QuakeQuiz – A Case Study on Deploying a Playful Display Application in a Museum Context

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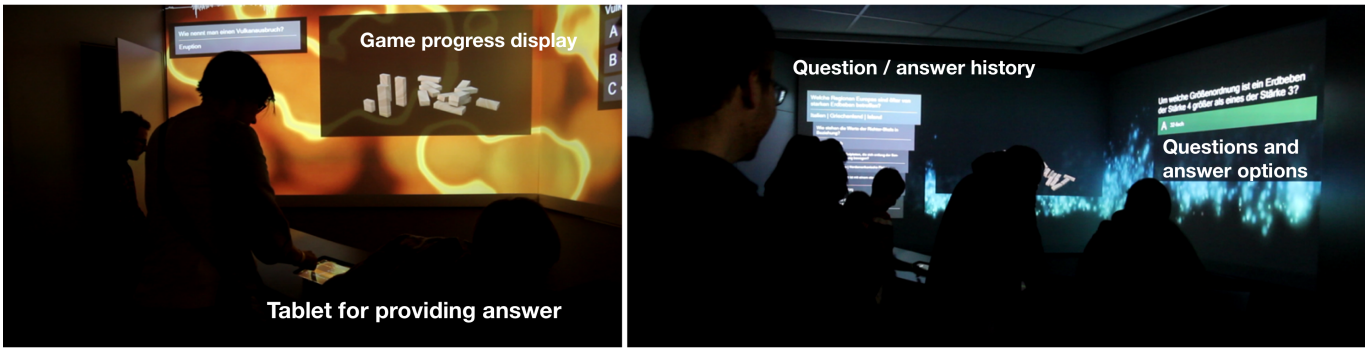

Figure 1. QuakeQuiz is an interactive display application we deployed in a museum. Visitors can collaboratively answer questions on plate tectonics, earthquakes and volcanoes by means of four tablets. Questions and a history of questions and answers are shown on a large projection screen. We report on the design, development and evaluation of the quiz.

ABSTRACT

In this paper, we present a case study in which we designed and implemented an interactive museum exhibit. In particular, we extended a section of the museum with an interactive quiz game. The project is an example of an opportunistic deployment where the needs of different stakeholders (museum administration, visitors, researchers) and the properties of the space needed to be considered. It is also an example of how we can apply knowledge on methodology and audience behavior collected over the past years by the research community. At the focus of this paper is (1) the design and concept phase that led to the initial idea for the exhibit, (2) the implementation phase, (3) a roll-out and early insights phase where we tested and refined the application in an iterative design process on-site, and (4) the final deployment as a permanent exhibit of the museum. We hope our report to be useful for researchers and practitioners designing systems for similar contexts.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords

Museum; Case Study; Deployment

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INTRODUCTION

Over the past years, interactive public displays have found their way into our everyday life. They are deployed as information displays in libraries [14], stores [8], airports [4, 25], and train stations [7]; digital bulletin boards serve as a digital meeting point for local communities [1, 20]; civic discourse applications give locals a voice [12, 23, 27]; interactive games entertain the audience in waiting situations [17, 28] and museum exhibitions are enhanced by the use of interactive applications on large displays or tabletops [9, 11].

Deployments at these locations motivated researchers to investigate different aspects that contribute to the success of public display installations. These include, but are not limited to, audience performance, user experience, user acceptance, user performance, display effectiveness, privacy, and social impact [3]. At the same time it has been recognized that many of the findings are specific to certain settings [10], and that universally applicable design guidelines as well as best practices are difficult to obtain. Rather, there is a need for reports on pervasive displays being integrated in a variety of different contexts to serve as a reference for both researchers and practitioners who want to deploy displays in such environments.

As a result, the call for papers of the MUM conference[1] explicitly requests reports on case studies and field trials, hence encouraging the community to share insights on how previously obtained knowledge can be applied in practice. With this paper we respond to this call by reporting on a project in which we created an interactive museum exhibit.

