REXPLORER: Using player-centered iterative design techniques for pervasive game development

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Abstract. REXPLORER is a pervasive game that helps tourists explore the history of Regensburg, Germany. In the game, historically-based spirits are stationed at points of interest throughout the city. Players use a special "paranormal activity detector" (a device composed of a mobile phone and a GPS receiver in a protective shell) to interact with location-based and site specific spirits. A novel mobile interaction mechanism of "casting a spell" (making a gesture by waving the wand-like detector through the air) allows players to awaken and communicate with spirits to receive and resolve quests. The game is designed to make learning history fun for tourists and influence their path through the city.

The game design of REXPLORER has been inspired by rhetorical methods of persuading players into the game, and persuading players to keep on playing. This accounts for game storytelling techniques as well as the spatialization and contextualization of game mechanics. In this chapter, however, we will concentrate on describing the design process. The development of our game has evolved significantly from its initial conception due to the use of iterative design techniques and helpful feedback from tourists. Traditional desktop iterative-design techniques, such as paper prototypes, are of limited use for pervasive games because they only capture a very limited part of the player experience. In this chapter, we specifically take a look at prototyping techniques used to create both low and high fidelity prototypes of our game to enable testing with end-users. We believe that this prototyping process can support the design of future pervasive games.

1 Introduction

The interactive nature of video games has a unique ability to captivate and engage their audience. By this, video games already have a rhetorical and a persuasive quality. Researchers have recognized this quality and are trying to leverage it to create a new field of *Serious Games* [17, 16], where games are used

to inspire, educate, and train their target user base. Although REXPLORER is not a video game due to its location-based gameplay as well as physical player mobility, it applies the serious game concept to the domain of tourism, helping visitors engage with the history and culture of their destination in an innovative way. Thus, we consider REXPLORER an example of a city-wide game turning an unfamiliar space into a place through play: a "playce".

REXPLORER is a part of the Regensburg Experience[3] (REX) museum in Regensburg, Germany. The museum itself contains interactive exhibits to allow visitors to experience different aspects of the city's cultural heritage, such as medieval music, and poetry. REXPLORER is designed to extend the visitor experience beyond the museum walls, showcasing the most significant attraction of Regensburg: its mostly gothic and romanesque urban silhouette and architecture. Regensburg is a UNESCO world heritage site and if not the best-preserved medieval city in Germany, mostly untouched by widespread bombings in WWII. REXPLORER engages players to narratively and, by physical mobility, link city sites, creating an interconnected mental map, and changing the visitors' perception of the destination.

2 Game Overview

The target group of REXPLORER mainly consists of younger visitors with German language proficiency. The theme of the game is techno-magical: Visitors are asked, as scientific assistants, to examine paranormal activity recently discovered outdoors in the Regensburg medieval city core within one hour. Fictional "scientists" have discovered that the phenomena seem to be linked to a child's gravestone inscribed with a mysterious secret language shown in Figure 1. The gravestone is a real artifact in the Regensburg cathedral, and historians (factual) have found that the symbols used instead of letters cover up the identity of the child buried, who is thought to be an illegal offspring of a Regensburg cleric - a scandal in the 16th century!

For field research, the scientists have developed a special detector device (see Figure 2) that is able to measure paranormal activity at specific sites in the city core. The detector has artificial intelligence and is able to talk directly to the players. This makes the device a character in the game, encouraging players to anthropomorphically relate to it as a team member helping them achieve their goals. The detector reacts to a variety of gameplay situations, for example when the player idles for a longer time. Most importantly, the detector notifies players when they are in the vicinity of paranormal activity (and a point of interest) through it's own excited heartbeat, further emphasizing its human qualities. To make the detector character even more accessible, and entertaining, its voice acting is highly expressive, excited, and often self-ironic.

When near a historically significant site, players can evoke one of the gravestone symbols by drawing the symbol through the air, similar to casting a spell

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[3] http://www.rex-regensburg.de
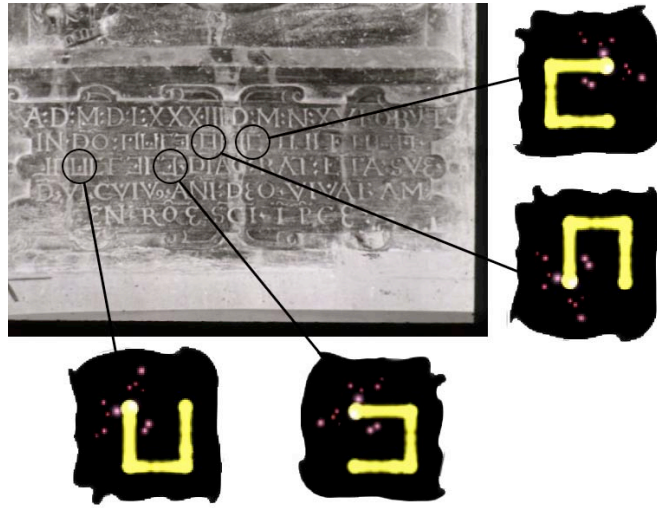
Fig. 1. A child's gravestone inscribed with a secret language serves as inspiration for the gesture vocabulary of REXPLORER. The long-term goal of the players is to unveil the mystery behind these symbols by solving as many other challenges in the city as possible during their game session.

with a magic wand. Each symbol draws power from one of four medieval elements (earth, water, fire, or wind) and establishes a communication channel to the spiritual world, allowing the either historical or mythological spirits to tell their "cliff-hanger" stories through the loud speaker of the device. Each story challenges the players to fulfill a quest by going to a different point of interest in the city. Players need to listen carefully to the spirits to capture the verbal clues indicating which gesture to use to accept a quest. When the quest is completed at another site by interacting with another spirit, the "cliff-hanger" narrative is resolved, and a new quest is offered. For each completed quest, players receive points, allowing them to level up from a rookie research assistant to a master research assistant during their game session.

