



Context-Aware Procedural Content Generation with Player Modelling in Mobile Action Role Playing Game

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Abstract—This paper aimed to discover how player satisfaction is affected by context-aware elements based on physical, real-world factors in an action role-playing game. The possibility of utilizing player modelling to counteract the reduction in player empowerment in a game heavily influenced by external factors was also explored. This was accomplished by creating an ARPG heavily integrated with various weather, and daytime, context data obtained from web-based APIs. Followed by conducting qualitative tests with help of eleven participants during a time period of a week. The evaluated results were presented in a manner of relevance for both context-driven applications as a whole, and for further exploration within game developments utilization of state of the art technology.

Index Terms—Procedural content generation; Context awareness; Player modelling; Action role playing game; Mobile game; Application programming interface; Game development; Context-aware games;

I. INTRODUCTION

Weather and season are big parts of everyday life, even though often only seen as an entity in the subconscious part of the day. It is possible for weather to become salient when people integrate it into their personal narratives [1]. Thanks to the vast amount of free web services and application programming interfaces (henceforth API), such as “Open-WeatherMap” [2] and “Sunrise-Sunset” [3], contextual data about the real world is gradually becoming more accessible over the Internet at all times. Opportunities arise for more contextually dependent applications, even with a more playful approach making it possible to amplify natural shifts in the real world within both time of day and season to further enhance virtual world experiences by making them more dynamic and intertwined with real life.

Computationally inexpensive procedural content generation (henceforth PCG) methods are fit for mobile games due to the need to cater to a broad player base as the platform offers [4]. Catering to a large player base can be done with help of adapting game content depending on specifically constructed player models from not only playstyle but also difficulty management [4].

The outline of the remainder of this paper is as follows. Firstly, related research will be evaluated then important terms for the paper is defined. Secondly, the goal of this study is presented. Followed by an explanation of the methodology

in use and a discussion about the choice of the particular execution of it. Afterwards an explanation of the artifact created is given to finalize prerequisite understanding needed before continuing onward to the result section, discussion and conclusion of the paper.

A. Related research

Previous research has been carried out to adapt games after different scenarios and needs of the consumer [5], [4]. Research has shown that there is a demand for more games that adapt after the players needs and circumstances [5]. Consumers want play sessions which are suitable for them instead of being limited from progression based on their access to playable times [5].

1) **Procedural Content Generation (PCG)**: Procedural content generation is a problem area in both games research and game development given that the opportunities present in crafting artifacts for player consumption. As defined by PCG Wiki: “Procedural Content Generation (pcg) is the programmatic generation of game content using a random or pseudo-random process that results in an unpredictable range of possible game play spaces” [6]. Current trends in game development focus on shorter development times while also increasing content available for the consumer, a powerful tool for this is PCG [7].

Computationally expensive methods are not suitable for mobile games due to the limitations of the devices in question. However, cheaper PCG methods are suitable for mobile games due to the large audience the platform provides. The mobile game market has a larger focus on casual games and gamers, which in hand requires support for a wider range of player capabilities [4], [8].

2) **Context Awareness (CA)**: A system using context awareness (henceforth CA) is being provided with information about location, weather, or other relevant data, about the device’s current surroundings to provide the user with relevant services depending on the task being handled [9].

Context is seen as information usable to identify the surroundings, or situation, of an entity. An entity is not limited to being a place or device, it can also be a person, system user, or computational object. Possible context information could be a specific city, the weather conditions of the city, or the amount of relevant connected devices in that city. The

definition of context-awareness in this paper is when making use of context to provide relevant information and services to the user [9].

3) **Player Modelling (PM)**: Player models (henceforth PM) are computational representations built on top of dynamic, or static, information that has been obtained from a player's behaviour in one, or more, game sessions. After the construction of the model it is used to change the gameplay experience to be more suitable for players in regards to their personally constructed player model [10], [11]. There are two approaches to player models, one being the model-based approach (also known as top-down), and the other being the model-free approach (also known as bottom-up) [10], [11], [12].

Player models input are divided into three main types: gameplay data, objective data, and game context. Gameplay data is information about the player's behavioural responses when playing the game. Objective data is measurements as pulse, eye tracking, etc. measured while playing the game. Lastly, game context is characteristics about the game world itself as e.g. how many rooms that exist in a given dungeon. [10].

PMs are fit for dynamic difficulty adjustments according to playstyle and performance [4], [13]. There has also been investigations made on how PM can make games more engaging or fun for various types of players [14].

