Combining a location-based mobile game and a connected wearable for history learning purposes

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Södertörn University | School of Natural Sciences, Technology and Environmental Studies
Master’s dissertation 30 credits
Media technology | Spring semester 2019
Interactive Media Design Programme
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ABSTRACT
While much attention in location-based game and wearable research is about their benefits as in-class education or is aimed at children, rather less research has been done about the combination of location-based games and wearables in private use. This paper investigates a game solution for the low history knowledge of German teenagers and focuses on the learning success of the combination of a proposed location-based mobile game and wearable, called ‘Geocation’ for educational purposes as well as the enjoyment of it. Two prototype sets, functional and appearance, about the location-relevant topic ‘King Ludwig II’ were created and tested with 36 teenagers in Munich. To analyze the learning success pre- and post-test surveys were conducted and applied to the strategy of gamification. The enjoyment of the combination of the location-based mobile game and wearable was evaluated by connecting it to the GameFlow theory and conducting post-test interviews. The study has shown that the connected wearable was not crucial for the player’s learning success; however, it contributed to the user’s motivation and enjoyment.

CCS CONCEPTS
• Information systems → Location based services • Human-centered computing → Mobile devices • Software and its engineering → Interactive games

KEYWORDS
Location-based games, pervasive games, wearables, gameflow theory, gamification

1 Introduction
Teenagers are fascinated by many things including trends and new technology [36], unfortunately history does not seem to be one of the fascinating topics. Recent studies provide evidence that teenagers, in particular German adolescent, do not show a high interest in history [5]. Inevitably, a consequence of this lack of history interest is the lack of history knowledge [8]. There are multiple reasons why teenagers are rather less interested in history but one of the reasons could be that teenagers tend to be rebellious [3] and therefore refuse to be interested in this school subject. However, during this phase of life one adopts behavioral traits that one will easily stick to throughout the entire life [6].

Therefore, it is extremely important to challenge this lack of history interest and the consequential lack of history knowledge by investigating in how teenagers can be familiarized with this rather unpopular topic. In order to successfully target this young age group there needs to be a connection of something they are interested in (trends and new technology) and the desired trait (improvement of history interest & knowledge). Hence, this present research investigates the participatory design and testing of a proposed location-based mobile game with a connected wearable bracelet.

The target audience of the proposed location-based game and connected wearables are German teenagers. In general, teenagers nowadays are part of the so-called Generation Z [7]. 2017 there were 5 million 15 – 20 year old teens living in Germany [29], however, the focus of this present study is on 13 – 19 year old teenagers.

Now looking deeper into the media usage of German adolescent, 99% of German teenage girls and 97% of German teenage own a smartphone [23]. This is important to mention because smartphones are used for the proposed location-based game. In 2018 the JIM-Study has shown that 73% of German teenagers play digital games between daily and once in two weeks [23], which supports the idea that German adolescent are great to target with a mobile game. Due to the reason that members of the Generation Z prefer a cool product over a cool experience [17], it is believed that the additional connected wearable, which was designed with the help of six teenagers, will find positive incentive among the target audience.
The aim of this research is to provide a solution to improve the low history knowledge of German teenagers and to give some insights in the learning success of the combination of a location-based mobile game and a connected wearable as well as the enjoyment of it. To evaluate the learning success and enjoyment two prototype sets were created and used in testing sessions.

This paper examines the main research question ‘How can the low history knowledge of German teenagers be improved?’ Furthermore it investigates the two sub-questions ‘To what extent does the combination of a location-based game and a wearable contribute to German teenagers’ history learning success?’ and ‘To what extent do German teenagers enjoy the combination of a location-based game and a wearable in educational situations?’.

2 Background

Since the focus of this paper is on both a location-based game and a wearable, first there is a need to look into relevant research studies of both fields.

2.1 Serious Games

Before looking into the specific type of the proposed game, there is a need to define the term ‘serious games’. By reviewing related literature, many definitions appeared, however most agree on serious games to be ‘(digital) games used for purposes other than mere entertainment’ [31]. In general, serious games are games that try to connect playing and learning. This type of game comes with positive impacts for players such as developing numerous different skills [31].

However, it is important to note that there is a difference between games, serious games and training simulators. Johnston and Whitehead compare this with books, whereas novel books are typically read for pure enjoyment, ‘despite what the [reader] may learn in the process’, in educational settings textbooks are used to teach the reader about a topic and manuals are exclusively for a practical purpose and generally not read for enjoyment [14]. Similar explanation can be transmitted onto games, where games are solely played for enjoyment, serious games are used to educate the player and training simulators closely resemble the player’s reality [14]. Nonetheless, according to Johnston and Whitehead it is difficult to draw a line between these types of games, because eventually the difference lies in how the player perceives the experience [14].

2.2 Location-based Games (LBG)

Location-based games (LBG), which make use of the GPS technology in smartphones [26] can be designed in form of serious games. LBG are games, which are played in physical space and simultaneously supported by content and actions in a linked virtual space [2].

Location-based games can appear in four game patterns or a combination of them. Lehrmann describes the two most common game patterns of location-based games as Search-and-Find and Follow-the-Path. In a Search-and-Find LBG the player simply has to find a specific geolocation, whereas in a Follow-the-Path LGB the player also has to reach a certain destination, however the focus is on the path to reach the destination. Other game patterns are Chase-and-Catch, where players hunt a moving object within the game world, and Change-of-Distance with the goal of getting closer to or further away from a geolocation [22].

The combination of Search-and-Find and Follow-the-Path game patterns make scavenger hunts possible, such as the one used in the present research, where players have to go from station to station and collect a variety of miscellaneous (virtual) items and information.

Compared to wearables in education settings (see chapter 2.3.), more research has been done about location-based games in this field.

Even though their focus is on Augmented Reality (AR) one great example is the research of Harley et al. who compared virtual and location-based AR history mobile learning. 31 undergraduate students were divided in a laboratory/virtual group and an outdoor/location-based group. The findings revealed that the outdoor group was more successful than the laboratory group [12]. Both groups showed high levels of enjoyment, however more enjoyment and less boredom was shown in the outdoor group.

Another study important to mention is the one from La Guardia et al. that tested an educational location-based game for children to learn about culture. La Guardia et al. proposed a game, which was specifically designed for children and consisted of a collection of mini-games. The ‘data analysis has shown that the game is enjoyable for children’ [18], however the researchers were not able to evaluate the educational value, which shows the need for further investigation of this field.

One very popular location-based game, which among other factors served as an inspiration for the proposed game is Pokémon GO. The mobile application game uses geolocation to create an augmented reality [34], where players need to move around to collect free-roaming Pokémon creatures. Among many positive effects of this game, it also increases the players’
socialization and visits to public parks, museums, and historical sites.

2.3 Wearables
In general, wearable technology and wearable devices are electronics and computers, which are somehow integrated into clothing or accessories and can therefore be worn comfortably on the body [35]. Labus et al. describe wearable computing as ‘the use of miniature computing devices in order to support various human activities’ [19]. There are no limitations for the size and shape of wearables; therefore, they can take for example the form of clothing or jewelry, e.g. rings, necklaces, glasses and bracelets.

Furthermore, wearables are used in all kinds of environments including fashion and entertainment, however a huge number of wearables is designed for fitness, health and medicine purposes [35]. Even though there is a lack of literature about educational wearables for the private use of teenagers, some researchers have specified on the general use of wearables for educational purposes.