During the game, the player's progress is tracked and used to create a personalized souvenir geo-weblog (blog). The player blog documents the player route over space by interfacing with Google maps and over time by chronologically listing all sites and characters the player has interacted with during her session (see Figure 3). The blog provides de-briefing web links concerning the characters appearing during gameplay to help the players learn more about the history behind the sites. During their game session, players can - and are reminded to - shoot pictures and videos of their field research. This image material is also automatically added to the blog with corresponding locations marked in the interactive map.
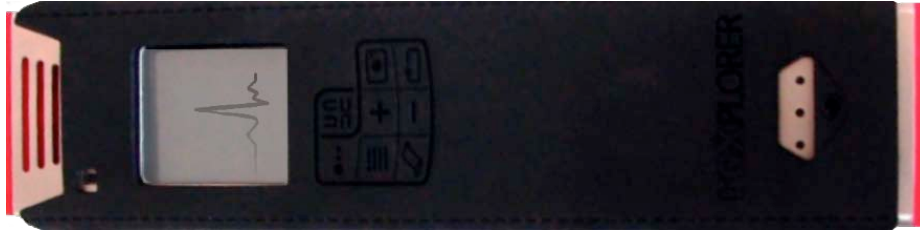
Fig. 2. The REXPLORER "detector" consists of a Nokia N70 mobile phone and a GPS receiver packaged together in a protective shell. A soft and stretchable textile overlay with a zipper on the back transforms the standard phone keypad into an 8-key game interface.

3   Detector Functionality

The detector's simplified keypad interface provides users access to the following functionality during the game. This simplified keypad functionality was refined through several iterative design stages.

– **Status button:** Players can check their status at any point in the game. The status menu shows them their current point score, their current level, and their current open quests including a short description to remind the players of the nature of the quests.
– **Gesture button:** REXplorer is the first pervasive and mobile game to enable magic wand style spell-casting. Players hold down this button while performing a gesture. Releasing the button indicates the end of the gesture. Gesture recognition is accomplished using camera-based motion estimation, as in [1, 22]. As motion samples are collected, they are rendered to the screen to allow players to see their gesture progress. After the gesture is complete, the motion trail is normalized and the data is passed to a gesture recognition algorithm. A legend of gestures is provided in a souvenir brochure players receive at the start of the game (see Fig. 4).
– **Repeat button:** Players can always repeat the verbal communication from the spirits at any point during game play if they missed important details because of real-world interruptions such as traffic noises or the many other roaming tourists during the peak season.
– **Volume buttons:** Players can adjust the volume of the device at anytime to adapt to changing environmental conditions and social scenarios.
– **Map button:** Since the players are tourists, they generally have difficulties navigating through a foreign city. To compensate this, we provide a physical tourist map in the souvenir brochure, incidcating the paranormal activity sites (see Figure 4). As an additional aid, the players can see their current position on a smaller on-screen map using this button. The on-screen map also shows the destinations for the current open quests to help the player navigate through the city to fulfill quests.
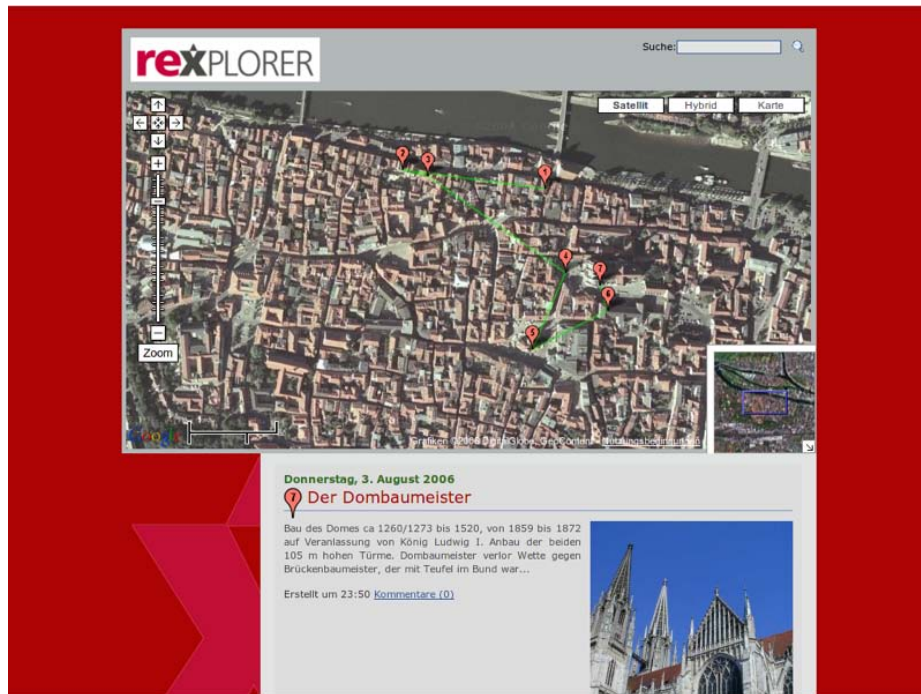
Fig. 3. A souvenir blog documents the player route, visited points of interest, and player-generated content (pictures and videos). Clicking on a point of interest in the map brings the visitor to in-depth historical information with external links and a bibliography for them to explore and learn more.
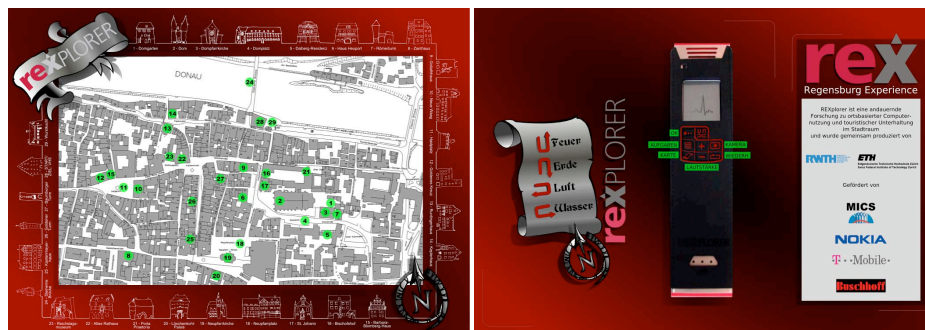
Fig. 4. (Left) The front of the souvenir brochure has a large map with points of interest marked. (Right) The back of the brochure displays a legend for device buttons and gestures. Players receive the brochure when they rent the detector to start playing the game.

– **Camera button:** Players are encouraged to capture their own memories with photos and videos using the built in camera. The player-generated content is automatically uploaded to a personal weblog with the location marked on an interactive map.