4) **Context Aware Procedural Content Generation (CAPCG)**: Context-Driven PCG is a term for content generated with regard to the player's explicit or implicit requirements, e.g. a defined time limit to the play session [4]. Experience-Driven PCG on the other hand is when the generated content relies on player-generated, or player-observed, data such as an implicitly measured level of skill [12], [10].

Both the explicitly defined context-driven perspective as well as the implicitly defined experience-driven perspective can be seen as context-awareness, specifically within the human factors [15]. Human factors can be split into three categories regarding the user: information (as in habits and emotions), social environment (such as location of others, social life, group dynamics) and tasks (activities, engaged tasks, general goals) [15]. In the area of PCG human factors are a good fit with the concept of PM for dynamic adjustment of content [4], [13].

5) **Context Aware Games (CAG)**: Context-aware games (henceforth CAG) make use of details about the environment in which they are played to adapt the game content or experience in a certain way. Location is the most commonly used context in CAGs [5], [16], [17], [18], [19], [20]. However, there is more context to utilize than location [15] such as driving related data [21], air pollution data [22] or bus schedule data [5].

The reasoning for using context-awareness in games differ significantly by each instance [5], [16], [17], [18], [19], [20], [22], [21]. There are games like "CABDriver" which uses driving-related data from a car to increase passengers awareness of the driver's behaviour which in turn can possibly

result in refraining from speeding and other bad driving [21]. Games such as "Bus Runner" which utilizes context about the specific bus ride so that the player knows where the bus is taking them even though focusing on the game rather than looking out of the window. It also ensures that a play session has a desirable duration correlating to the duration of the specific ride [5].

Other games like "Free All Monsters!" and "Pokmon Go" use context to encourage physical exploration and visitation of local landmarks [16], [20]. Location-based games have also been developed to help freshmen get to know their surroundings quicker by conveniently providing them with information about landmarks in the area [19].

The game UKKO makes use of CA to encourage children commuting to and from school by foot to take a less air-polluted path [22]. This is possible thanks to both an air pollution API and location data from the device being used to play on [22].

B. Research questions

Previous research has shown a correlation between context awareness and satisfaction [4]. However, there is exploration to be done within the idea of tying geolocational context awareness together with more conceptual context awareness of the player decisions [4]. With that in mind this paper looks to explore the following two questions;

- RQ1 How is player satisfaction affected by context-aware elements based on physical, real-world factors in an action role-playing game?
- RQ2 How can PM be utilized to counteract the reduction in player empowerment in a game heavily influenced by external factors?

To further clarify "Player empowerment" in RQ2 alludes to the situation in which players feel irrelevant (less empowered) due to a game world heavily adhering to external factors rather than the player itself.

The contributions of this paper are aimed at investigating the effectiveness of using CA and PM within PCG to increase replayability and enjoyment from generated macro-level puzzles. As well as how the dynamically changing behaviour and difficulty of the game based on player performance affects player decision making and relevance within the game world. Due to the player's own decisions being one of many various systems affecting the game world it was seen as a reduction of player empowerment in a heavily context-aware game world compared to that of a mostly static world where change only revolves around player actions. This will be implemented into the game Dungeon Clearer, an action role playing game [23] (henceforth ARPG) from a top-down perspective. Dungeon Clearer is inspired by games in the likes of the early games of the Legend of Zelda franchise [24], Diablo 3 [25], Hero Siege [26], Fate [27] and Fable 2 [28]. The game was designed specifically for testing and implementation of contextual elements.

II. METHOD

This paper follows the formal suggested design research methodology defined by Peffers et al. [29] It is broken down in the following six steps:

- 1) **“Problem Identification and Motivation:** Define the specific research problem, and justify the value of a possible solution. The problem definition will shape the solution, so atomizing the problem may be useful in order to find a possible solution.”
- 2) **“Define the Objectives for a Solution:** Here one should infer the objectives of a solution from the problem definition established in step 1, with knowledge of what is possible and feasible. The objectives can be quantitative or qualitative.”
- 3) **“Design and Development:** During this step the artifact is created. This activity includes determining the artifact’s desired functionality and its architecture and then creating the actual artifact.”
- 4) **“Demonstration:** Demonstrate the use of the artifact to solve one or more instances of the problem. Could be by using it in experimentation, simulation, case study, proof, or other appropriate activity.”
- 5) **“Evaluation:** This activity is used to observe and measure how well the artifact supports a solution to the problem. This involves comparing the objectives set in step 2, with the gathered results from where the artifact was used in step 4.”
- 6) **“Communication:** The final step is communicating the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to relevant audiences.”