One of the early researches about this topic was conducted by Nakasugi and Yamauchi who focused on the development of a wearables learning system for history education. Ten 10-46 year olds at University of Tokyo tested a see-through display which overlays past events on the live scenery. The findings strongly suggest the positive effects on the motivation of history learners. The wearable also allowed ‘users [to] experience and feel history as a reality’ [24]. Since this research focused on history learning it is extremely relevant to the present study, however further research needs to be conducted as Nakasugi and Yamauchi used a wearable with Augmented Reality.

Engen, Giæver and Mifsud have explored the potential and challenges of using wearable computers to support teaching and learning within a secondary classroom context [10]. 21 pupils and one teacher in ninth grade took part in the study. All pupils were provided with a smartwatch for mathematics, PE and social sciences classes for a two-week period. The observatory and interview data showed that the introduction of wearables is motivating for pupils. Furthermore, the researchers argue not to underestimate the value of wearables in mathematics classes. However while the smart watches raised interesting cross-disciplinary possibilities in designing learning activities, it also raised concerns about privacy issues [10]. Even though this study was focused on in-classroom use instead of private use, it is still important to the present study as it proves the potential of wearables for pupils in the tested learning fields. Therefore, it needs to be tested whether or not this also applies to learning about history.

The fact that available research was mostly conducted for in-classroom use and not focused on German teenagers, shows the research gap in this field.

3 Theoretical Framework
To understand the learning success and the enjoyment of the proposed mobile game and the connected wearable the theories of gamification and GameFlow are explained in the following chapters and later (see chapter 9.1 & 9.2) applied to the study data.

3.1 Gamification
In order to look into the learning success of the combination of the location-based game and a wearable the strategy of gamification in educational settings was examined. In general, gamification is described as the use of characteristics, which are usually related to video games, in non-game contexts [21]. Educational gamification aims at using ‘game-like rule systems, player experiences and cultural roles to shape learners’ behavior’ [30].

There are various researchers investigating gamification and game-based learning. This resulted in a great number of models and theories within this field, however the most appropriate one for this present study are the 11 crucial game-design factors by Shi and Shih, which aim to ease the development of more interesting educational games [28]. All factors are dependent and affect each other.

![Figure 2: Gamification Attributes](image)

**Game Goals** are the core concept of game design, which all factors are based on. Here game designers decide what type of experience they want to provide for players. The players then follow the game goals. In-depth designer should consider short-, medium-term and long-term goals [32].

**Game Mechanism** facilitates frictionless function of the virtual world and refers to promoting player actions to achieve the designer goals. **Interaction** is part of Game Mechanism and includes all interactions between the game and the players. Among others certain game responses which are triggered by the players’ actions. **Freedom** allows autonomy for players and also belongs to Game Mechanism. This factor depends on the several
aspects, including game genres, control modes, game processes etc. Some games feature player possibilities to create individualized avatars, some focus on role control and others on overall planning and controlling.

**Game Fantasy** refers to the environmental and background context that supports the virtual world imagery, including stories and multimedia. For educational games, it is important to make the player feel deeply involved in the game. **Narrative** is a Game Fantasy factor that characterizes what occurs in the virtual world. Shi and Shih explain that narrative can appear in form of words but occurs in a greater extend in media [28]. For educational games narrative is an essential factor, yet the importance of narrative differs from game to game. **Sensation** is part of Game Fantasy and defines the multimedia presentation of the virtual world. According to Huang in order to improve players’ motivation, simulation, audio and graphic elements are extremely important factors and motivation is an important impulse for success in learning [13].

**Game Value** boosts the players’ game motivation and immersion. ‘Achievements and tasks are the goals and challenges of players, which lead to rewards’ [28]. **Challenge** is a factor related to Game Value that describes the effort of players to reach the game or personal goals. Within game-based learning challenges are essential. **Sociality** also belongs to Game Value and refers to the interaction between people through the game system. This factor includes social behavior like communication, cooperation, competition and conflicts. Finally, **Mystery** is part of Game Value too. Mystery offers an original experience with curiosity and exploration for the player. Shi and Shih describe Mystery to be important but not an inevitable factor [28].

### 3.2 GameFlow Theory

Enjoyment is one of the most important characteristics of a game – if players do not enjoy a game, they will most likely not continue to play it. In order to evaluate the enjoyment of the combination of the location-based game and a wearable the GameFlow theory, elaborated by Sweetser and Wyeth, will be used. Schell puts the Flow theory in its proper place as one so-called ‘lens’ out of a hundred. Schell’s ‘lens’ collection summarized the things that affect a player’s experience of games [27]. Next to The Lens of Pleasure, the most appropriate theory is The Lens of Flow. Based on the widely accepted model of enjoyment ‘Flow’ by Csiksentmihalyi (1990) the researchers Sweetser and Wyeth adjusted it to the enjoyment in games and called it GameFlow.

Their model includes eight elements, which are concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction.” [33]. All eight elements are closely interrelated and interdependent and each of these elements contain a number of criteria. Even though GameFlow is great to understand the enjoyment in games, Sweetser and Wyeth explain that some GameFlow criteria are more suitable for specific games [33].

First of all the game has to require **concentration**, which means the player has to be able to concentrate of the game or a task. Then a game should **challenge** and match the player’s **skill** level. Furthermore, players should feel like they have some sort of **control** over their actions in the game. In addition, games should provide **clear goals** and give **feedback** at suitable times. Moreover, games should be designed in a way to enable players to experience deep but effortless involvement in the game. Finally, games should provide opportunities for **social interaction** [33].

<table>
<thead>
<tr>
<th>GameFlow Elements</th>
<th>Criteria</th>
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| **Concentration** | - games should provide a lot of stimuli from different sources  
- games must provide stimuli that is worth attending to  
- games should quickly grab the player’s attention and maintain their focus throughout the game  
- the player shouldn’t be burdened with tasks that don’t feel important  
- games should have a high workload, while still being appropriate for the player’s perceptual, cognitive and memory limits  
- players should not be distracted from tasks that they want / need to concentrate on |
| **Challenge** | - challenges in games must match the player’s skill level  
- games should provide different levels of challenge for different players  
- the level of challenge should increase as the player progresses through the game and increases their skill level  
- games should provide new challenges at an appropriate pace |
| **Player Skills** | - players should be able to start playing the game without reading the manual  
- learning the game should not be boring, it should be part of the fun  
- games should include online help so the player doesn’t need to exit the game  
- players should be taught to play the game through tutorials or initial levels that feel like playing the game  
- games should increase player skills at an appropriate pace as they progress through the game  
- players should be rewarded appropriately for their effort and skill development  
- game interfaces and mechanics should be easy to learn and use |
Control
- players should feel a sense of control over their character or units and their movements and interactions in the game world
- players should feel a sense of control over the game interface and input devices
- players should feel a sense of control over the game shell (starting, stopping, saving etc)
- players should not be able to make errors that are detrimental to the game and should be supported in recovering from errors
- players should feel a sense of control and impact onto the game world (like their actions matter and they are shaping the game world)
- players should feel a sense of control over the actions that they take and the strategies that they use and that they are free to play the game the way that they want (not simply discovering actions and strategies planned by the game developers)

Clear Goals
- overriding goals should be clear and presented early
- intermediate goals should be clear and presented at appropriate times

Feedback
- players should receive feedback on their progress to their goals
- players should receive immediate feedback on their actions
- players should always know their status or score

Immersion
- players should become less aware of their surroundings
- players should become less self-aware and less worried about everyday life or self
- players should experience an altered sense of time
- players should feel emotionally involved in the game
- players should feel viscerally involved in the game

Social Interaction
- games should support competition and cooperation between players
- games should support social interaction between players (chat etc)
- games should support social communities inside and outside the game

4 Method
The proposed game, named ‘Geocation’ is designed based on the theory of GameFlow and Gamification and is structured like a scavenger hunt, meaning the game starts at a specific GPS coordinate and continues at different locations until the player reaches the final location. At each station, players receive information about a topic as well as instructions on how to find the next station. During the hunt the players have to answer questions, where they receive a ‘Gulden’ (value 15 points) for each correctly answered question. In addition, players can collect trophies throughout the game; however, some of the trophies can only be collected with a certain number of ‘Gulden’.