4   Gameplay Scenario

Anna and Peter are a young couple visiting Regensburg on a day trip. At the tourist information office, they notice REXPLORER advertised as a city-experience game, and decide to try it out. They are renting the detector (see Fig. 2) and a souvenir brochure (see Fig. 4) directly at the tourist information center. Then they are shown a short three minutes movie introducing them to the gravestone, the paranormal activity, and their task as a scientific assistant to help solve the mysteries of the city to eventually solve the riddle of the gravestone after ending their game session.

As they leave to start playing, Anna is holding the detector and Peter is in charge of the brochure. They turn the corner and Anna notices a heartbeat vibration indicating the detector is excited (see Fig. 5) and that the couple has reached a point of interest. From the introductory movie, Anna knows that there is a spirit here that she can awaken by casting a spell.

She looks at Peter, who flips over the brochure map, looks at the different gestures, and points to "wind" for Anna to try. After glancing at the legend to get an idea for the gesture shape, Anna holds down the gesture button and waves the device through the air, just as she saw in the introductory video. As she moves the device, she sees her gesture progress on the detector screen (see Fig. 6) and hears the gesture mode audio sample. Once the gesture is complete, she releases the button, and a short "tornado" video with audio playback confirms that she has successfully completed the wind gesture.

A figure is shown on the detector screen and a spirit begins to speak to the players:

> REXPLORER*! It's nice to see you. I am a salt trader. People like me used horses to pull heavy ships, full of expensive salt, up the river Danube to Regensburg until around 1820 A.D. Usually, the excursions last 4 weeks at a time. Yep, my life is tough and dangerous. Thieves plague the salt trading routes, but I have a loving wife who constantly prays in a nearby church for my safe return. Only the fire of her love keeps me alive. Would you be willing to deliver a message to my woman? Then show me the appropriate gesture.*

After listening carefully to the text, Anna understands that she must cast the "fire" spell to accept the quest. She looks at Peter and asks: "Which one was fire, again?". Peter shows her the gesture legend, and Anna successfully completes the fire gesture to accept the quest. Then she hears:

> *I thank you from the bottom of my heart! It pleases me that you are willing to deliver my love letter to my wife at the St. Ulrich Church near*
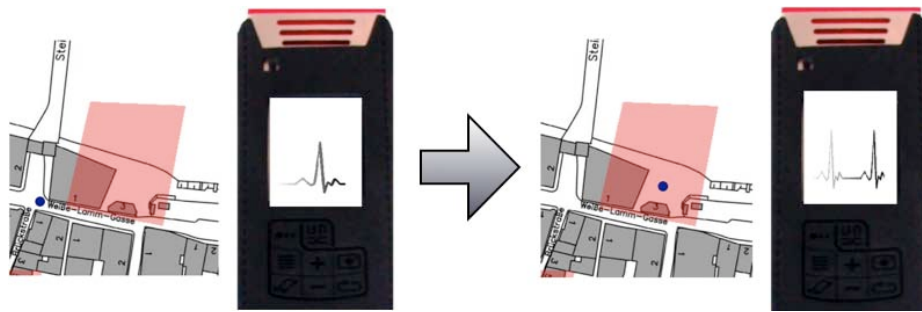
Fig. 5. As players move through the city, a slow heartbeat indicates that there is no unusual paranormal activity. When a player moves close to a point of interest, inside a hotzone, the detector's heartbeat gets excited and speeds up. In the excited state, there is additional vibration and audio feedback to emphasize the new state.
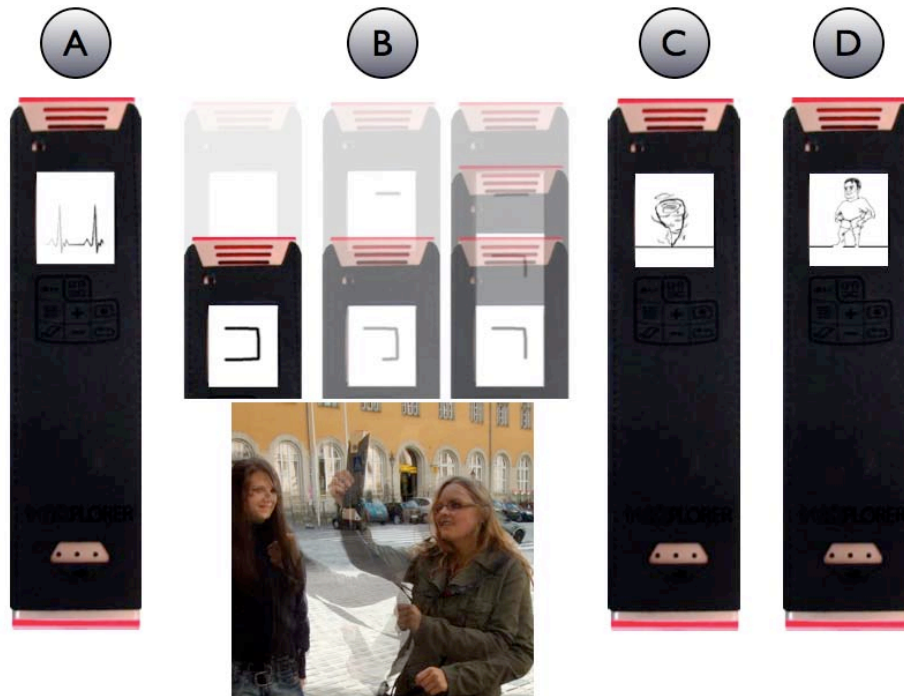
Fig. 6. (A) The excited heartbeat indicates that the player is in a hotzone and can interact with a spirit. (B) The player casts a spell by drawing one of the gravestone symbols in the air. Audio feedback, as well as visual feedback is given to the player displaying the gesture progress. (C) An element animation (in this case 'wind') confirms which gesture was recognized, whilst the attached audio plays back. (D) The likeness of the character is displayed on the screen as the spirit communicates with the player.

the Cathedral. Oh! My colleagues are already waiting for me at the river. Good luck! Take care of yourselves.

Peter looks on the brochure map and quickly finds the next location. He looks to Anna and asks: "where are we now?". She presses the map button on the detector which shows them their current position and the destination of their open quest. After orienting themselves, they start walking towards the St. Ulrich Church to complete their mission.

5 Related Work

In recent years, the field of pervasive and mobile experience design has been growing rapidly, bringing forth exciting works. Although heterogenous in scope and intent, a number of recent projects can be related and compared to REX-PLORER in order to contour the scope of our project.