A. How the method was used

1) **Problem Identification and Motivation:** Full control over the game was desired for the experiment. The reason being that having full control over all relevant variables and logic of the game made it easier during development to create the desired game mechanics and dynamics deemed necessary and relevant for the research questions of this paper. Since the game has external dependencies such as web-based APIs it was desirable to keep the core game free of additional external dependencies. This could be guaranteed by developing it specifically for the experiments. The solution to this requirement was found by developing an ARPG where it is possible to change ways of representing the external CA factors of the game world, as well as changing the internal PM factors of the player, depending on feedback received from play tests during the development.

Thanks to having developed the artifact with extensibility in mind the CA and PM systems had been abstracted into

their own components which could easily be altered without seeing rippling change throughout the whole application.

2) **Define the Objectives for a Solution:** The goal was to create an effective combination of CA and PM in a game such that the player noticed the external changes caused by the CA while the PM ensured that the players did not feel as if their decisions or playstyle did not matter to the game [30], [10]. Decisions such as a player avoiding an enemy or taking them on modified the amounts of enemies that appeared further into the game. This would cater to the players play style and give their decisions importance to the game. The context variables changed the world aesthetic to immerse the player in the world as they drew parallels to the game from their real life surroundings. In other terms; to provide a living game world without making the player feel irrelevant in the big picture of it.

An artifact was created to ensure full control over all the parameters and data needed to change the specific spawn amount of enemies, world changes and stats on enemies or items. Thanks to having full control over all the variables it was easier to control the various effects to achieve the goal of this paper.

It is important to acknowledge that even though extensibility was paramount for the development and focused upon, the most important aspect for the paper was to be able to convey the CA and PM in such ways that it could lead toward answers for the research questions. Due to specifics like this it was deemed more appropriate to develop an application rather than force a context system into a previous existing application.

3) **Design and Development:** Creation of the digital mobile game was done by using the video game engine Unity [31]. Within the game the player controls a character which purpose is to repeatedly clear dungeons. This is achieved by defeating the dungeon boss. If the player succeeds rewards in form of updated statistics (see the “Dungeons Cleared” in Fig. 1) and new items were granted. However, if they lose, all progress of that dungeon would be gone. The game world itself adapted with regard to data extracted from the real world at the location of play with use of web-based APIs.

4) **Demonstration:** The players were a group of eleven testers. The test session was a period of time spanning for one week. Testers played the game during different times of the days, to accommodate for different times and weather types. Once the tests were over all testers in the group received a questionnaire that included questions formulated so that information regarding whether the players enjoyed and noticed the differences that the CA and PM brought to the gameplay sessions. After the questionnaires had been filled, out a personal interview was conducted with every tester. During the interview more nuanced questions were asked regarding the enjoyment and satisfaction of the game. It is worth noting that this means that all the results recorded are subjective opinions and no means of objective psychological statements were measured. The opinions measured were those believed to be expressed by the test candidate.

The questionnaires and interview questions were formulated using the methods defined by Sweetser et al. [32]. The eight criteria for player enjoyment are as follows:

- 1) “**Concentration:** Games should require concentration and the player should be able to concentrate on the game.”
- 2) “**Challenge:** Games should be sufficiently challenging and match the player’s skill level.”
- 3) “**Player Skills:** Games must support player skill development and mastery.”
- 4) “**Control:** Players should feel a sense of control over their actions in the game.”
- 5) “**Clear Goals:** Games should provide the player with clear goals at appropriate times.”
- 6) “**Feedback:** Players must receive appropriate feedback at appropriate times.”
- 7) “**Immersion:** Players should experience deep but effortless involvement in the game.”
- 8) “**Social Interaction:** Games should support and create opportunities for social interaction.”

The subset of criteria deemed relevant in regards to testing the PM and CA are as follows: challenge, player skills, and control are relevant for PM. This because the PM will be affecting how difficult the game is in regard of enemies in the dungeon depending on the players choices made and actions during previous gameplay. Control fits well as it is the player themselves who control their playstyle that the PM is built from. Challenge and player skills go well together due to the difficulty rising with said PM construction. Feedback, immersion, and social interaction are relevant for CA, as they cover relevant areas that CA affect such as helping the player feel more viscerally involved or experiencing that they are progressing towards their goal. It also encourages the player to discuss the game both online and offline in regards to weather. Questions for the questionnaire and interview had a large focus on these points.