[1] http://www.mum-conf.org/2017/index.php?web=papers

We were approached by a major Munich museum[2] to extend an exhibition with a digital, interactive installation that blends well with the existing exhibits. The project followed several goals. The museum was interested in an exhibit that appeals to a wide range of age groups (children, teenagers, adults), supports knowledge acquisition, and encourages collaboration among both acquainted visitors and new ones.

We report on the design, development, and evaluation process that led to a permanent exhibit in the museum. We focus on (1) ideation and concept, (2) implementation, (3) an on-site pretest, and (4) the final deployment. We describe the interplay with the different stakeholders, how the exhibit was iteratively refined, and finally present insights into its use by visitors.

RELATED WORK

A lot of work reports on insights from the deployment of interactive displays in public spaces and various environments. Preceding our case study, *museums* served as testbeds for public screens: Block et al. investigated group interaction with a tabletop in a museum [5]. Hinrichs et al. also deployed a tabletop in a museum, focusing on multi-touch gestures [11].

Various research on personal experience with cultural heritage was conducted within the PEACH project[3]. As an example, Rocchi et al. focus on seamless interaction between stationary and mobile devices with personalized content, especially in educational environments like a museum. They particularly aimed at adressing young visitors [21]. Kuflik et al. further extend the PEACH idea. They report on challenges when designing enhanced user experience in a museum, especially regarding small groups vistiting the museum together [13].

Several other deployments were conducted in the context of the meSch project[4]. Petrelli et al. report on the possibilities with the novel meSch approach. They highlight tangible interaction, personalization and Do-It-Yourself as important aspects when integrating technology within the user's experience with cultural heritage [19].

Moreover, various research was done on *games* in cultural and educational areas. Cheung and Wallace present the development of two multi-surface and multi-space games. They report on their collaborative design process with experts, development of design goals and discuss design implications for interactive surfaces to support scientific outreach [6]. D'Angelo et al. report on their fishing game deployed at a local aquarium, focusing on encouragement of visitors, letting them learn and discuss about the problems of overfishing [9].

Apart from educational or cultural settings, research that focused on interactive displays in specific, non-university environments is of particular interest. For example, the Ubi Hotspots deployed across the city of Oulu [18] allowed for investigating display deployments in public squares, libraries [2, 14], and a swimming hall.

Several deployments take place in *public transportation* settings: Alt and Vehns report on an interactive food station with tablets as point of contact in the arrival area of Munich airport [4]. Szymbor deployed a touch wall at Copenhagen Airport [25]. Steinberger et al. enhanced a bus stop with an interactive civic discourse app, where users could cast their vote by stepping onto a physical button [23]. Storz et al. deployed a projection screen in a bus stop underpass [24]. Coenen et al. showed how consecutively situated displays could be used as way finding signage in a train station in Brussels [7].

Retail stores have also been subject to research: Colley et al. deployed digital see-through signage in a large supermarket [8]. Meschtscheriakov et al. deployed a dynamic map in a retail store [16]. Further deployments took place in *cafes*: Taylor et al. deployed a display in a cafe in the city of Wray which let community members share photos [26]. Scheible and Ojala created an interactive music installation, where people could vote for their favorite songs on a public display [22].

There are a number of papers that summarize lessons learned from deployments in specific settings, providing other researchers with guidelines to inform how successful deployments can be run. For example, Storz et al. report on the eCampus system, providing lessons learned with regard to technology and deployment, monitoring, content creation and working in public spaces [24]. Memarovic et al. presented the P-LAYERS framework which discusses the challenges of community-supported public display deployments with regard to hardware, system architecture, content, system interaction, and community interaction design [15].

In a similar way, we contribute to this body of knowledge by providing insights into the design, development and evaluation process of an interactive installation at a museum.