Sustainable servicing – Site-based rental controller vs. subscription: Most pervasive games to date are event-based and of an experimental nature. The most notable exceptions have been (a) commercial and (b) attempts to establish continuing, subscription based servicing. Mogi [13], for instance, is a cell phone and web based persistent item collection and trading game where the actual geo-position of a subscriber correlates to the position in the game world. Created by the French Telecom supported Newtgames and commercialized in Japan by the operator KDDI in 2003, Mogi was discontinued in 2006. Another example of a mobile phone subscription service is the GSM-cell positioning SMS-shooter game Botfighters [18], created by Swedish company *It's Alive* and launched for the first time in 2001 by Swedish operator Telia.

In the spirit of Mogi and Botfighters, REXPLORER is set to become a sustainable service rather than an occurrence, based on a public-private partnership between the ETH Zurich, RWTH Aachen University, REX, and the Regenburg tourist information center. The goal of REXPLORER is to achieve a research prototype of a robust, sustainable service, but as opposed to Mogi or Botfighters, the REX museum and the Regensburg tourist information will operate REX-PLORER as a local, site-specific offer, using rental smartphones embedded into custom made shells as game controlling devices. A rental service not only amplifies the touristic non-everyday experience, but also allows easy handling of a number of typical service processes, for example

- player log in / log out;
- custom software installation and hardware configuration;
- maximum runtime of each gameplay session;
- hardware maintenance and battery charging.

Un-puppet – Exogene vs. endogene orchestration: REXPLORER requires personnel to service tourists. Costs related to servicing the game include building, hosting, and operating the terminal which shows the intro and outro movies; service maintenance; and staff employment. However, there are no plans to hire additional staff. Instead, the existing tourist information staff will be trained to be able to cater to customer needs. For this purpose, we develop training guidelines and procedures.

This cost-effectiveness policy also accounts for the game service itself: Contrary to the rather generalized notion that pervasive games *per se* face the challenge how to enable "the real-time management of a live game", for example by incorporating puppetmasters [2], REXPLORER faces the financial and service challenge to operate game sessions without exogene, human intervention at all, whilst tendering a fun, meaningful, and playful experience for a majority of visitors in the target group. In order to provide a form of "endogene orchestration" instead of puppetmastering, we are producing sandwiching game elements that not only tease and tutor the player (pre-game experience), but also extend the experience for the player after the game has ended. Such game elements include:

- professionally produced and techno-magic style intro and outro short movies for the rental booth at the tourist information
- the individualized geo-webblog, a personal souvenir in the form of a website, which each player receives after playing the game.

Playing tourist – Pervasive games for non-entertainment purposes: A number of pervasive games have been designed for non-entertainment purposes such as city marketing, learning, or emergency simulation.

Amongst the earliest examples of a serious pervasive game is the multiplayer indoor experience M.A.D. Countdown [21], where a "rescue" team of players - one of which role plays a saboteur - has to locate an atomic bomb within eight hours and disarm it; players use wirelessly networked PocketPCs, browse puzzle websites, call fake answering machines, and interact with physical game elements such as lockers which contain game clues. In an educational game, Savannah [2], children role play lions, practicing hunting, and thereby learning about prey behavior in wildlife habitats. Environmental Detectives [11] embeds high schoolers into an authentic situation where teams of players representing different interests have to locate the source of pollution by drilling "wells" and "sampling" with PDAs. The role playing game Frequency 1550[4] blends Internet and mobile phone gameplay with location-based puzzles to supplement the city history curriculum at the Montessori school in Amsterdam.

Specifically Frequency 1550 is of interest in our context, as it demonstrates how to convey site specific knowledge with the help of game mechanics. Both De Souza e Silva & Delacruz [6] and Thomas [19] describe a number of other relevant projects, examining potential uses of pervasive gaming for educational purposes. These theoretical approaches are interesting for the REXPLORER gameplay, which aims at conveying knowledge about touristic sites.

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[4] http://freq1550.waag.org

A rhetorical landscape – Site specific augmentation with audio: In addition to being an educational experience, the game design of REXPLORER is, intentionally, attempting to persuade players to move between city sites by using the concept of applying rhetoric to game design [20]. In particular, players are presented with audio drama based cliffhanger puzzles spoken by site specific characters. By the way of these audio cliffhangers, characters offer quests to the player, which can only be resolved at other sites, demanding the player to keep moving in order to play the game, and thus, complete quests. Through this core mechanic, REXPLORER erects a spatio-ludic rhetoric, where the audio augmented city becomes not only a game board, but also a "playce", that is: A space influencing behavior, which rewards the playing tourist with destination- and mobility-based closure.

Connecting sites through spatial gameplay narratives: Similar to REXPLORER, site-specific narratives and spatial storytelling - that is, connecting site A with site B through a story - are eminent features in History Unwired [8], which was tested during the 2005 Biennale of Contemporary Art in the most touristed city worldwide, Venice. History Unwired is not a game, but an innovative and entertaining linear walking tour around one of Venice's less-traveled neighborhoods, involving location-aware smartphones and interactive art pieces at sites which are embedded into the tour.

Contrary to REXPLORER, the designers of History Unwired decided for linear storytelling, where users had few opportunity to "choose their own adventure", which is an important feature in the non-linear gameplay of REXPLORER.

6 Player-centered iterative design

REXPLORER has applied a player-centered iterative design throughout the design process. The fields of Human-Computer Interaction and Game Design have long recognized that user interfaces should be designed iteratively [15, 5, 10], because the requirements for an interactive system cannot be completely specified at the beginning of the lifecycle [7]. Instead, the design needs to be prototyped and tested with real users to reveal any false assumptions or unforeseen problems with the existing design. These problems can then be corrected in the next iteration of the prototype, which should then again be tested to ensure the problems are resolved. Currently, we are lacking the tools, and conceptual frameworks to fully support iterative player-centered design in the domain of pervasive games, because existing methodologies for the desktop computing, such as paper prototypes, do not scale to ubiquitous computing applications [14]. A desktop environment is targeted for one user, one set of hardware, and a single point of focus. In pervasive games, complexity is added in every direction; there are multiple players and player backgrounds, dynamic contexts of use, diverse spatial qualities, different metrics for successful interfaces. and varying stakeholder as well as political and economical interests that may change over time. This work starts to fill the gap by showing how to apply an iterative player-centered design

process to pervasive game design. Each iteration was important in reaching the current design which balances conflicting forces and satisfies both stakeholders and players in our user tests.