5) **Evaluation:** During the evaluation process the results from the demonstrations (step 4) were reviewed. While reviewing them all answers are taken into consideration towards the criteria mentioned and then grouped together into their respective categories. After categorizing the answers into groups, depending on similarity to other participants answers, at least one answer from each group was presented in the paper as to not repeat similarities unnecessarily. Revision of the extracted criteria occurred in consideration to how the tests had played out as well.

6) **Communication:** In the end the results was documented and submitted, a discussion and conclusion were included to open up for further research as well as present what had been found out during the study, respectively.

B. Method discussion

Once the research questions were identified other CAGs were looked into to get a better understanding of their CA aspects. Due to the lack of successfully finding ARPGs

utilizing CA identification and examination of other types of CAGs were conducted. By expanding the understanding of what types of CA that seemed to work better or worse in different CAGs the problem could be brought up in abstraction level to one with known and useful methodologies.

Due to the desire of wanting to solve a problem of adding context aware components in digital games, identified by previous research with a digital system, the decision was made that the design research methodology by Peffers et al. [29] was a good choice, and would provide a structured and proven process for building and presenting a solution to the problem. By applying evaluation methods from Sweetser et al. [32] it was possible to generate and present metrics that measure enjoyment from the CA and PM elements of the game. This enabled measurement of the viability of the design towards the player and also made it easier for further research in this area to compare their results with the ones presented in this paper.

III. DUNGEON CLEARER

A. Description

Dungeon Clearer is a single player ARPG for mobile devices focusing on completing and advancing through procedurally generated dungeons. While a session will at the very least last around two minutes, because you can not reach the end goal before that amount of time, it will not last more than approximately 10 minutes. This is to make sure that the players time is not wasted and that an interruption will not hinder players progression [33]. This is guaranteed by keeping track of the time as part of the dungeons generation algorithm. When a dungeon is completed the player is rewarded with a piece of equipment scaled accordingly to the difficulty of the dungeon. Dungeons gradually grow more difficult for each previously cleared dungeon by the player.

Dungeon Clearer takes inspiration from games like The Legend of Zelda [24], Diablo 3 [25], Hero Siege [26], Fate [27] and Fable 2 [28]. The game features melee combat and puzzles that the player needs to solve to traverse the dungeon.

B. Game overview

A play session starts with a menu in which the player can advance into their inventory to prepare their equipment for the upcoming dungeon. Moreover it is possible to see the number of dungeons cleared, as well as exit the application, and see the credits, from this screen. See Fig. 1 below.



Fig. 1: The main menu in Dungeon Clearer.

In the inventory menu the player is presented by various inventory slots, descriptions and buttons. The Inventory slots

will be empty from the start, but as the player clears dungeons items will be rewarded and appear there. The description shows the stats of the selected item or of the player depending on which description tab is activated. The grid under the player consists of currently equipped items for the player. Lastly, the back button brings the player back to the previous menu (Fig. 1), “Delete” removes the selected item and “Play” starts the dungeon. See Fig. 2 below.



Fig. 2: The inventory GUI in Dungeon Clearer.

From this menu (Fig. 2) the user presses on the play button to start a dungeon. The first room of the dungeon is procedurally generated when the player presses the button. Other rooms are generated as the player traverse the dungeon in that specific direction.

As the game progresses in the dungeon the player has to complete missions such as unlocking doors by defeating enemies or solve puzzles to advance through the rooms until finding the room containing the final boss. Once the final boss of the dungeon is defeated the player is rewarded with equipment and sent back to the menu (Fig. 1).

If the player dies while playing a dungeon they are sent back to the menu (Fig. 1) without getting any equipment or other reward, which leads to a loss for the player. See (Fig. 3) below for examples of rooms that can be found in the dungeons:

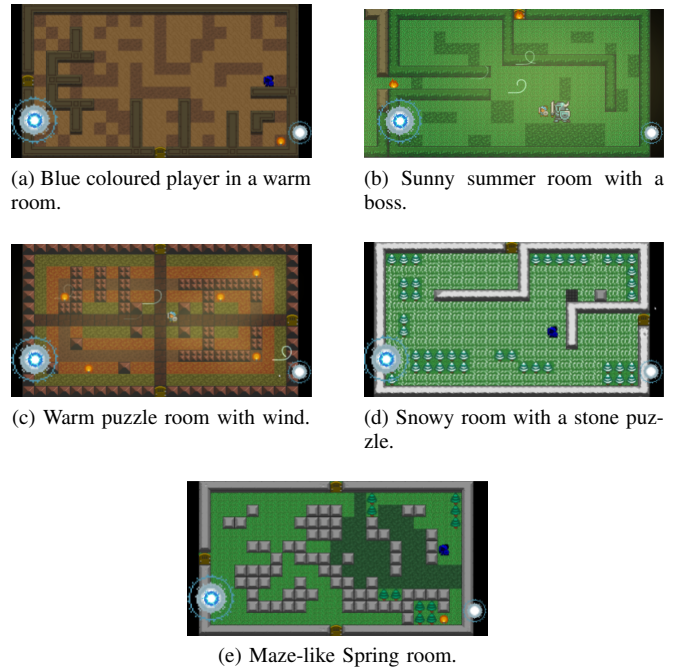


Fig. 3: Various rooms in dungeons.