The wearable bracelet not only serves as a navigator by lighting up either red or green, depending on if the player walks into the right or wrong direction, in addition it shows the user their current scores. In the daily life, the user is able to wear the wearable as a fashion accessory [25], which theoretically gives a signal once the user gets close to the starting point of a scavenger hunt. After reading the notification about the topic and the duration of this scavenger hunt users can spontaneously decide whether they want to play. The final version of ‘Geocation’ would feature multiple scavenger hunts all over Germany, however due to time restrictions this study is limited to only one scavenger hunt about ‘King Ludwig II’.

The topic was chosen due to the reason that even though King Ludwig II was the Bavarian King in the 19th century, he is still of extreme value nowadays as his castles are all around Munich, where the testing took place.

Wearables used for other purposes, e.g. fitness wearables, proved themselves to be ‘the ultimate motivational tools’ [11]. Furthermore one recent study by Kettunen & Kari, who investigated digital coaching in sport and wellness, showed that ‘the most common features relating to increased motivation were […] gamification and being able to see your results. Also, social pressure seemed to increase motivation for some participants’ [16]. This shows the need to investigate whether or not the proposed wearable improves the learning success and enjoyment of German teenagers playing the location-based learning game.

Hence two prototype sets (consisting of game/app prototype & wearable bracelet prototype), one for the appearance (see figure 7 & 8) and one for the functionality (see figure 9 & 10), were created and designed with the input of a focus group as well as interviews with history teachers and German teenagers. This was followed by testing sessions in Munich with 36 teenagers. All participants were split into three groups, including two control groups in which one group tested the game without the wearable and the other simply read an information pdf. However all participants took part in the identical pre- and post-test surveys in order to evaluate the learning success. The enjoyment was judged by the means of additional post-test interviews of the group that tested both the game and the wearable.

The aim of this study is to provide evidence of the learning success and enjoyment of the proposed location-based mobile game and the connected wearable as a solution to the lack of history interest and knowledge of German teenagers.
5 Mobile Location-based Game & Wearable

As described above, the proposed game ‘Geocation’ is a location-based scavenger hunt game for smartphones, which in addition is connected to a wearable bracelet. During the game players need to walk from one station to the next station, while learning about King Ludwig II. The players need to answer multiple-choice questions in order to earn points/’Gulden’. Certain scores are needed to collect trophies, which show up along the way to the final destination.

Below the two game modes as well as the structure and content of the game are explained. Furthermore, the connection of the wearable is described.

5.1 Modes

The game itself can be split up into two parts, the Map Mode and the Information Mode. Both modes show completely different content, however the only button that stays the same in both modes is the menu button. Here players can access their trophy inventory, where all collected trophies and ‘gulden’ can be found.

5.1.1 Map Mode

The Map Mode is where the player can see the own location on a map of the surrounding in satellite view. Due to the reason that the game uses the GPS information of the phone, the player can track the own location even while walking. Additionally the map shows the location of the next station and of a trophy, if available. While in this mode, there are no clickable buttons on the map apart from the menu button. During the testing sessions the lights, which are attached to the wearable bracelet prototype, were controlled by the supervisors. However, the goal for the actual product is to make the lights interactive in the map mode depending on weather the user walks into the right or wrong direction to the next station.

5.1.2 Information Mode

The information mode is triggered when the user is located within a 7-meter radius of the starting point of the scavenger hunt, a station or a trophy. This mode is very versatile, as it features all types of content as explained in 5.2. This includes text, images, videos and multiple-choice questions. The information mode is similar to a slide show, where each slide contains certain information. Furthermore, while being in this mode the game also sends notifications to the wearables. These notifications include information about new collected trophies and new scores.

![Figure 4: Example of Map Mode](image)

![Figure 5: Example of Information Mode](image)

5.2 Structure & Content

Below the structure and content of both the actual game (function prototype) and the app (appearance prototype) are explained. In the final product, the actual game would be integrated as part of the app.

5.2.1 Scavenger Hunt Game

As described in 5.1 the game is split up into two modes. While the map mode shows the location of the player, stations and trophies, the information mode is where the actual content is placed. The scavenger hunt for the testing sessions consists of 30 stations, including seven trophy stations. Each station or trophy station consists of different content pages e.g. text, text + images, videos or multiple-choice questions. In total, there were two short video clips, 35 images (both recent and historical images) and six multiple-choice questions used in the scavenger hunt about ‘King Ludwig II’, which was used in the testing sessions. In addition, a voiceover for each content page was produced and implemented; however, for some unknown reasons this feature did not work in practice, but it would be crucial for the actual product.

At the beginning of the scavenger hunt, the participants received a text message on the smart watches. The text message states that the player is located close to the start of a certain scavenger hunt and listed the topic and the duration of this particular scavenger hunt.

It is important to build a game in a way that makes sense to the players, therefore the scavenger hunt about ‘King Ludwig II’ was structured in a chronological order to tell the story of the King’s life. Each station was named after the year of the events, which served as some sort of timeline.

The interviews with the three history teachers revealed that in order to motivate teenagers to learn about history, it is necessary to:

1. establish an importance to the present,
2. teach about topics that teenagers can relate to,
3. include historical resources,
4. teach about topics that were important to the society in particular times.
The importance to the present was established by including historical and recent pictures about buildings that are still standing. Furthermore, memorial sites, which can still be visited, were shown and events, like two wars and the equalization of Jews were covered.

Topics that teenagers can relate to include the Munich Oktoberfest, which is still the most popular fair in Munich, as well as all sort outstanding historical remains of King Ludwig II.

Historical resources were used in form of short music compositions, old historical letters and historical images of King Ludwig II and people he was surrounded by.

Topics that were important to the society in King Ludwig’s II time were among others the rebellion due to the increase in price of beer as well as homosexuality as an illness.

After finishing the actual scavenger hunt the players were shown a short summary of the learned content on their smartphone screens and received a notification on the smart watch about their score and the fact that they reached Level 2 now.

5.2.2 App

Now moving from the actual game to the app, which theoretically features additional information in the final version. For the design, a minimalistic structure and some light green colors were chosen. The app ‘Geocation’ features a regular menu bar at the bottom to ensure easy navigation. After opening the app, a log-in page appears, to guarantee privacy/security for the player. After the login, the app will connect itself to the wearable. The app features pages like home, settings, community, friends’ ranking, friends list, challenges, a map and a list of scavenger hunts (to play the actual game), profile, a summary of learned information and a quiz page with regular tests to recap the learned information (see figure 6).