PROJECT DESCRIPTION & CONCEPT

The "Museum Mensch und Natur" (Human and Nature Museum) in Munich is famous for its various interactive, though analogue, exhibitions. It is especially popular among families and children. The museum presents scientific topics such as genetics and biology in a fun and interactive way. A big part of the museum is their exhibition "Unruhiger Planet Erde" (Restless Planet Earth) which explains plate tectonics and the earth's development. In the fall of 2015, the museum expanded this exhibition with a physical earthquake simulator conveying the topic more tangible for visitors. To further enhance the visitors' experience, the museum team sought to complement this exhibition with a new, digital exhibit. They approached us to create a concept and implement a new digital media station, contrasting the existing analogous interactive elements.

Objective & Requirements

The project had several objectives given by the museum staff's expectations, the visitors as target group and the exhibition itself.

(R1) Interaction between visitors A main objective was to stipulate interaction and collaboration between visitors, in particular among visitors who did not know each other yet. In this way, collaborative learning on the given topic – plate tectonics and earthquakes – should be supported.

[2] http://www.mmn-muenchen.de
[3] http://peach.fbk.eu
[4] http://mesch-project.eu

(R2) Address a diverse audience A second objective was to address a diverse audience. Visitors of the museum include adults, teenagers and children. Hence, the goal was to provide information on different levels of depth and detail.

(R3) Integration into the existing exhibition Third, the new station had to be integrated into the existing exhibition.

Ideation

We started with an iterative design process in cooperation with the museum team. As a very first step, we took a guided tour through the museum, especially through the exhibition presenting planet earth and got the chance to try the earthquake simulator. We had several brainstorming sessions, each followed up by a presentation in front of the museum staff.

We developed different concepts for the new, digital exhibit: (1) an interactive globe with a 3D projection of tectonic plates and their movements, (2) an informative application on a multi-touch-table in an interactive media room, and (3) an interactive quiz application.

As the museum staff prefered an interactive quiz to stipulate interaction with the topic and among visitors, we ultimately decided to implement a quiz and integrate it in an existing movie room that used to show static movies.

Game Concept

The game concept should support the topic of plate tectonics and earthquakes, related to the physical simulator. We thus decided to let players rebuild a house, destroyed by an earthquake. This *game goal* highlights a positive aspect of solidarity within the overall topic of catastrophic events.

To support different *levels* of information for different visitors and to adress a diverse audience (**R2**), the museum provided questions for three difficulty settings. Players can choose a level and an appropriate category at the beginning of the game.

A virtual building of wooden bricks is shown as the *main game component* and motivation. Its size depends on the difficulty level. The building is destroyed by a virtual earthquake at the game's start. Players rebuild it with correct answers. To support collaboration, we neither count points per player nor publicly show who got a question right or wrong. Each correct answer puts one building block back into place (**R1**).

Game time per question is limited. In our original concept, the timer always runs to its end after all players have answered, to motivate players to discuss and rethink their decisions.

Each game consists of a fixed number of questions from a chosen category. At the *end* of a game, players can decide to stop playing or to continue with another category to further reconstruct the building.

IMPLEMENTATION

Following the ideation and concept phase, we implemented the described game so as to convert the whole chosen room in the museum into an interactive quiz application: To create an immersive experience, the game is shown on a large projected surface that spans two wall segments. Interaction with the game is possible using tablets. Figure 1 shows the final setup.

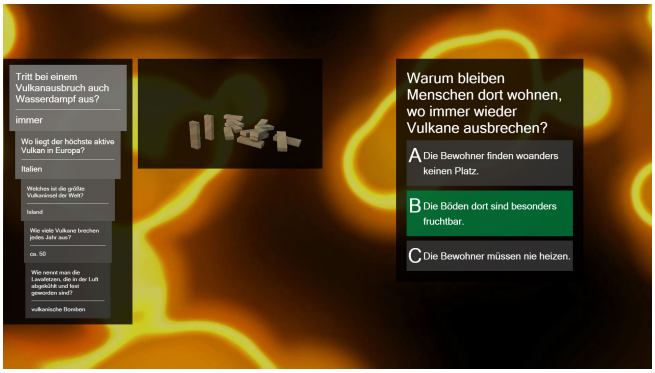

Figure 2. QuakeQuiz projection: The screen shows the current question and answer options (right), the current state of the rebuild process (center), and a history of the last 5 questions played, including the correct answer.