1) Stats:

- **Health Points (HP):** Characters are alive if the HP are above 0, otherwise they are dead. Characters lose HP when taking damage.
- **Damage:** When attacking a target, it takes damage based on this stat.
- **Elemental damage:** Bonus damage with a specific element.
- **Elemental resistance:** Removes a specific percentage of elemental damage taken.

2) **Items:** A player can acquire several different types of unique equipment that affect gameplay. When a player receives an item that suits them they can equip it. There are several item types, such as one handed and two handed weapons, breastplates, helmets etc. All of these affect gameplay in a different manner, when a player is using a one handed weapon they are able to deal a moderate amount of damage as well as equip a shield in their other hand to increase their defensive stats. Players can also decide to wear a two handed weapon which gives rise to the more offensive approach of play style by dealing higher amounts of damage, while sacrificing defensive stats usually found on shields.

C. Features

1) **Combat:** Combat in Dungeon Clearer is melee combat between the player and the enemies. Players will have to dodge attacks by outmaneuvering the attacks using the environment to their advantage.

2) **Puzzles:** The game features several different types of puzzles, a typical one the players will be able to find in the game is to move an object on top of a platform to open a door. Other puzzles consists of hitting the right combination of objects or to simply slay the specific enemies guarding

a door that will not unlock as long as they are alive. The puzzles are designed to be a small obstacle for the player to overcome before being able to proceed toward the next room.

D. Progression

The player will progress with their character by clearing dungeons to gain equipment as well as incrementing the number of dungeons cleared listed in the menu (Fig. 1). There is also personalized progression to be seen with the help of utilizing the built PM as discussed further in the next section. As the player clears more dungeons the difficulty of the dungeons rise, the more difficult the dungeon is the more powerful equipment will be rewarded to the player at the completion of said dungeon.

E. Aesthetics

Aesthetics does not provide any form of advantage in the game, but gives the player further capabilities of bonding with their character by styling it in a particular way depending on playstyle. To further involve player decision as a meaningful part of the game aesthetics are affected by the built PM. For example the player's colour is affected by the average percentage of enemies slain out of all enemies seen in the dungeons traversed.

F. Player modelling

As players progress through Dungeon Clearer they will encounter several enemies, in order to reach the end of a dungeon they will have to decide whether or not to kill the monsters. After every completed dungeon stats are updated. The player as well as the next dungeon is affected by this. The player models colour is updated according to their percent of enemies killed. While the player is closer to having killed all possible encountered enemies their colour will be closer to red, if they have only killed half of the encountered enemies their colour will be white and while they have avoided a majority of all the enemies their colour will be closer to blue. There are different shades of the colours between the ranges of 0 to 100 indicating how many enemies have been killed or avoided. The percentage of killed enemies also directly affects the amount of them that spawns per room, when a player achieves a higher percentage of enemies killed more of them spawn inside every dungeon room, while a lower percentage leads to a lower amount of enemies being spawned. The values used to calculate the percentage start from zero and has a linear increase in relation to the amount of enemies the player has killed or avoided out of the total number of enemies encountered.

G. Procedural content generation

The PCG utilized inside of Dungeon Clearer works at a macro-level, putting together handmade rooms to create an ever expanding dungeon. All the rooms are handmade as to better define how quests play out as well as making sure each room can be progressed through a preferable pace. A room that suits the layout of the dungeon is selected to be

placed towards the position the player is heading when the player reaches a door. This limits the variety of different dungeons that can be generated and chosen however it grants a more structured dungeon which guarantees that the player will never encounter a dead-lock where the dungeon can no longer be traversed. While the room is created enemies are also placed in the room, the amount of these are dependent on the current PM values while the type of enemies are affected by the time of the day acquired through the CA system.

The neighbors of a dungeon room (henceforth neighbors) is defined as a Von Neumann neighborhood with the Manhattan distance, or simply distance, of $r = 1$ [34].