6.1   Early Concept Prototyping

In the early stages of the design, we generated a number of game ideas and formalized these ideas into one page conceptual design treatments, briefly describing formal and dramaturgical elements of the games [9]. We presented these treatments to our main stakeholder, the REX museum. After REX stakeholders had opted for the basic idea that eventually became our game, we created scenarios and storyboards outlining potential core mechanics of the game (see Figure 7), as well as a first physical prototype in the form of a board game (see Fig. 8), next to a simple map application indicating Regensburg sights and the walkability of the city core.

We used this demonstration and simulation material to collect feedback from the target group. We presented the game to two German high school classes - 10th grade and 11th grade - living in a city three hours away from Regensburg, followed by a questionnaire and a focus group discussion. Generally, the feedback showed that the magic theme was very important in attracting the interest of this age group and that the idea of a history game alone wasn't as attractive. However, the feedback helped us to move away from the original purely magic theme to a techno-magic theme involving science elements. The target players expressed high interest in playing the game themselves, and they found the technical aspects novel and interesting. In general, specifically the board game prototype and the storyboards were a success as mechanisms to flush out the different gameplay elements and get high-level feedback on the early game concept from our target players.

Following our target group research, we created a design document draft with functional specifications and an iteration of the board game prototype, as well as a video walkthrough of the gestural interaction. These conceptual techniques served a very important role in communicating our ideas to various stakeholders to win their support. In REXPLORER, there were a wide variety of stakeholders whose concerns needed to be addressed. Our clients, the REX museum, were trying to portray an image of historical integrity. Our conceptual material was effective in assuaging fears of too much fantasy and too little historical content. We also used the mentioned material to win over support of the municipal government to provide space and resources necessary for the proper operation of the game. The conceptual material was also instrumental in convincing local tour-guides that we were not attempting to compete with them and even helped recruit them for content oversight. Eventually, these early concept prototypes helped communicate the abstract game concept in a concrete fashion to sponsors.
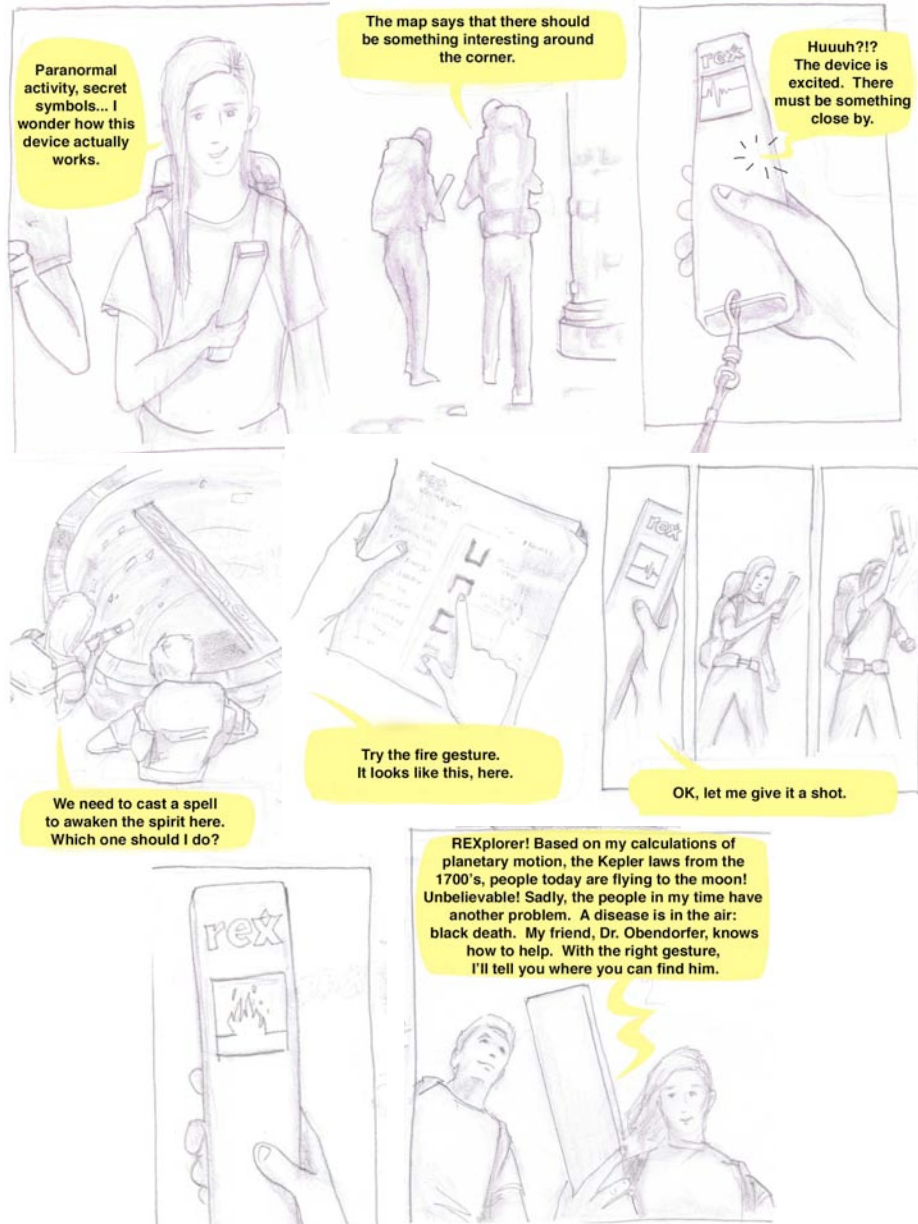
Fig. 7. Storyboard conveying game play

Fig. 8. Board game prototype of REXPLORER

6.2 Board game Prototyping

In addition to being a demonstration tool, a board game prototype provides a world-in-miniature that allows the gameplay to be easily tested. This form of prototype is very useful for early stage content testing by reading the content aloud as the players progress through the game. It helps express spatiality, get a feeling for travel times, oversee proximities of sights, achieve narrative consistency, and helps to ensure that the underlying game is fun. Dice and event cards can be used to regulate the progress through the city streets to give a more realistic simulation of the way people actually move in the city.