Technical Background

We chose a Node.js server to manage the game and MongoDB to store the questions. The front end is web-based, and can be used on any platform with a browser.

The server is mainly responsible for the game flow. Depending on the level and category the visitors choose on the tablets, questions are fetched from the database and sent to the tablets in a random order. Furthermore, our server controls on which tablet the level is chosen and prohibits the choice for the others. Nevertheless, other clients can join the game at any time. The server receives the clients' answers and sets the question timer.

Projection

An atmospheric projection on multiple walls is the central component of our game (see Figure 1 and 2). We chose this size and arrangement within the room for three reasons: First, the large size (together with ambient sound) emphasizes the forces of plate tectonics, similar to the physical earthquake simulator. Second, the projection can be seen from outside the room to motivate people to enter. Third, the projection allows visitors that do not directly interact with the game to read and think along, even when standing in a crowd.

The projection has four main parts: current question, a video showing the progress of rebuilding the house, a history of questions, and a seismogram which builds up along the entire width of the projection as the question time is running out.

At the start of a game, the projection shows the building's collapse by a virtual earthquake. During the game, a video is shown, adding building bricks to the house, depending on the number of correct answers the players have given. After the video has been played, the next question appears. At the end of the game, we show videos transforming the building bricks into a more realistically looking house in order to reward players for reaching the goal.

Interaction

Tablets serve as game control units for the visitors and allow interaction with the game. The first interacting player can choose the level and category. Other visitors can join at any point during a running quiz, using a free tablet.

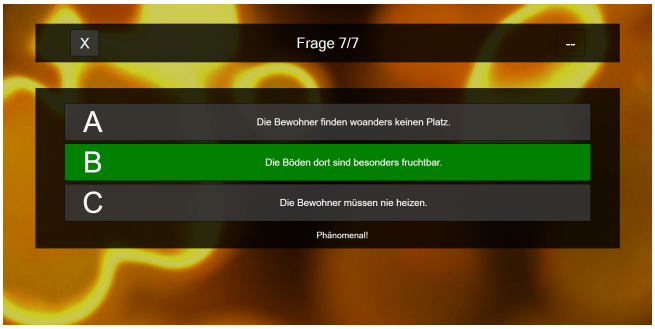

Figure 3. QuakeQuiz Tablet Client: On the client we show the answer options. In addition at the top we provide an option to explicitly leave the game (X) as well as how many questions have already been played.

For each question, the tablets show the possible answers for visitors to choose from (Figure 3). The question itself is not visible on the tablet but only on the projection in order to avoid that the players only focus on the tablet.

Remaining time, hints (e.g. *more than one answer may be correct*) and finally the solution are shown. The tablet UI and the projection share the same background visuals, depending on the chosen category.

We used two tablets during the implementation phase to gain first insights in the wild. For the final setting, the museum administration decided to offer more interaction possibilities using four tablets. Our system is expandable to more clients. In the future, visitors could participate with their mobile phones.

STUDY I: GAME CONCEPT

We first evaluated the game concept by presenting it to a panel of experts from the museum as well as by deploying a first version for use by visitors in the exhibition.

Expert Evaluation

In a provisional setting at our research institute, we presented our quiz application to a panel of experts in education. They identified several aspects of our game concept to be improved, mainly concerning the game flow.

They identified the lack of a way to cancel the game at any time. Additionally, the experts preferred to immediately send given answers and continue the game, instead of waiting for the time to run out for each question (20 seconds). While this removes the opportunity for changing answers, the experts felt that as the game proceeds without waiting time, suspense and motivation would be kept up, addressing impatience. Finally, the experts suggested including feedback on the game progress. In the first version, it was not obvious to players how many questions remained to be answered in the current game.

First Insights in the Wild

The chosen former movie room in the museum was provisionally transformed into the planned quiz game media room. For a time period of two weeks, we collected qualitative data on-site. We observed 20 games with subsequent interviews with the players. The main goal of the study was to evaluate the gameplay experience in general. Based on this iteration step, we refined the game and interaction as described next.