The general overview of the PCG algorithm used within Dungeon Clearer is as follows;

- Have a defined set of rooms.
- Place an initial room in the dungeon.
 - The initial room is chosen arbitrarily since no rules apply without neighbors.
- When a new room is needed to be placed in the dungeon.
 - Iterate through the set of rooms and remove all rooms which information does not adhere to the specific rules in place by the system. For example, removing all rooms that have no pathway to connect with the door from the room that is already placed in the dungeon.
 - When only valid rooms are left, pick one of them and place it into the dungeon.
- Add fitting weather components to the room adhering to the rules of the context information.
- Add fitting day-time components to the room with regards to the context information.
- Check if the room should have a boss in it or normal enemies by chance, the chance of a boss appearing increases in a linear fashion with time.
 - Iterate through the collection of enemies or bosses, depending on which was needed, and assign a value on a cosine-curve, to give higher probability of enemies being chosen the closer their preferred day-time is to the current context information, to a corresponding collection called u .
 - Randomize a value between 0 and the sum of every element in u , call it k .
 - Initialize a value called s to 0.
 - Iterate through u starting at index 0 and add the value of the element into s .
 - * When s is larger than or equal to r , return the enemy or boss with the corresponding index as iterations through u in their collection, which will be populated into the room.

H. Context awareness

The context data affects more than just the room design and layout, such as gameplay elements affecting the enemies and player movement. Some changes to note are that of each meso-detailed room. Each room in the dungeon has preferred

weather types which heightens or lowers the chance of that room appearing in the dungeon depending on what kind of context the game is currently taking place in.

All factors are bound to a specific room e.g. if it is raining when entering a new room there will be rain in that specific room but not necessarily so in other rooms. The context does not go outside their assigned room. This is intentional due to the chances for weather changes to occur during the playthrough of a single dungeon.

Since a detailed explanation of every different form of context aware decision made by the room generation is deemed unnecessary for the research questions of this paper a brief description of the main features are as follows;

If the dungeon is generated in a windy context gusts of wind pushing the player and enemies will appear in intervals. The wind pushes everyone within the room eastwards. The time between the intervals and the force of the push are affected by how windy the context is, measured in meters per second.

Depending on the atmospheric illumination times of specific geolocation, or more commonly referred to as brightness of day, the game will present a darker or brighter shade filter to the world. All enemies have preferred parts of the day which they rather appear in e.g. a human has the highest chance of appearing during solar noon, while a green slime has the highest chance to appear during sunset.

While all weather effects have their own aesthetic differences, they mostly consist of different graphical representations that vary in intensity depending on the context data values. Weather types are connected to different in-game stats that affect the powers of player equipment and monsters, e.g. while it is raining water stats will be affected. Players water items will be extra powerful and enemies will start dealing water damage to the player, a player with a lot of equipment consisting of water-based stats will therefore be more powerful in dungeons while it is raining.

IV. RESULTS AND ANALYSIS

The most relevant data extracted along with an analysis on both the questionnaire as well as the interviews will be presented here. All of the participants had similar explanations of the game before the start of any tests.

To easily present data gathered from the questionnaires and interviews, three categories have been formed:

- Immersion - What role context awareness takes on in producing a more entertaining user experience.
- Decision making - How were the players influenced by choices that were left open to be explored inside the game?
- Appreciation - Highlights which roles of context awareness that were, or were not, beneficial for the user experience.

The reasoning behind these specific categories is due to the general discussions that took place during the interviews as well as their relevance to the goal of this paper. To further clarify, immersion and appreciation are of importance to RQ1 while decision making is mostly aimed for RQ2.

A. Immersion

During both the creation of Dungeon Clearer's CA system and the interviews the focus on immersion inside of Dungeon Clearer was shown to have improved players interest in the game and connection of parallels with the real world during play sessions. It is worth noting that some answers below have been translated from Swedish to English by the authors of this paper.

During the interviews reasoning as to why the participants felt a sense of improvement was shown:

- 1) "It was interesting to see how the game reacted to different forms of conditions. In a standard game you usually figure things out quickly, but here that is not completely possible. I would like to try again in winter to see how it is then."
- 2) "Was fun seeing different kinds of enemies at different times of the day."
- 3) "I really enjoyed the aesthetic differences between game sessions as they made the world more interesting."

However, one participant had not experienced any form of daytime changes during the test period due to always having played the game at the same time of day.