6.3 Content Prototyping

The content directly supports the main purpose of this serious pervasive game: educating the players historically and mythologically. Therefore, it was important to carefully craft a high quality narrative, as well as graphical art and animations. In the following, we are exemplifying the content prototyping process with regards to the non-playable characters (NPCs) and the character dialogue progressing the game.

In order to create the NPCs so that they could, eventually, be recorded with 19 voice actors, we reviewed the city of Regensburg's overview list of over 1400 protected historical buildings, describing each site's erection, make up, and usage over time. We then cross compared a number of city sightseeing guides including the city's tourist website, filtering 29 sites of interest, which represent typical

sights tourists would want to see during a day long visit. With the first design document draft, we had decided that each builing or a building's main function over time should be represented by a site specific character.

Early Character Sheets: To prototype these characters and in order to give them personality depth, we used a character sheet format. This is a one-page description of the different characters that provided an at-a-glance overview to simplify the review process. The sheets included the following entry fields:

- **Bookkeeping elements:** including name, building address, character ID.
- **Physical Characteristics:** including age, height, hair color, weight, vocal characteristics, species, remarkable features, and sketches of each character.
- **Inspiration for spoken text:** including typical quotes, description motivating why this character belongs at this location, and a brainstorming list of what the content could include.

These character sheets were important in communicating our more detailed content ideas with the local tour-guides for content oversight, as well as briefings for the voice actors. The character sheets provided a compact and highly-browsable format which supported an effective review process. The tour guides were able to suggest improvements or changes in character selection very easily using this format. The changes at this stage were easy to incorporate and they prevented significant rewriting of the full script later on.

Narrative production: The main challenge of narrative production laid in bridging the characters so that they would be connected meaningfully, as well as emotionally, through quests. In the design document, we created guidelines as to which general emotional dimensions could bond the characters so that players would want to travel from site A to B to fulfill a quest in order to hear the resolution of a cliff hanger. In the game dialogue script, we applied emotional bridges such as romance, greed, or fear to the NPCs quest stories, whilst planting clues into the NPC's sentences as to which element gesture the players needs to cast. For example, at the site of the historical character Barbara Blomberg, we embedded the clue for the expected gesture element "water" when Barbara, crying, asks the player to take the "tears of her love" to emperor Karl V., who she had a son with, but only saw the royal once.

After having created example quests between characters, the script draft was reviewed by stakeholders. Based on the feedback, we eventually created 59 quests with the help of a travel journalist as a co-writer. The final script was iteratively fine-tuned, and was recorded at a professional recording facility.

The detector character's script needed special attention, too: As the player's everpresent companion, we decided that this character should be supportive, always positive or even enthusiastic, yet ironical to catch the player's attention. In addition, the script was developed so that the detector character reacted to special situations during gameplay, for example to remind the player that pictures can be taken. On site playability testing proved useful to indicate which

situations occur during gameplay that the detector should react to in order to maintain immersion for the player, and persuade players to keep on playing.

6.4 Game Statecharts

The formal UI statecharts were important for defining exactly what text needed to be written for each character. By flushing out the design formally, we were able to ensure that we had accounted for every possible game state and error condition before the script was written and recorded. The statecharts also served as a design document for the software implementation of the game engine.

6.5 Hotzone Prototyping

GPS can have problems in urban spaces due to buildings or even clouds obstructing signals from the satellites. It is very important to test the location system thoroughly to ensure proper functionality. Our hotzones are defined iteratively based on GPS measurements. We developed a tool (see Fig. 10) that allows us to define the hotzones visually based on the GPS measurments from testing. Using this tool we were able to iteratively define hotzones, and were able to determine that GPS alone is not sufficient for the accuracy that we require. To support location detection, we are also using Bluetooth beacons, as well as providing the ability for players to select their own location when the location detection fails.

6.6 Detector Prototyping

The form and functionality of the detector including the keypad - aka the game controller - went through many iterations before we ended with the final design. In a design studio class we supervised, a small group of students co-created the detector, seeking input from industrial design professionals, and from a manufacturer specializing in leighweight metal bending and laser cutting. There are many considerations that need to be addressed in the design, for example it needs to

1. house the phone and GPS receiver together in a tamper-proof, protective shell.
2. support the atmosphere of the game by providing a look that fits the story description of a scientific detector and a feel that mimics a techno-magic wand.
3. provide a skin for the phone keypad to provide a customized game interface.
4. allow for quick recharging of devices.

