.

A. *Science, Gamification and Complexity*

The simulation provides an insight into the development of various weather phenomena. As described in Section III, the user learns what weather conditions have to be given to create, e.g., thunderstorms, rain, or hail. The weather phenomena are presented in an abstract form and only selected influences can be changed. This, in combination with the underlying scientific basis ensures a focused learning experience. The necessary criteria for each weather phenomenon are based on scientific research to ensure the correct visualisation and a knowledge increase. Interaction is required in Cloud Computing through the already mentioned quests and levels. Experiencing dangerous weather phenomena in a safe, virtual environment can be fun. Animation, immediate feedback and hints provide for a smooth gameplay. The motivation of the user is supported by a decent difficulty of the tasks. They are neither too easy, nor too challenging.

In the game, weather is simulated in an abstracted form, by focusing only on some aspects. But they are still recognizable for the user. The abstraction was implemented by developing weather phenomena in a shorter period of time, since their formation would need more time in nature. Complex processes like seasons are not taken into account.

B. *Aesthetics*

The novelty aspect of the game is the new approach of a holistic simulation of interactively changeable weather. Thereby, we wanted to cover more aspects of the topic than other games. The abstracted presentation of varying islands with trees, mountains, rivers, lakes, sandy beaches, and much more contributes to the aesthetics of the game. The coloured and uniformly presented quest clouds suit the uniform style of the game. We tried to create a clear and suitable presentation of details at the specific levels to accomplish an aesthetic view and facile understanding. The quest presentation as well as the self-explaining three levels for each slider were created to increase the sleek and simple appearance. The introduction shall prepare the user for the game efficiently, so no further explanation is needed during the game. Furthermore, solved quests disappear to contribute to a clean and structured overview. To provide a comprehensive overview throughout the game, a restricted camera navigation and first person view is used. With the appearance and consistency of the label, buttons and windows we tried to contribute to the clarity of the game. The informativeness of the game is high (Section IV.C), as only needed information is presented and hints can be used if necessary. The different buttons are self-explaining as well as the score level on the right hand side as shown in Fig. 6.

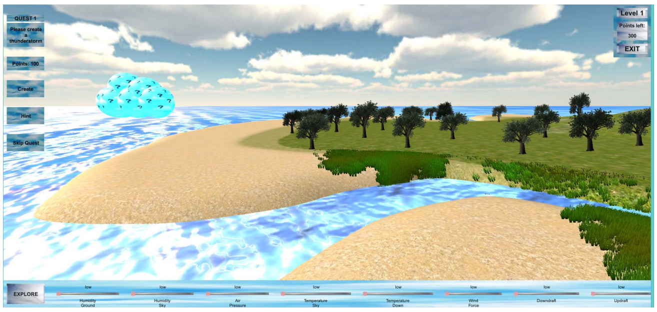

Fig. 6. Scene with Sliders and Quest Cloud before choosing a quest to solve

C. *User Survey*

To get feedback about the game, a user survey was conducted. 34 persons provided feedback, the age of the experimentees ranged from 16 to 31. First, the knowledge of the experimentees about serious games, weather in general and weather phenomena in particular were identified by asking about prior knowledge on the mentioned topics. Therefore, the survey started with the questions "Do you know the term `serious games'?", "Have you ever played a serious game?", and "Do you have detailed knowledge about the formation of weather?" 50% of the experimentees knew the term "serious games", 44.88% already played a serious game. Only 18.18% had detailed knowledge about the formation of weather phenomena. Afterwards, the experimentees were asked to experience the game and answer questions about the game play. In detail, we asked about the navigation throughout the game, intuitiveness, representation, fun, learning factor, and willingness to recommend. The answer possibilities were each "poor", "fair", or "good". All criteria were mainly evaluated with "fair" to "good", details can be seen in Table 1. Noteworthy is the high fun value (46.88% rated "good") and that only 6.25% criti-

cized a "poor" learning factor. As a last, the experimentees were asked to overall rate the game, answer possibilities were "excellent", "good", "fair", "poor", and "very poor". A majority rated the game as "good" or "excellent" (48.39%, respectively 22.58%), no one said it was "very poor", the remainder rated the game "fair" or "poor" (19.35% respectively 9.68%).
With these results, further improvements, e.g., on the navigation throughout the game, can be made.

	Poor	*Fair*	*Good*
Navigation	15.63%	**46.88%**	37.5%
Intuitiveness	9.38%	**50%**	40.63%
Representation	6.25%	**53.13%**	40.63%
Fun	12.5%	40.63%	**46.88%**
Learning	6.25%	**59.38%**	34.38%
Willingness to recommend	15.63%	**43.75%**	40.63%

Table 1. Results of the user survey.

V. Conclusion and Future Work

The aim of the project was to create an educational game. The presented game idea was compared to related games, the concept idea and design decisions were explained in detail. In addition, the complexity of the topic, the simulation and the user experience were introduced. All in all, the learning game is ideal to get a basics knowledge about and understanding weather. It is by no means usable, however, for weather research as an accordingly complex representation and necessary details are not integrated. For future work, it would be possible to expand the abstracted model or create real world scenarios with more complex phenomena like ocean currents or the coriolois force. Therefore, additional sliders or "bonus quests" could be added. In addition, it would be possible to integrate seasons, climate change and different climate zones, as they are not represented in this model. A great extension would be the combination with other games. For example, a game with the goal to grow plants could use the sliders to change the weather and therey the growth in specific niches. In a real-time strategy game, the power to influence the weather could become a strong ally in epic battles – all, of course, inspired by actual historic events.

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