The nature of the test duration came into consideration during all interviews. Due to the tests spanning no longer than a week many participants did not experience close to all the different combinations of weather and environments that the game is capable of representing. Therefore questions arose if it would be a better game if it had not been context-aware but rather give out different forms of dungeons in a pseudo-random way. As seen below the participants seemed to have a rather unified outlook on that context awareness is the more interesting choice. However, it is essential that the players play for a longer time than a week for it to be the more entertaining choice.

- 1) "If it had been a real game you would play for a longer duration and it would have been better to utilize context awareness. However as it is now the game is actually just a container to test context awareness within, it is not a very impressive game as a whole."
- 2) "If you only play the game for a week it is probably better without context awareness, just randomize different weather types instead, that way there will be more variation. But if you play the game like a real game it is more fun with context awareness because the game gets an edge. Had it rained in Stardew Valley [35] whenever it rained outside I would always play during rainy days so that I would not have to water my plants."

To further clarify participant 2 was asked to define what was meant by "play the game like a real game" to which their response was:

“To play when you feel like it or have time, during a longer period of time. Like when I used to play World of Warcraft [36] actively for several months.”

B. Decision Making

The participants in the test experienced a rather unanimous result regarding choices made inside the game. All the participants advanced through the rooms by killing all the enemies as they felt like they were either forced to or could not find any other efficient way to get through rooms.

- 1) “Because there were not many other ways to pass a room. Some rooms were so filled with enemies that I did not see any other way out than except murdering everyone in the room.”
- 2) “It often felt like you did not have much of a choice so I killed them all.”
- 3) “I was aware of there being different kinds of rooms, but it always felt easier to kill the enemies before finishing the puzzles.”

A participant also commented on how they did not figure out that there were other ways to advance than to kill every enemy in the room.

“If it is possible to do other things than kill I have not figured it out yet.”

C. Appreciation

Structure was needed for the sake of presentation in this paper. Here we present the categories of:

- **Graphical changes:** Utilization of CA that only change the graphical aspects of the game.
- **Gameplay changes:** Changes aspects of the gameplay with regard to CA data.

Firstly, graphical changes are adaptations such as the tilesets changing based on temperature. This does not change any of the behaviour of the game, it is simply to reinforce the coherent feeling so that the mood and theme of the dungeon fits with that of the given context. The goal of this was well received by participants as can be seen by:

- “I preferred nights as the monsters were cooler.”
- “I really enjoyed the aesthetic differences between game sessions as they made the world more interesting.”

Secondly, gameplay changes are elements such as the wind in the game pushing players and enemies alike when breezes appear. A lot of different forms of gameplay changes could have been made, but for this study it was kept to wind with possibilities for extensions in mind.

When participants were asked about elements of annoyance or dislike in the game wind became apparent as an entertainment killer in the game, with answers such as these:

- 1) “Being pushed by wind when trying to pass through doors/1-tile passages was annoying.”
- 2) “The wind.”

- 3) “The wind. It was mostly in the way of the rest of the gameplay... and it was always windy.”
- 4) “Wind was annoying.”
- 5) “It was slow, the wind was annoying.”
- 6) “All the weather elements were fun, except the wind.”

However it is worth noting that during the interviews it became clearer that it is not the idea of gameplay elements changing by CA that was negatively perceived. Which can be seen for example by these answers when asked of fun ways to utilize CA:

- 1) “It would be fun if the ground would for example freeze and create ice on the ground that makes you slip or skate around.”
- 2) “If, when it is cold outside, enemies and maybe the player would freeze and slow down it would be pretty cool.”
- 3) “The wind might have been better if you could hide behind walls or something to not be pushed. Also some form of indicator when it appears so you can time it.”

It is rather a case of how wind was utilized in this experiment. It was not a fun game mechanic to be pushed around with no way of blocking or escaping it.

D. Future interest in the game

Participants were asked if they would like to revisit the game in the future to experience the four seasons of the year within the game. The general consensus was positive to the idea, especially about experiencing the world in winter, due to snow.

“I feel as if I have seen spring now, and that is kind of the same as summer at least here in Sweden. I would like to see something vastly different though, like winter when it is snowing, dark, and cold!”

Another participant also expressed strong emotions about trying the game again in the future, however due to another aspect other than wanting to see just snow. Mind that this reason would need further implementation to work fully, however is still regarded as an interesting point for the paper.

“When I played World of Warcraft [36] I always loved the yearly events, like when they celebrate Christmas, Midsummer, or Halloween. But the one thing I always thought was kind of lame was that the event just pops out of nowhere and vanishes as quickly again when it is over. It would be cool if those things were integrated together with the real world info so that events and everything gradually appeared and disappeared more like in the real world. You get the Christmas feeling long before it is Christmas due to stuff gradually appearing.”