Refinements

Experts and visitors identified similar aspects to be improved.

Time to Solution

In the original design, players had a certain time to answer. The remaining time was shown both as a countdown on the tablet and additionally as a growing seismogram on the projection. After the countdown, the selected answers were locked, the correct answer was revealed in the projection, and players received individual feedback on the tablet.

We chose this approach to give the players enough time to choose their answer and to possibly change it, hence supporting collaboration. However, this fixed feedback time resulted in the players getting bored and impatient. Some players even left the room. Others turned to the observers to find out if the game was not working properly. We thus decided to accept the answers as soon as all players had chosen a response.

Players' responses showed that the game dynamics improved greatly. The suspicion that this change would make the game more competitive was not confirmed. In contrast, this change promoted the overall interaction among the players.

Game Progress

Players criticized that they could not see how far they are into the game. We had thought that it would be sufficient to show the rebuilding progress. However, most players did not connect the rebuilding progress with the game progress. Thus, they quickly lost track of the game progress. Hence, we added a counter to the tablet view, which shows how many questions remain. We found that players remained more motivated when they knew how many questions they still had to answer, and a clear end was predictable.

Cancel Option

In the first version, the game had to be played to the end in the chosen level and category without any option to cancel.

Being stuck in a level or category, which they no longer wanted to play was very demotivating. Many players left the room in such situations. The game continued by time running out for the following questions. Visitors newly arriving only had the chance to play the current running category or wait for the game to end. After the pre-study this was changed and a cancel button was added to the tablet view. It allows players to return to the menu and modify the settings as desired.

Reward Videos

In the first version, a bonus video was shown after successfully completing the easiest level. However, such a video was not shown in the other categories. This was disappointing to the players. Thus, we added bonus videos for all levels. Players looked at the video as a reward, saw their mission as successfully accomplished, and were curious about the bonus videos of the other levels. As a result, they stayed in the room longer and played the quiz in other modes.

Final Element

If players collected enough stones to rebuild the house in the middle of the category, they still had to answer the remaining questions of the category after the reward video. This confused

Figure 4. Tablet Arrangement, left: S1, right: S2

players and motivation to answer the remaining questions without a reward was rather low. Hence, we changed the game so that it ends directly after the house is restored.

Players also wanted end game statistics, which show the number of correctly answered questions for each player. Such a ranking was intentionally avoided in order to decrease competition and pressure. However, possibly motivating aspects of competition may be investigated with a future game update.

STUDY II: TABLET ARRANGEMENT, USER BEHAVIOR, UX

After implementing the changes that resulted from the first study, we conducted another study in the preliminary setting. This time we focused on tablet arrangement and users' experience. The advantage of the preliminary setting was that the two tablets had not yet been permanently installed, but could be moved freely around in the room.

Study Design and Procedure

To determine the best arrangement of the tablets we video-recorded 33 games with a GoPro camera, installed on the ceiling. Signs at the entrance and in the room itself informed the visitors about the video recording. Since we mounted the camera on the ceiling (see Figure 4), faces of visitors were not recognizable. Furthermore, to collect insights on users' behavior and experience we directly observed and interviewed a total of 30 visitors with an average age of 15.27 years. 36% of them visited the museum with their class, 47% with their family and 17% individually. We used questionnaires for these structured observations, asking visitors about the following five areas: Demography, gameplay, usability, tablet position in the room, and general user experience.

Tablet Arrangement

In order to find out how the tablets should be positioned in the final installment, two different tablet positions were evaluated, as shown in Figure 4. In setting one (S1), both tablets were placed next to another facing the wall with the projected questions. In the other setting (S2), tablets were arranged in a 90 degree angle facing different walls. We changed the setting in the middle of each of two days of recording.