5.3 Wearable

Within the function prototype the smart watches, did not have an actual technical connection. However, there was a sim card in every smart watch, which allowed the game to send interactive text messages to each smart watch. Comparing the function and the appearance prototype of the wearable (see chapter 6), it is clear to see that the actual/final wearable is supposed to be a lot smaller than the smart watch. The appearance wearable prototype was designed with the help of six German teenagers, to make it look as much desirable as possible, as Generation Z prefers a cool product over a cool experience [17]. For the actual product, the wearable would be connected to the game on the smartphone via Wi-Fi or Bluetooth to serve as an extension of the smartphone game/app. There would not be simple text messages, but rather more detailed and more visual appealing notifications. However, this was not possible to create due to missing programming skills.

6 The Geocation Game Prototype

First step was to conduct some literature analysis of the problem of German teenagers’ low history knowledge as well as serious games in particular location-based games and wearables for learning purposes. Furthermore, literature about the target audience of German teenagers was analyzed.

The second step was to develop prototype sets for both the usability and the design. By conducting participatory design and in order to provide appropriate prototypes, a focus group with five German teenagers was run as well as interviews with three history experts and six German teenagers were conducted. The history experts approved the idea to focus on King Ludwig II as the topic for the testing sessions and explained what type of content should be used in this specific case and how it should be taught in the game. The German teenagers helped designing the look of the wearable and app prototype. The interviewed teenagers mentioned important characteristics for wearables to be small in size, easy usability and possible individualization, among others. All ideas and suggestions of these six teenagers were considered during the design of the prototypes.

The goal was to create two prototype sets. One prototype set of the appearance (see figure 7 & 8) for later interviews and one prototype set of the functionality (see figure 9 & 10) in order to test the learning success and enjoyment that comes with the combination of the location-based mobile game and the connected wearable. The prototype set of the appearance consists of a clickable App prototype, created with Justinmind [15], and bracelet prototypes (crafted with normal jewelry parts).

![Figure 6: App Structure](image-url)
The prototype set of the functionality consists of the game/scavenger hunt prototype, created with FreshAir Editor [9], and DZ09 Smart watches with a light attached. The final product would consist of the scavenger hunt game integrated into the app and a functional wearable bracelet looking like the appearance prototype.

The location-based game is in form of a scavenger hunt and was created with the FreshAir Editor to work on all smartphones. Important for the testing was to own a smartphone with the ability to receive GPS data, due to the reason that each scavenger hunt station was set on a certain GPS coordinate. The area of the testing session was in Munich where the 30 stations were set up in the FreshAir editor (see figure 11). The location of most stations was related to the content shown in the game at this particular station. The game/scavenger hunt itself takes approximately 45 – 60 minutes to complete. Furthermore, it was assumed that all teenagers are able to connect their phones to the internet; however, Wi-Fi hotspots were provided.

Finally, testing sessions were run to investigate the learning success and the enjoyment of the combination of a location-based game and a wearable. To gather a variety of data all subjects were split into three groups including two control groups (see figure 12). Group 1 and 2 were then divided into small groups of four teenagers due to the limitation of four prototype sets. To test the learning success data was collected of all groups taking part in the identical survey on a provided tablet before and after the testing. To evaluate the enjoyment of the combination of the location-based game and wearable, a questionnaire was given to all participants to rate their enjoyment.
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A Wi-Fi hotspot was provided for the subjects to download the game to their phones and each of the four testers in each group was given one smart watch with the attached light. This was followed by a short personal instruction of the game and the smart watches; in addition, the actual game/scavenger hunt started with an explanation of how it works.

The subjects were told to start the game on their own and answer the questions individually. However, in case they meet each other during the testing sessions they were allowed to talk and compare their scores. Due to the reason that the bracelet prototype is a Wizard-of-Oz, which simply pretends to be working correctly, there was one supervisor staying close to each subject during the testing session. Lights, which are attached to the smart watches, were controlled by each supervisor depending on if the subject walks into the right (green light) or wrong (red light) direction to the next station. However, the subjects were told that the lights are connected to the app just like the smart watch and the supervisor simply stays close by in case any questions occurred.

The testing was followed by the subjects filling out the post-test survey on the provided tablet. Furthermore, group 1 was additionally interviewed (see figure 12) where they were able to explore the prototype set of the appearance as well. Though two subjects of group 1 were not able to take part in these structured interviews.

<table>
<thead>
<tr>
<th>Group</th>
<th>Who</th>
<th>What</th>
</tr>
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<tbody>
<tr>
<td>(1)</td>
<td>12 teenagers</td>
<td>- Pre-Test Survey</td>
</tr>
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<td></td>
<td></td>
<td>- Testing the game &amp; bracelet prototypes</td>
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<td></td>
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<td>- Post-Test Survey</td>
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<td></td>
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<td>- Structured Interviews</td>
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<tr>
<td>(2) Semi-control group</td>
<td>12 teenagers</td>
<td>- Pre-Test Survey</td>
</tr>
<tr>
<td></td>
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<td>- Testing just the game prototype</td>
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<td></td>
<td></td>
<td>- Post-Test Survey</td>
</tr>
<tr>
<td>(3) Control group</td>
<td>12 teenagers</td>
<td>- Pre-Test Survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reading an information sheet on their phone</td>
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<tr>
<td></td>
<td></td>
<td>- Post-Test Survey</td>
</tr>
</tbody>
</table>

Figure 12: Test Groups

7.1 Participants

The subjects were collected by using the simple random sampling strategy. Random teenagers who stayed close to the starting point of the scavenger hunt (Max-Joseph-Platz; Munich) were approached. This choice was made due to location reasons, since this strategy allowed the testing session to begin straight away, without having to get the subjects to the starting point first. Teenagers aged from 13 – 19 were targeted, which resulted in 36 testers of all genders.

7.2 Procedure

The data was collected between April 6th and April 19th, 2019 in Munich with 36 German teenagers divided into three groups of 12 participants (see figure 12), which again were split into sub-groups of four teenagers. One sub-group at a time took part in the testing session.

7.2.1 Group 1

Thanks to the simple random sampling strategy, only four teenagers were approached at the same time to have nobody waiting. First all subjects were instructed to fill out the pre-test survey on the provided tablet. A Wi-Fi hotspot was provided for the subjects to download the game to their phones and each of the four tester in each group was given one smart watch with the attached light. This was followed by a short personal instruction of the game and the smart watches; in addition, the actual game/scavenger hunt started with an explanation of how it works.

The subjects were told to start the game on their own and answer the questions individually. However, in case they meet each other during the testing sessions they were allowed to talk and compare their scores. Due to the reason that the bracelet prototype is a Wizard-of-Oz, which simply pretends to be working correctly, there was one supervisor staying close to each subject during the testing session. Lights, which are attached to the smart watches, were controlled by each supervisor depending on if the subject walks into the right (green light) or wrong (red light) direction to the next station. However, the subjects were told that the lights are connected to the app just like the smart watch and the supervisor simply stays close by in case any questions occurred.

The testing was followed by the subjects filling out the post-test survey on the provided tablet. Furthermore, group 1 was additionally interviewed (see figure 12) where they were able to explore the prototype set of the appearance as well. Though two subjects of group 1 were not able to take part in these structured interviews.