V. DISCUSSION

Dungeon Clearer emulates the presence of intricate context aware systems within a game to give a more fulfilling

feeling to the virtual world presented. As stated in previous works and shown here context-aware applications are relying heavily on APIs to output accurate data [5].

Our belief is that due to this requirement reliable API services need to be provided, or developed specifically, for the usage within CAGs. When it comes to such broad aspects as weather or time of day and night there already exists good resources as OpenWeatherMap” [2] and Sunrise-Sunset” [3] however for more specialized context needs this aspect has to be taken into consideration.

Good understanding of the services used should be considered, for example during the development of the wind feature in Dungeon Clearer it became apparent that not enough information was given to make the representation in game very accurate compared to the real world. During testing this was proven to be a liability for the development process, as overlooking parts of the values that the API sent out is easily done. This meant that during specific conditions some participants were unable to start the game and had to wait for a patch that corrected the problems before continuing with testing. While the mistake was on the developers, it showed that the reliability of the API services are essential for future access to the game, which is a liability in case they close down.

The game was developed for mobiles due to the ease of access to data such as geolocational values with the help of a GPS built into the device. However due to the nature of the game it would work just as well on other platforms if the data could be obtained with the use of other forms of technology, e.g. with the help of IP addresses. It would also be interesting to add more location based changes. Such as changing the gameworld due to information such as if the player is in a urban or rural setting.

Although temperature is universal, the perception of what is regarded as hot, cold, etc. is not as well specified. This means that a game on a global scale need to take this into account which may further complicate the development process.

A balanced game, excluding player versus player, typically means to have sufficient difficulty control within the game [34]. The process of balancing games can be hard, when introducing context aware systems into the game there is even more to balance, ways that one might not have thought about at first. Due to the large range of possibilities that can occur and need to be thought about it is easy to introduce a mechanic or effect into the game that does not work very well at every situation which may be considered as a risk in the development process of a game.

In regards to game design the CA elements of the game were proven to be interesting enough to keep a future interest in the game amongst most participants of the game tests. Many showed interest in starting the game during a different season than the ones they were limited to during the week of testing to see how the world would change with different weather climates. However certain aspects of the implementation were also proven to be at large disliked by most participants. A notion clearly represented in the surveys

and interviews done with participants was that movement hindering, represented in our game as wind, which was seen as an annoying obstacle that serves no purpose. Arguments for it being too strong and too frequent were taken up, these points could be fixed in development.

The PM used inside of Dungeon Clearer was widely misunderstood by testers. Out of the participants 100 percent said that they preferred killing all the enemies. This meant that as players progressed through the dungeons their characters colour would change towards red as this indicated that the player had been killing a lot. However as this was not explained well inside of the game, it left players confused as to why their colour had changed and what effect it actually had on the game. While players were killing more enemies the amount of enemies spawning increased for every dungeon they played through, after having finished around ten dungeons testers felt like the difficulty increased tremendously. This lead to the game being unbalanced and players unable to progress any further.

Initially when developing the game fear that the player would feel irrelevant inside of the game, as the CA would influence the world which in turn would make players own choices matter less for the game world as a whole. However the results from the test participants indicates that this is not the case.

It is also worth noting that participants did not feel confused nor overwhelmed by any of the reality based context in the game, which hints on the possibility that it is generally easy to understand mechanics and dynamics extensively based on real life context.

VI. CONCLUSION

Results have been presented with the intention of shedding light on what kind of context aware elements are appreciated in a mobile ARPG. There is not a lot of studies to be found combining context-awareness together with player modelling which denotes possibilities for further development and future work.

The results show that participants enjoy the idea of having context affect the game. Surprisingly so even when it comes to simple graphical changes without any effect on the game play. However game play changes are encouraged by all participants, despite the specific change in Dungeon Clearer being poorly received. Results from interviews indicate that effects too predominant are disliked, while the idea of more subtle changes are enjoyed. This leave room for future work in regard as to how to identify where the line between subtle and predominant effects lie.

One concern for Dungeon Clearer was that of players feeling irrelevant in the ever changing world that did not care for their player actions, but rather context data. However all participants reported feeling as much in control as in any other game. This shows that player modelling is not as crucial due to the presence of context awareness as suspected when starting the study.

Our belief is that the players do not feel overwhelmed by dynamics, such as weather changes, due to how heavily

based they are on real life. This would be an interesting point for future research.

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