Video analysis revealed cases where people entered the room, showed interest in the setting, but visibly did not understand what to do. In consequence, they left the room without any interaction with the tablets and without even starting a game. This happened a lot more often for S2 (20 times), than for S1 (2 times). In addition, questionnaires and play times indicated that S1 overall provided a better user experience than S2. Moreover, in S2 interactions between visitors and players only took place when they knew each other. In contrast, S1 promoted this sort of interaction a lot better.

Figure 4 shows typical player behavior for the two settings. Players in S1 arrange themselves in a semicircle around the two tablets, solving questions together. In S2, two teams compete. While members of each team know each other and interact, there is no interaction between the teams. Most observed games in S1 showed such cooperative play, while most S2 games seemed competitive.

We concluded that the more cooperative installation S1 was better suited for our objectives in this museum. Moreover, since there were other visitors in the room almost all the time, the museum administration decided to use four instead of two tablets in the final deployment.

User Behavior and Experience

Visitors played until the end of the category in more than half of the observed games. Most players also started a second or third round with other categories if they did not finish rebuilding the house in the first round. Similarly, most players who finished the house rather quickly in one round directly started another round. However, they then did not finish this second round again. Regarding difficulty, we found that 54% of all answers were correct. This was slightly higher (65%) for finished games, which suggests that successful players stayed longer, likely since they were more motivated to complete their progress. Based on these numbers, player feedback, and our observations, we thus concluded that the level of difficulty was adequate.

FINAL DEPLOYMENT

In fall 2016, the final deployment was introduced to the museum visitors during the "long night at the museum" event, which takes place once a year.

Setting

Following our studies and the resulting improvements, the room was transformed into its final, quiz show-like setting. The final room has four tablets, organized in a semi-circle and integrated into a desk. Two of the four positions have a seating support. The projectors are hidden in the ceiling in such a way that visitors cannot disturb the projection. Figure 5 shows an outline of the final setting.

Game Statistics

After the opening, we collected data with the final deployment for two months. We logged data to answer questions concerning the game flow: How many players start together? Which level do they choose? Do they finish the game? How do they perform in giving the right answers?

Games

In the evaluated period, a total number of 1650 games was started (approximately 25 games per day): 790 in the easiest level, 385 in the medium one, and 475 in the hardest level. Overall, 63% of started games were finished; 70% on easy, 59% on medium and 56% on hard.

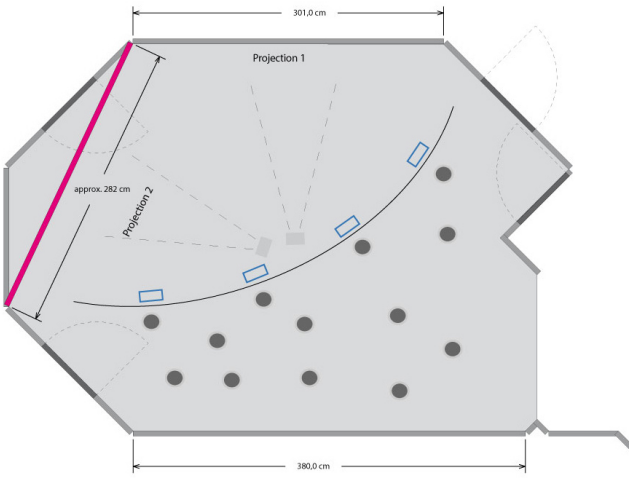

Figure 5. Final Layout of the media room. The Projection is shown on two walls. Four tablets, arranged in a semi-circle and integrated into a quiz-show like desk, allow visitors to interact with the game.

Overall, 53% of the started games resulted in a fully rebuilt house; 22% of those who finished the house managed to do so in one round. Half of all games were continued after finishing the first round (i.e. the first chosen category).

Questions and Answers

During the evaluated two months, a total number of 16,622 questions was played: 6794 easy questions, 4178 medium ones, and 5650 on the hardest level.

Players performed relatively well. For the easiest level, the ratio of correct answers is 62% for one player games, 59% for two player games, 59% for three players, and 56% for four players. For the medium level, these ratios range from 40% to 51%. In contrast, the hardest level has a worse ratio of 29% to 32%, but this may be partly due to the fact that more than one answer can be correct on the hardest level; hence, a player has to select all correct answers to answer the question correctly.