Figure 13: Group of Teenage Girls during a Testing Session

7.2.2 Group 2

The testing session of group 2 worked exactly as the testing session of group 1 however there were no smart watches involved and the subjects only tested the game without any bracelet prototypes. Furthermore, this group was not interviewed after the testing (see figure 12).

7.2.3 Group 3

After filling out the pre-test survey on the provided tablet group 3 was given a Google Drive link to download the information sheet as a pdf to their phone. For this, a Wi-Fi hotspot was arranged. The 12 teenagers were instructed to read the information sheet and afterwards fill out the post-test survey on the provided tablet. Again, this group was not interviewed after the testing either (see figure 12).

8 Results

Below all relevant results of both the pre- & post-test surveys of all groups and the post-test interviews with group 1 are listed.

8.1 Pre- & Post-Test Surveys

Here all relevant results of the pre- & post-test surveys of all groups are mentioned in order to evaluate the learning success in chapter 9.1.
8.1.1 All Pre-Test Groups

To begin with, it is interesting to mention some statistics about the participants of all groups (see figure 12) which might have had an influence on the learning success.

At the time of the testing, participants were part of four different types of German schools between 5th and 12th grade. All subjects attend history classes, however the majority (63.9%) are not and rather not interested in history (see figure 14). 61.1% of all participants were born in Munich and exactly 50% already own a type of wearable. 55.6% of all subjects regularly play online games.

![Figure 14: Level of History Interest of all Participants](image)

As mentioned above there is a lack of history knowledge [8], however King Ludwig II is a topic that is extremely relevant to Munich, where the testing sessions were run. Though the knowledge of all participants about this topic was extremely small, as for all questions less than 8 of 36 participants knew the correct answer.

The cross-tabulation technique allows to explore the relationship between two variables. Yet after conducting various cross-tabulations there was no outstanding difference in previous knowledge about King Ludwig II between participants of the different grades, different types of schools or whether or not the participants were born in Munich.

8.1.2 Comparing All Pre- & Post-Test Groups

As previously mentioned 36 participants were split up into three groups of 12 participants - group 1 which tested both the game and the wearable, group 2 which tested just the game and group 3 which read an information sheet. In order to see which group learned the most, comparisons of answered questions were made. Before the testing sessions, wrong answers of all pre-test groups were relatively constant and between 9 – 12 wrong answers per group, however there were two exceptions in group 3. In two questions, this group only had 6 wrong answers and 4 right, which is better compared to the other two groups. Nevertheless, since all participants were randomly selected this exception is not further investigated.

Looking at the results of the post-test surveys it was clear to see that group 1 and group 2 answered most questions correctly. Group 1 (tested game & bracelet) correctly answered all questions by 91.7% and group 2 (tested only the game) correctly answered the majority of the questions by 83.3 – 100%. In two questions however only 9 out of the 12 participants (75 – 100%) in group 2 chose the correct answer. Group 3 (read an information sheet) was the least successful group who answered the majority of the questions correctly by 25 – 50%, with three exceptions of 66.7 – 83.3% of the group answering the question correctly.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Group 1 Game &amp; Bracelet</th>
<th>Group 2 Just Game</th>
<th>Group 3 Information Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>10.</td>
<td>12</td>
<td>100,0</td>
<td>9</td>
</tr>
<tr>
<td>11.</td>
<td>11</td>
<td>91,7</td>
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<td>12.</td>
<td>11</td>
<td>91,7</td>
<td>10</td>
</tr>
<tr>
<td>13.</td>
<td>10</td>
<td>83,3</td>
<td>9</td>
</tr>
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<td>14.</td>
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<td>100,0</td>
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<td>22.</td>
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</tr>
<tr>
<td>25.</td>
<td>12</td>
<td>100,0</td>
<td>11</td>
</tr>
</tbody>
</table>

![Figure 15: Number of Participants (N) & Percentage % of Correctly Answered Questions](image)

8.1.3 Game and Wearable

Now knowing that group 1, which tested both the game and the wearable, answered the most questions correctly and presumably learned the most; it would be interesting to see whether there was
a difference between participants who already own a wearable and the ones who do not, between participants who regularly play online games and the ones who do not and between different grades, type of schools and levels of history interest. However due to the reason that the testing groups were rather small and the fact that after testing the game and the wearable most participants of group 1 chose the correct answer to all questions, it is not possible to draw any informative results of a cross-tabulation test. A huge number of cross-tabulation tests were run with the data collected from group 1; and even when combining the data of group 1 and group 2 there were not clear findings.

8.2 Post-Test Interviews
Below is a report of all relevant results of the post-test interviews with group 1 to evaluate the game enjoyment in 7.2. Next to information about the enjoyment, the post-test interviews also revealed other interesting insights into the participants’ opinion towards both prototype sets, which might be relevant to future research. It is important to mention that two of the 12 participants of group 1 were not able to take part in the post-test interviews due to lack of time, however they told their supervisors to have enjoyed the experience.

8.2.1 Combination of Scavenger Hunt and Smart Watch (Functionality Prototype)
When asking the remaining 10 participants of group 1 to rate their enjoyment of the scavenger hunt connected to a wearable on a scale 1 – 5 (1 = less enjoyment; 5 = high enjoyment) 80% of them rated the experience to be a 4 or a 5. Only two participants rated it as being a 2 or 3 and preferred the scavenger hunt to be a little shorter.

All 10 interviewed teenagers believed the scavenger hunt game as well as the smart watch were easy to understand with easy usability. Furthermore, all participants liked the fact that the game is an outdoor game.

90% of the interviewees agreed they would like to use the game and wearable in their free time. However most participants mentioned two conditions, which were a smaller bracelet and more topics. One person explained to rather use it on vacation in unknown cities instead of the home city.

Again 90% of the 10 teenagers would recommend the game and wearable to their friends. Some were motivated to recommend it to their friends in order to play together and against them. However, one person stated to rather not recommend it to their friends, unless there were other topics included.

Scavenger Hunt (Functionality Prototype)
Even though the game is an educational game, most of the participants of group 1 explained to like the learning aspects of the scavenger hunt. However, some stated again that they would prefer a shorter scavenger hunt. One teenager suggested adding an extra test a few days after playing the scavenger hunt to check one’s knowledge.

The 10 teenagers were asked if there were any other topics they are interested to play scavenger hunts about. Four teenagers mentioned to really like the history topic of the testing session and believed history topics to be suitable for this game. A list of other interesting topics include among others politics, geography, sport, recent topics, flowers, general knowledge, celebrities, architecture and science.

Smart Watch (Functionality Prototype)
When it comes to the bracelet/smart watch, all participants considered the notification on the smart watch to be motivating and fun. Some mentioned to especially like seeing their score rising on the bracelet and others found it motivating to compare their smart watch notifications with their friends. One teenager explained that the notification (about the topic & duration of a scavenger hunt) in the beginning of the game would definitely motivate him to start the game.

Compared to the positive feedback about the notifications, the lights were not rated as positively. In general, they seemed to be ‘annoying’, ‘unnecessary’ and ‘too big’. Only a small number of participants thought the lights were helpful and a good idea. This information will be relevant to future work and further elaboration of the wearable.

8.2.2 App & Wearable (Appearance Prototype)
The last part of the post-test interviews consisted of introducing the appearance prototype set to the participants and asking them about their opinion.