During the prototyping phases, different materials were tested. Plastic was the first choice, but it proved not to be robust enough. A thin aluminum skeleton was used in the final design, wrapped with a soft and stretchable textile into which the keypad layout was lasered.
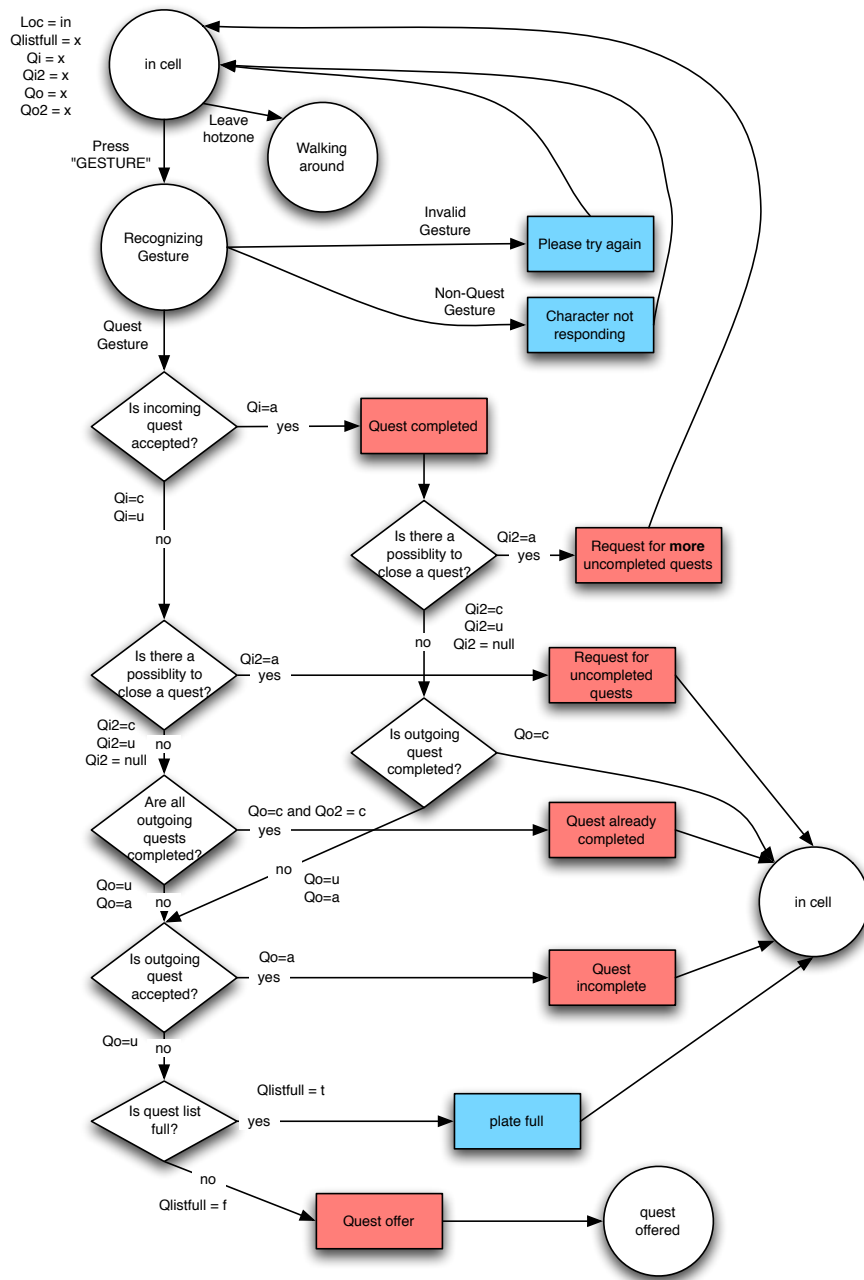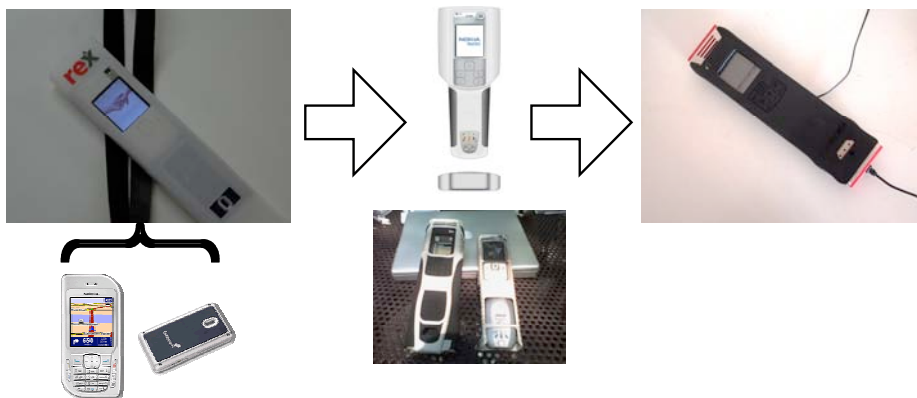
Fig. 9. Statechart showing the reaction to a gesture. The colors determine whether the spoken text is from the character or the device itself.
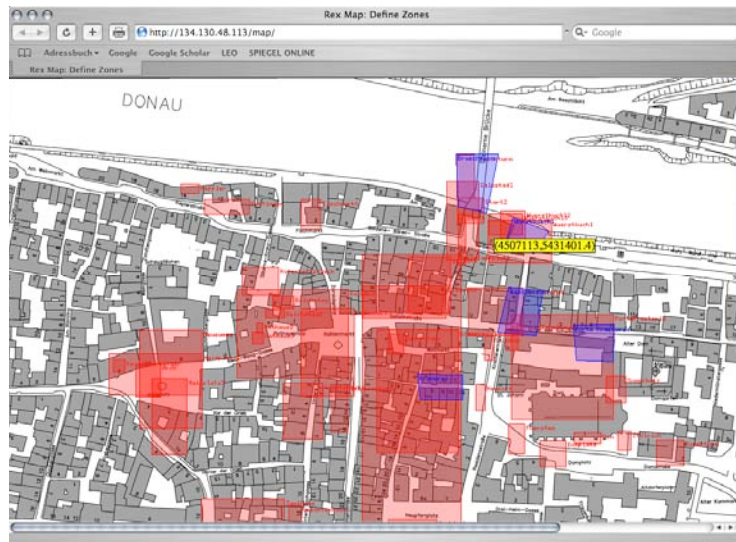
Fig. 10. Map tool that allows us to visually define hotzones based on GPS measurements from testing

Fig. 11. The detector houses the GPS receiver and the mobile phone in a protective shell; it is wrapped by a stretchable and soft textile into which the keypad layout is lasered. Many iterations of material and form were used before reaching the final design.

Fig. 12. For the playability tests, Wizard of Oz techniques were applied using the Nokia 770 tablet. A test administrator uses the tablet to manually input the players' position as they follow the players through the city to simulate a fully functional location detection system.

6.7 "Wizard of Oz" Playability tests

For late stage prototyping, we performed an on-site player study. Our location detection enhancements were not ready yet, so we used a "Wizard of Oz" prototype to simulate a fully functional game. In this prototype, we used a Nokia 770 internet tablet with a custom application that allowed a test administrator (a wizard) to follow the player and manually input the current player location on the touch screen as the player moved through the city streets. The Nokia 770 was connected via a bluetooth connection to the mobile phone housed in the game controller. The communication protocol from the tablet to the REX-PLORER detector was identical in format to a standard GPS receiver, so the software implementation of the detector required no additional changes for this prototype to function properly.

For the structure of our study, we used a product-interactive focus group [12]. Traditional focus groups center on discourse regarding a early concept guided by a moderator, similar to the techniques we used with our storyboards and early board game prototype with high school students. In product-interactive focus groups, on the other hand, users are asked to perform a certain set of tasks using a product before the group discussion. In the case of REXPLORER, 12 participants played a full one hour game session before joining a focus group discussion with several other players at the end of their game session.

7 Design Rationale

Each iteration in the design process helped formulate the current design based on a great deal of feedback from our stakeholders and players. In this section, we will outline the most significant factors that resulted from the many prototype iterations. Specifically, we will discuss how we were able to balance conflicting forces that pulled the design in competing directions. This rationale should serve to inform the design of future pervasive game systems, eventually leading to a language of design patterns [4, 3].