Join and Exit Behaviour

We analyzed players' join and exit behavior in games that were played for one or more rounds, in other words games that were not cancelled before finishing at least one category.

For games started by four players (181 games on easiest, 87 on medium, 129 on hardest level), the team stayed together in the majority of cases (78% on easy, 73% on medium, 51% on the hardest level). Since these teams started together right at the first question, it is likely that the players know each other.

Games started by less then four players have places left to fill. Here, our analysis shows that there is an active exchange of players. In particular, we found a peak of joining players at the second question. Most likely, these are visitors who watch others playing the first question, before deciding to join themselves. After the second question, the number of players tends to decrease. This indicates that in teams that do not start together – which suggests that players might not know each other – not everyone sticks around to the end.

DISCUSSION

One of the main challenges of this case study was to suitably integrate a new digital exhibit into a so far mostly non-digital museum environment (**R3**). During our iterative design process, we received essential feedback from multiple stakeholders. Based on this, we could improve our system in several steps. Experts as well as visitors of the museum got in touch with our system in early stages of development and provisional settings. Our quiz was influenced by the experts' input regarding content and game concept before we conducted our in-the-wild study with regular visitors of the museum.

After our improvements regarding the implementation of the game and the museum's conversion of the room into the final quiz-show setting, we could successfully integrate the QuakeQuiz into the existing exhibition (**R3**).

Based on our experiences in this case study, we highlight that user feedback is indispensable for such public deployments. Particularly in very specific settings like our museum exhibition, it is necessary to test the application with its target group in its original environment. The feedback we received throughout our study iterations greatly helped us to improve the game concept and its physical setting.

Regarding the quiz concept, we found that players form teams which start and play collectively, in particular when the tablets are arranged in such a way that users are standing next to each other. In our final setting with a semi-circle tablet arrangement, players that start together as a team stay together throughout the game. This suggests that our game supports collaborative play, at least for visitors that know each other (**R1**).

QuakeQuiz is well accepted among visitors: During our in-the-wild study, 83 games were started in the provisional setting. During the first two months of the final deployment, visitors started 1650 games; 63% were played until the category's end, and 888 houses were finished. Moreover, all levels of the game are played (easiest level: 790 games, medium level: 385 games, hardest level: 475 games). We cannot say how visitors choose their quiz level, e.g. according to age or knowledge, but we assume that QuakeQuiz addresses a diverse audience as all levels of difficulty are played (**R2**).

Based on these results and further feedback, we conclude that our system is popular among visitors of the exhibition. It appears that playing QuakeQuiz helps users gain knowledge collaboratively. Since the quiz is running in its final setting, the head of the exhibition remarked that visitors asked basic questions about earthquakes less frequently.

CONCLUSION

The research community has studied public displays in a wide range of different environments. Many findings are specific to certain settings, and universally applicable guidelines and best practices are hard to obtain. This motivates case studies that share valuable experiences with researchers and practitioners.

In this paper, we presented a case study in which we designed and implemented an interactive museum exhibit. Our concept and development process involved different stakeholders at several stages of the project. Before we finally deployed the

resulting game, QuakeQuiz, in the museum, we presented it to a panel of experts as well as to visitors of the exhibition in provisional settings. Based on the obtained feedback, we iteratively refined both game software and physical setting.

We profited from the feedback in several ways. We could improve the system and game concept to make it more comprehensible and better integrate it into the overall museum setting and visitor experience. Besides iterating on the digital part of the game, we also learned about the fundamental impact of seemingly small choices with regard to the interior design of the deployment room. We especially concentrated on the tablet arrangement and could further support player collaboration with a refined placement, informed by insights from on-site observations as part of our iterative process.

As a result, QuakeQuiz has become a permanent exhibit in the museum. Observations and data from its first months show that visitors like the new exhibit and play quite often.

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