App (Appearance Prototype)
The usability of the clickable app prototype was overall positively rated. Although all 10 teenagers agreed to an easy usability, two teenagers mentioned they would add some finishing touches.

The design was mainly described as good and middling. While around half of the participants described the design with positive adjectives like clear, modern, good and simple; the other half interpreted the design to be ‘nothing special’, ‘not stunning’, ‘upgradeable’ or ‘a bit childish’. Yet in general, the majority agreed to find the design of the app prototype clear and okay.

Some interviewees additionally mentioned to like following features of the app: news feed, being able to compare friends’ scores to get motivated and to change the settings of the bracelet.

Wearable Bracelet (Appearance Prototype)
Among the 10 teenagers the bracelet appearance prototype was evaluate extremely positively. All teenagers liked the design of the wearable, including the three small displays, the small size of the wearable, the possibility to fully customize it and the different colors.

The final question of the post-test interview was whether they would wear such wearable bracelets. While 90% of the teenagers...
stated they would like to wear it, one teenager would only wear it if there are even more bracelet designs available.

9 Discussion

Below the results relevant to the learning success and to the game enjoyment are discussed by the means of GameFlow elements and Gamification attributes. For the evaluation both prototype sets are taken into account. Here answers to both sub-questions ‘To what extent does the combination of a location-based game and a wearable contribute to German teenagers’ history learning success?’ and ‘To what extent do German teenagers enjoy the combination of a location-based game and a wearable in educational situations?’ are provided. Furthermore a general discussion is added to clarify some additional important study results.

9.1 Learning Success – Gamification

By comparing the pre- & post-test survey-results of all groups, it was obvious that group 3, which only read an information sheet about King Ludwig II, had the least learning success compared to both groups that actively used the location-based game outside. This finding is similar to the one of the above-discussed study of Harley et al., which also revealed that their outdoor group was more successful [12].

Just like the findings of Nakasugi’s and Yamauchi’s research [24] as well as the one of Giaver et al. [10], where the use of wearables showed evidence to have positive effects on the motivation of learners, the wearable connected to the location-based game used in the present research also stimulated participants’ motivation.

A conclusion of this might be that using a gamified learning tool allows higher learning success than simply reading about a topic. To analyze the proposed game ‘Geocation’, which is a combination of a location-based scavenger hunt game and a connected wearable, first of all the game goals need to be specified. The game goals of ‘Geocation’ are to provide a fun way to learn about history (in this study about King Ludwig II), to support orientation between historical locations in order to get a better feeling for them and to integrate a fashionable wearable into a location-based game in order to attract the young target audience, since it is evident that this generation prefers a cool product over a cool experience [17]. According to Swartout and van Lent short-, medium- and long-term goals should also be considered [32] when speaking of game goals. The short term goal of ‘Geocation’ is to make a player spontaneously decide to do a scavenger hunt by receiving a notification on the wearable. Furthermore the medium term goal is to keep the player motivated to continue the game and the long term goal of ‘Geocat’ion’ is that the player learns about history from the game and keeps the knowledge by regular tests within the app.

The next gamification attribute category is the game mechanism, which covers the function of the virtual world. Here the proposed location-based game is making use of GPS technology and the wearable prototype using sim cards to create a connection between the wearable and the game. However the final version of the wearable would establish a connection to the game via Wi-Fi or Bluetooth and the game would be integrated in the, for this study separate, app. Part of the game mechanism is the attribute interaction, which describes the interaction between the game and the player. ‘Geocation’ starts by introducing the game features to the player in the beginning of the game, this is followed by the player walking from one station to the next. Here the shown content and the player’s location are interdependent. Furthermore the notifications on wearable and the player’s score are dependent on the number of correctly answered questions, hence the trophies shown on the map also depend on the player’s score. Moreover there is an information summary shown in the game and in the app as well as a wearable notification of the score and level in the end of one scavenger hunt. All app features (see chapter 5.2.2) are also included in this Gamification category. Freedom, which also belongs to game mechanism, refers to the actions that can be performed. Combining all actions from the actual game, the app and the wearable there is a long list of actions that can be performed, however the main actions are the individual time- and location-management of players, the consumption of different multimedia content, the search for the next stations and trophies, joining challenges, comparing scores with friends on the wearable and app, looking up own trophies and scores, reviewing learned knowledge and taking part in tests in the app and individualizing the wearable bracelets.

Game fantasy indicates the game environment and background, which in the case of ‘Geocation’ is the minimalistic map mode that only shows the player’s location and the location of the next station and trophies. Furthermore game fantasy includes the clear information mode with different multimedia where the player gathers information, the colorful app design and the deep involvement in the game through notification on wearable. Narrative covers the occurrences in virtual world. However the final goal is to provide a variety of scavenger hunts about different topics, which means the narrative depends on the topic of each scavenger hunt, though the game goals and game mechanics remain the same. The notifications on the wearable are part of the narrative. In the specific case of this study the narrative attribute includes the story of the life of King Ludwig II and multimedia embedded in the timeline of his life. In addition to narrative another Gamification attribute of Game fantasy is sensation summarizing the multimedia presentation. The game itself features multimedia like audio, text, images, videos and multiple choice questions, whereas the app includes text and graphic elements and the wearable displays text and graphic elements. As mentioned above Huang is convinced that simulation, audio and graphic elements improve players’ motivation [13], which can be partly confirmed by the conducted post-test interviews.

The last Gamification attribute category is game value, explaining the player’s motivation and immersion. The motivation of ‘Geocation’ players are most likely to earn points/’gulden’ and then collect trophies. Additional motivations might be to play with and against friends and to show high scores.
on the wearable bracelet. The goal in the long run would be to learn about history (or other additional topics). As the conducted testing sessions have shown, players using ‘Geocation’ where highly motivated which resulted in high learning success. Challenges and the player’s effort to reach goals include walking from station to station to complete the scavenger hunt, correctly answering questions, earning enough points to be able to collect all trophies and persuasively beating friends’ scores. Sociality includes the interaction between people through the game system. Sociality in ‘Geocation’ refers to app features like the news feed or joining challenges and the information that is shown on the wearable, as the conducted post-test interviews have shown that participants enjoyed comparing their wearable notifications. And finally the mystery attribute which involve an original experience with curiosity. In the case of the ‘Geocation’ game the next information is only revealed when next station is found. So far this is the only mystery feature ‘Geocat’ion has to offer, however even though mystery provides an additional bonus effect for games, it is not an inevitable factor [28].