Designing for narrative consistency: One of the primary challenges of designing a history game for the city of Regensburg is that the city's history spans several periods starting from the Roman empire as a strategic military fortress, through the middle ages as a vital trade center, up to the early 1800's were it served as an important political center as the permanent seat of the Imperial Diet for the Holy Roman Empire of German Nation. Focusing on any of these periods would not do justice in conveying heritage of the city, yet having a game that spans the different periods risks inconsistency, or overly structured linearity. The difficulty is finding a story that appropriately bridges these periods. In REXPLORER, we use the "haunted house" and "techno-magic" themes to bridge these historical movements in a non-linear story.

Early on in our discussions, the "magic" theme was negatively received by many of the stakeholders. It was perceived as too close to the "Harry Potter" series or too much oriented towards "Disney", as our client valued a strong academic and historical basis that would be seen as educational instrument and not pure entertainment. On the other hand, we wanted to create a game that was fun and exciting, and not just an uninspired audio guide regurgitating the facts from the history books. By the way of the iterative design techniques, we were able to find an appropriate balance of fun and seriousness, blending fact and fiction in a way that conveyed historical information effectively, yet preserved the engaging techno-magic background.

One key breakthrough that helped us reach this goal is recognizing that local folklore is an important part of the history and culture of the city. We leveraged local folklore to create a number of our fictional characters. We also derive the techno-magical gesture vocabulary using a real historical artifact, blending game make-belief with fact. These were key design decisions that helped us ultimately win over skeptics. The tradeoff here is that we make the game less portable to a different site, but with a history game it is important that all of the content is tailored to the site, including details such as the inspiration of the gestures.

Balancing competitiveness and leisure: From the playability tests, points and game levels were a polarizing topic. People who were avid games players demanded it. However, non-gamers (especially our older participants) mentioned that points made the experience feel competitive and detracted from a relaxing tourist experience. Our compromise was to keep points away from the main

screen and move them to the status menu. This made points visible to those seeking them, and hidden in the background for those who weren't interested.

Balancing physical engagement and social awkwardness: The gesture-based interaction was chosen to physically engage our players in the story. From our playability tests, most of the players found the gestures to be an important element of gameplay. They found it heightened the sense of magic and mysteriousness. However, we also discovered during the playability tests that a few of our players (especially our older participants) found the gestures awkward, and they requested labeled buttons to select the symbols. As a compromise, we designed an alternative gesture selection mechanism through an on-screen menu that can be used anytime an invalid gesture is performed, effectively allowing people to avoid gestures altogether. Players who choose to avoid gestures are penalized by not earning points.

Balancing a cooperative experience vs. outdoor play: Tourism is rarely an activity enjoyed in isolation; instead, it is an activity that is shared with family and friends to create common experiences and memories. REXPLORER is designed to support shared experiences through cooperative gameplay, where two or three people can share a single controller. To support this model, the controller was designed to primarily use the phone loudspeaker instead of headphones. The shell is designed to reflect the audio playing from the phone loudspeaker towards the players when holding the device in front of them, making use of the shell as a resonator. The controller is surprisingly loud, and in our playability tests, most had no problems hearing the audio. In some scenarios, unusual levels of street noise made the audio difficult to hear, but players were easily able to cope by holding the loudspeaker closer to the ears between the heads. The controller also has a "repeat audio" button to handle cases when something prevents the text from being heard. Plugging in headphones is also supported by the controller by the way of a cut-out, but headphones isolate the player and should only be used in single-player scenarios.

Designing for replayability: One of the design goals that we strived for was replayability, such that if a player decided to play the game again, it would be as interesting as the first time they played. There are several elements in the game that promote replayability. First, the number of characters in the game far exceeds the number of sites the player can reach in the limited game time. During the outro, the player state is saved and logged so that the player can pick up where they left off at a later point. The non-linear, self-directed nature of the game allows players to pick a unique path each time they play. Additionally, for each character, we designed several different quests that can be offered to the player. That means that even if a player has addressed a character before, they will receive a different quest the next time they visit. This leaves the complexity of the quest network indeterministic and seemingly infinite to the players, making them want to explore more to find new interconnections between the characters.

Fig. 13. REXPLORER is designed to be played in groups of two or three.

Designing for a "heads up" experience: One criticism that we received early in the design process was the concern that people would have their attention focused primarily on the device screen, and that this would detract from the real attraction of Regensburg: the medieval architecture. There are also safety concerns when people are moving through a physical space while visually engaged with a handheld screen. This criticism focused our design to discourage the player from looking at the device screen. First of all, this led us to choose the small screen form factor of a phone instead of a larger PDA, or tablet computer. On the screen, only simple visualizations are used. The black & white static sketches were chosen over vivid color animations to enable people to get an impression of the character at-a-glance and spend the rest of the time visually absorbing their environment. During our playability test, the black & white content had another unexpected benefit of providing a high-contrast interface suitable for bright sunshine.

The small display makes it more difficult to navigate with the on-screen map. However, we provide the players with a map brochure intended for navigation. The device map additionally serves to help pinpoint their current position. The small on-screen map makes it undesirable to focus attention on the map while

moving through the city, which helps to divert attention away from the device screen.

Multi-modal feedback also allows players to keep their visual attention away from the screen during gameplay. When players enter a hotzone, the device notifies them with an accelerated heartbeat that they can hear, see and feel. The haptic and audio feedback allows them to keep the device at their side until they have reached their next destination.

8 Conclusion

Human-centered iterative design techniques as well as Game Design techniques are instrumental in building interactive entertainment applications for desktop computers. Our use of these techniques to pervasive game design helps demonstrates how player-centered iterative design improves the quality of pervasive games. Early conceptual prototypes were important as communication tools that helped convey our ideas to both end-players and other stakeholders. Their feedback was extremely formative and helped identify critical conceptual stumbling blocks that helped us frame controversial elements such as spell-casting, our techno-magical theme, and the threat of gameplay taking priority over tourism. Low-fidelity prototypes helped flush out the details of the game design to ensure that any critical game flaws could be addressed before the high-production value content was produced. The high-fidelity prototypes helped verify the overall game concept and flushed out lingering minor improvements that help the overall experience of the game. These techniques should be seen as exemplary, to aid the design and improve the quality of future pervasive and mobile games.

9 Acknowledgements

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