<table>
<thead>
<tr>
<th>Gamification Attribute Category</th>
<th>Geocation</th>
</tr>
</thead>
</table>
| **Game Goals**                 | - Fun way to learn about King Ludwig II  
- Orientation between historical locations  
- Integrating a fashionable wearable into a location-based game  
- Short term goal: players spontaneously decide to play the game  
- Medium term goal: Player stays motivated to play the game  
- Long term goal: Player learns from the game and keeps the knowledge |
| **Game Mechanism**             | - Location-based game making use of GPS  
- Using sim cards to create a connection between wearable & game  
- App |
| **Interaction**                | - Introduction of game features in the beginning  
- Content and player’s location are interdependent  
- Notifications on wearable & score are dependent on correct/wrong answers  
- Trophies are dependent on the player’s score  
- Information summary and wearable notifications in the end  
- App features |
| **Freedom**                    | - Individual time management of players  
- Players are free to move around  
- Consumption of different content  
- Search for next station/trophies  
- Join challenges  
- Compare scores with friends on wearable & app  
- See own trophies and scores  
- Review & test knowledge  
- Individualize bracelet |
| **Game Fantasy**               | - Minimalistic map mode  
- Clear information mode with different multimedia  
- Deep involvement in the game through notification on wearable  
- Colorful App design |
| **Narrative**                  | - Story of the life of King Ludwig II  
- Timeline with multimedia  
- Notifications on wearable |

| Sensation                      | - In game audio, text, text + images, videos, multiple choice questions  
- In App text and graphic elements  
- On wearable text and graphic elements |
| **Game Value**                 | - Earn points/Gulden’  
- Collect trophies  
- Play against friends  
- Show high score on wearable  
- Learn about history |
| **Challenge**                  | - Walking from station to station to complete scavenger hunt  
- Correctly answering the questions  
- Earn enough points to be able to collect all trophies  
- Beat friends’ scores |
| **Sociality**                  | - Newsfeed in App  
- Challenges in App  
- Information on wearable |
| **Mystery**                    | - Next information is only revealed when next station is found |

Figure 17: ‘Geocat’ion related to Gamification Attributes

Furthermore the data collected from pre- & post-test surveys of group 1 (that tested the game and the wearable) and group 2 (that tested only the game) provide evidence that group 1 showed a slightly higher learning success than group 2. Though it is not extremely clear that the wearable was decisive to the slightly better learning success of group 1 compared to group 2, it surely contributed to the motivation of the players. Which is definitely a positive effect towards learning, as motivation is crucial to learning success [1]. Also one of the main findings of the post-test interview with group 1 revealed that the wearable notifications and comparing scores on the wearable with friends were motivating to the players. Therefore an interesting conclusion that one can draw is how the use of an additional device as well as the social interactions between players, by comparing score, affected the motivation of them.

Furthermore cross-tabulation tests of the data collected from group 1 and 2, to see whether the learning success depended on any person related factors like grade, type of school etc., were not revealing due to the reason that in both groups the majority of questions were correctly answered aside from a small number of exceptions. This might show supporting evidence that all teenagers have a high learning success from the location-based game and wearable but it also shows the need of additional investigation in further research.

9.2 Enjoyment – GameFlow

In order to enjoy something, it is also important to like the look of something. The assumptions of the six teenagers, which were interviewed before creating the prototypes, that went into the design of the appearance prototype turned out to be predominantly valid. All ideas of the six interviewed teenagers were taken into account during the design of the wearable and the app. Due to the reason that all interviewed participants of group 1 liked the design of the bracelets and 90% of them would definitely wear them, strongly supports the importance and
success of participatory design. The design of the app was not liked as much as the design of the wearable, however one of the reasons could be that there are many exceptional apps already available, which might have been used for comparison. However, the majority described the app as clear and okay. Suggestions for improvement were for example to make it look more minimalistic and less colorful. These suggestions should definitely be used in further investigation in this subject.

After testing both the game and the wearable, group 1 was interviewed and it became clear that the majority of participants fully enjoyed the experience of ‘Geocation’. The fact that 90% of the teenagers would recommend the game to their friends is also evidence of their game enjoyment. Another interview finding which supports the enjoyment of ‘Geocation’ was the interview question, whether the participants enjoyed the learning aspects of the scavenger hunt. As mentioned above most participants stated to have enjoyed it. The post-test interviews also revealed that all participants believed the scavenger hunt game as well as the smart watch were easy to understand with easy usability. Good usability is also important to enjoy something [4], which further supports the enjoyment of ‘Geocation’.

The player enjoyment in games can be based on and evaluated by the GameFlow elements and criteria. There are many criteria available (see chapter 3.2) however only the relevant ones are used in this evaluation.

The relevant criteria of the first GameFlow element concentration are as followed. ‘Games should provide a lot of stimuli from different sources’ [33]. In case of ‘Geocation’ players need to concentrate on three completely different but interdependent sources, which are the location-based mobile game, the wearable bracelet and the real world surrounding in the case of ‘Geocation’. Furthermore, ‘games should quickly grab the players’ attention and maintain their focus throughout the game’ [33], hence, the players receive a motivating notification on the wearable once they are located close to the start of a scavenger hunt. In addition, information about scavenger hunts in the surrounding can be found on the app in form of a list and a map. What might be motivating the most to start a scavenger hunt is the ability to see which friends have already done the particular scavenger hunt. In order to maintain the player’s focus throughout the game notifications about scores and trophies are received on the wearable during the whole game. Another relevant criteria of concentration is that ‘games should have a high workload, while still being appropriate for the players’ perceptual, cognitive, and memory limits’ [33]. For this reason ‘Geocation’ is designed in a way to not show too much content on each station and evenly spread out the information on all stations, which requires the player to do some short walking between each station.

The next GameFlow element is challenge, which includes two for ‘Geocation’ relevant criteria. ‘The level of challenge should increase as the player progresses through the game and increases their skill level’ [33]. Due to the reason that only one scavenger hunt (about King Ludwig II) was used during the testing session and there were not many possibilities to increase the level of challenge. The only thing that got more complicated during this particular scavenger hunt was the fact that in the first half of the game the stations were much closer to another than in the second half of the game. However, the goal is to provide multiple scavenger hunts, which would create the opportunity to provide different levels of challenge. Furthermore ‘Games should provide new challenges at an appropriate pace’ [33], this is why each station provides different content to focus on and in the app player would be able to join challenges to further challenge themselves.

The post-test interviews revealed that participants of group 1 found the ‘Geocation’ game easy to use. One reason of this might be the short introduction as part of the game. Here players were taught how the game works while already playing the game. This can be explained by the game flow element player skills especially with the two criteria ‘learning the game should not be boring, but be part of the fun’ and ‘players should be taught to play the game through tutorials or initial levels that feel like playing the game’ [33]. According to Sweetser and Wyeth another criteria of player skills is that ‘players should be rewarded appropriately for their effort and skill development’ [33] accordingly points/Gulden can be earned and trophies collected for correctly answered questions. This rewarding system was rated to be fun by the interviewed teenagers of group 1.

The first relevant criteria of the GameFlow element control is that ‘players should feel a sense of control over their characters or units and their movements and interactions in the game world’ [33]. This is possible since players are free to move around as fast or slow as they wish. Furthermore ‘Players should feel a sense of control over the game shell’ [33] which includes the functions of starting, stopping and saving etc. By receiving a notification on the wearable when being close to a scavenger hunt players can decide for themselves if they want to do this particular scavenger hunt. Also by scanning the list and map of scavenger hunts in the app the player is in control to decide which scavenger hunt they wish to play. Another relevant control criteria is that ‘players should feel a sense of control and impact onto the game world’ [33], this impact onto the game world can be achieved answering more questions correctly. The more correctly answered questions, the more trophies show up on the map to collect.

The one relevant criteria of clear goals is that ‘overriding goals should be clear and presented early’ [33] therefore the goals of learning about history, answering questions correctly, earning points/Gulden and collecting trophies are explained in the introduction in the very beginning of the game.

Feedback is also one GameFlow element. Here ‘players should receive immediate feedback on their actions’ [33] this is why the correct answer of the multiple choice questions are revealed straight after choosing one’s answer. Also the earned rewards (points/Gulden) for correctly answered questions are given to the player straight away. In addition the player receives regular notification on the wearable to see their current scores, because ‘players should always know their status or score’ [33]. This feature turned out to be one of the most motivating feature, according to the interviewed participants of group 1.
The one relevant criteria of immersion is that ‘players should experience an altered sense of time’ [33]. The ‘Geocation’ game is supposed to make history feel alive and by seeing one’s score on the wearable on the arm, where usually people wear watches and look at the time, might immerse players more into the game.

Finally the last GameFlow element is social interaction. Sweetser and Wyeth explain that ‘games should support competition and cooperation between players’ and ‘social communities inside and outside the game’ [33], therefore the app offers features like challenges with or against friends, friends ranking, a newsfeed and friends’ profiles. Furthermore, the interviewed participants of group 1 mentioned to like the fact that they were able to compare their scores on the wearable with their friends in real life.

<table>
<thead>
<tr>
<th>Game Flow Elements</th>
<th>Criteria</th>
<th>Geocation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concentration</strong></td>
<td>Games should provide a lot of stimuli from different sources</td>
<td>Location-based mobile game, wearable &amp; real world surrounding</td>
</tr>
<tr>
<td></td>
<td>Games should quickly grab the players’ attention and maintain their focus throughout the game</td>
<td>Wearable notification in the beginning and notifications throughout the game &amp; scavenger hunt information on app</td>
</tr>
<tr>
<td></td>
<td>Games should have a high workload, while still being appropriate for the players’ perceptual, cognitive, and memory limits</td>
<td>Not too much content on each station &amp; walking in between stations</td>
</tr>
<tr>
<td><strong>Challenge</strong></td>
<td>The level of challenge should increase as the player progresses through the game and increases their skill level</td>
<td>Stations more far away from each other throughout the game</td>
</tr>
<tr>
<td></td>
<td>Games should provide new challenges at an appropriate pace</td>
<td>Each station provides different content to focus on &amp; in app can join challenges</td>
</tr>
<tr>
<td><strong>Player Skills</strong></td>
<td>Learning the game should not be boring, but be part of the fun &amp; Players should be taught to play the game through tutorials or initial levels that feel like playing the game</td>
<td>Short introduction as part of the game &amp; interviewees found it easy to use</td>
</tr>
<tr>
<td></td>
<td>Players should be rewarded appropriately for their effort and skill development</td>
<td>Points/Gulden and trophies for correctly answered questions – interviewees found this motivating and fun</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>Players should feel a sense of control over their characters or units and their movements and interactions in the game world</td>
<td>Players are free to move around</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Game Flow Elements</th>
<th>Criteria</th>
<th>Geocation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clear Goals</strong></td>
<td>Players should feel a sense of control over the game shell (starting, stopping, saving, etc.)</td>
<td>Notification of starting point &amp; map in app to see other scavenger hunts</td>
</tr>
<tr>
<td></td>
<td>Players should feel a sense of control and impact onto the game world (like their actions matter and they are shaping the game world)</td>
<td>Answering more questions right results in more trophies show up on map</td>
</tr>
<tr>
<td><strong>Feedback</strong></td>
<td>Players should receive immediate feedback on their actions</td>
<td>Result of questions and reward straight away</td>
</tr>
<tr>
<td></td>
<td>Players should always know their status or score</td>
<td>Regular notification of wearable (interviewees rated this as good)</td>
</tr>
<tr>
<td><strong>Immersion</strong></td>
<td>Players should experience an altered sense of time</td>
<td>Game makes history alive &amp; seeing score on player’s arm instead of time might immerse them more into the game</td>
</tr>
<tr>
<td><strong>Social Interaction</strong></td>
<td>Games should support competition and cooperation between players &amp; Games should support social communities inside and outside the game</td>
<td>Score on wearable to compare (interviewees rated this as good) &amp; App features like challenges with friends, ranking, newsfeed and friends’ profiles</td>
</tr>
</tbody>
</table>

Figure 18: ‘Geocation’ related to GameFlow Elements

Another important finding of the post-test interviews that also relates to game enjoyment is that all participants of group 1 were extremely motivated by the wearable and its notifications. The study of Harley et al. also showed evidence that their group, which tested an outdoor wearable, showed high levels of enjoyment [12]. As mentioned above motivation is crucial for learning success [1], but it is also associated with enjoyment [20]. However, the motivating effects of the used wearable would need further investigation.

9.3 General Discussion

In addition to the learning success and the general enjoyment of the proposed location-based game and the wearable, it needs to be mentioned that the test subjects seemed to see this game set up as a social activity. Even though this factor is important for both the enjoyment and the learning success, it is listed as a separate aspect, due to the reason of the social activity possibly being the main reason of playing the game. However this social activity would come with the positive side effects of enjoying the game and actually learning about different topics.

Furthermore it is important to mention that the setup of the two different prototype sets did not allow the researcher to test some features of ‘Geocation’, e.g. the challenges and friends’ ranking.
These features might have contributed to an even higher learning success and enjoyment, however this assumption would require further investigation.

10 Conclusion & Future Work

In this study a game called ‘Geocation’ was designed through participatory design and based on the two widely used game theories Gamification and GameFlow. Furthermore, it connects the two popular technologies, wearables and mobile phones, which are popular among German teenagers. With this game a solution to the main research question ‘How can the low history knowledge of German teenagers be improved?’ was provided. Overall, the results from the testing session with the game and the wearable were positive. Players seemed to enjoy ‘Geocation’ and had a high learning success, but there was not an extreme difference between the group that used the connected wearable and the group that only tested the game itself. However, the GameFlow and Gamification analysis and the post-test interviews showed that participants’ motivation always seemed to come back to the wearable.

A general conclusion can be drawn from the findings. The combination of the proposed location-based mobile game and the connected wearable is an enjoyable and motivating game for teenagers which results in high learning success. The game is great to improve the low history knowledge of German teenagers, but it can also be further developed to be used in other educational fields.

Even though the setup of two types of prototype sets was an efficient way of testing the concept of this study, a suggestion for future work would be to use a more developed wearable by including better visualized featured instead of only using text messages. Furthermore, smaller lights attached to the bracelet should be used and actually connect them to the game instead of controlling them by a supervisor.

Furthmore, some participants of the post-test interviews wished for shorter scavenger hunts, therefore further research should provide scavenger hunts about different topics to choose from, which are in general a little shorter than 45 – 60 minutes. Additionally the voice-over should be included. Due to the reason that the testing session of this present study used a rather small group of participants, cross-tabulation tests did not result in any revealing findings. Therefore, it would be interesting to conduct a study that seeks to find out whether there was a difference between participants who already own a wearable and the ones who do not, between participants who regularly play online games and the ones who do not and between different grades, type of schools and levels of history interest.

Considering the learning success, enjoyment and positive feedback of participants, it is assumed that this idea has a future, though it needs to be further developed.

ACKNOWLEDGMENTS

I thank Giuseppe Calabrese, Maximilian Bach and Victoria Abelmann-Brockmann, who supported the testing sessions as additional supervisors to control the lights attached to the bracelet prototypes. Furthermore, I am immensely grateful to Kai-Mikael Jää-Aro for his constant feedback and the assistance during the whole research and writing process of this study.

REFERENCES

Combining a location-based mobile game and a connected wearable for history learning purposes


