MythHunter: Gamification in an Educational Location-based Scavenger Hunt

Armin Hutzler[1], Rudolf Wagner[1], Johanna Pirker[1], and Christian Gütl[1,2]

[1] Graz University of Technology, Austria
{armin.hutzler,rudolf.wagner}@student.tugraz.at,jpirker@iicm.edu
[2] Curtin University, Perth, Western Australia
cguetl@iicm.edu

Abstract. Location-based applications have great potential to let users explore the environment in an immersive and engaging way. Digital scavenger hunts have a great potential as teaching and instructional guiding tool. However, many tools only guide users but are not designed as meaningful and engaging experiences. Adding more story-based and exploratory playful game design elements such as quests or achievements can make such experiences and the according learning experiences more entertaining and motivating. This paper contributes by introducing concept and development as well as a qualitative evaluation of an location-based scavenger hunt application with focus on a playful and story-based design. It allows users (e.g. teachers) to create multi-staged quests in a web-based editor, which app-users (e.g. students) can then complete in a platform independent mobile application that makes use of game design elements. In a first qualitative study we focus on evaluating the game with regards to fun, learning factors, usability, and engagement. Results indicate that story-based scavenger hunt applications have a high potential as tool to engage users to learn more about their environment. Especially story-based and playful elements are rated as important element for engaging exploratory experiences.

Keywords: gamification, educational games, game-based learning, location-based learning, scavenger hunt, geodata

1 Introduction

In the last decades digital gaming has become a natural part of everyday life and has found its place in the modern culture. A study conducted by Newzoo and GlobalCollect in August 2014 shows that there are 1775 million video gamers worldwide, which are almost 25 percent of the total world population [1]. Computer games can keep people engaged for hours and motivate them to come back to the game again and again. As a natural consequence game elements where introduced in non-gaming contexts to improve the enjoyment of activities that are normally perceived as boring and not very motivating. This introduction of game elements is commonly referred to as "gamification". The positive effects of gamification and various game design elements are discussed by multiple authors [2, 3].

An important field that profits immensely from gamification is education [4, 5]. Studies [6] show that students in game-based learning environments are both more motivated to learn about a new subject and more likely to come back to study the subject after school hours. The introduction of games or game-like elements into classes can also help the students to get a better understanding because they excel in visualizing complex concepts. Thus, it is no wonder that more and more teacher make use of gamification in their lectures and even book publishers issue learning games alongside school books. Educational games have huge potential to create engaging learning scenarios, when designed in a meaningful, interesting, and challenging way [7].

Learning, however, does not necessarily has to take place in the classroom. Mobile applications allow teachers to take classes outside and students to easily take their schoolwork home. This allows the students to more flexibly shape their own learning process according to their own time schedule [8]. A very interesting feature of mobile devices is that they can make use of geodata. Using the "Global Positioning System" (GPS) mobile applications can link information to physical locations on earth. The use of such geo-based features can be a way to create interesting learning games. Playful applications, that make use of geodata are for instance Geocaching [9] and Ingress [10], where Geocaching is already integrated in educational processes (Educaching [11]). In an early prototype, we already demonstrated the potential of location-based applications for learning (blinded for review). However, the application failed to engage the target group - young students in a playful way.

In this paper, we want to create educational and instructional experiences for location-based mobile devices, which integrate game design elements which immerse users in a story and lets them explore the environment to learn about it in an engaging way. Following, we present a mobile location-based scavenger hunt game. The main focus is to make learning about the environment fun and motivating by incorporating gamification based on exploratory and story-based game design strategies such as quests with multiple tasks and achievements. The game consists of a web-based editor for creating new quests and a Unity mobile application that works cross-platform on Android as well as IOS devices. The application improves on the existing applications like geocaching by making the quest creation easier and therefore allows a broader range of people like teachers or tourist guides to develop quests for their students or people interested in learning more about their environment. The mobile application is also developed as user-friendly and simple as possible, to allow also students to easily follow and complete the quests.

With this work we aim to discuss the potential of mobile location-based games in educational and exploratory environments and making the following contributions:

1. Design and Implementation of a mobile location-based learning game
2. A first qualitative case-study with focus on measuring fun, learning, usability
3. Discussion of potential risks of location-based mobile applications

2 Background and Related Work

As Prensky states in his article about digital game-based learning [12] "*A sine qua non of successful learning is motivation: a motivated learner can't be stopped*". Digital game-based learning strategies are identified as successful tool to create engaging learning experiences. Gamification can be used to used as tool to extend existing digital applications with playful elements to create game-based learning experiences. In this section we look into the concept of "gamification", how it motivates people to learn and how it is applied in educational contexts. Furthermore, we will have a look at mobile applications that use gamification and analyze which methods they use keep their users interested in the game and motivate them to play and also learn outside.

2.1 Gamification

Deterding et al. describe gamification as "*the use of game design elements in non-game contexts*" [13]. Werbach sees gamification more as a process of making an application more game-like instead of just sticking in some game-like feature [14]. Both authors, however, agree that gamification should make an application more fun to use, encourage users to interact with it voluntarily and repeatedly come back to it. Some popular features that learning applications borrow from games are achievements/badges that encourage students to keep learning to earn the next badge for their collection. Points and leader-boards aim at the competitive nature of children. They enable the students to compare to their colleagues and score higher than them.

2.2 Gamification in Educational Environments

Studies suggest that using gamification in a learning environment has a huge potential if done correctly [15, 16]. The biggest chance these studies identify is that most students enjoyed the learning games and perceived them as very motivating. It is, therefore, not surprising that more and more learning platforms make use of gamification to make the often as boring perceived learning content more fun to use for the students [17].

The learning community Scratch [18] founded by the MIT institute teaches children programming skills in a fun and interactive way. The kids can "program" graphic animations by sticking blocks together and can then immediately play the animation and see what effects code-changes have. They can then upload their animations to a Web platform and compare with and learn from the animations of other children. Reiners and Wood [19] see the Gamification of Scratch in the game-like interface on one hand and the freedom of choice the children are given to develop their game. They can build their animations from scratch or take existing animations from the web platform and enhance those. The Information Resources Management Association [20] also highlighted the possibilities of Scratch as a motivating learning application.

2.3 Location-based Learning

A statistic by Newzoo from 2014 [21] shows that 740 million people in Asia and around 153 million people in Western Europe play games on their mobile devices. Clough [22] elaborates in his paper from 2010 the opportunities of location-based learning applications. It is, therefore, not a surprise that game-like learning applications found their way on these platforms as well. The advantage of such applications is that they can make use of the Global Positioning System (GPS). Using GPS the students do not have to learn about their, for instance, local castle from their classroom, but can be on site and study the castle with their own eyes while being given historical information about it. An added benefit is that learners go outside and exercise, which is beneficial for their health. Their exist many location-based learning games. Three of these applications that incorporate learning are briefly outlined in the remainder of this section:

Geocaching Geocaching is probably the most well-known location-based application. The goal of the game is to find physical objects in the environment that have been hidden by other users of the application. The possibilities of learning with Geocaching has been explored in multiple publications [23, 24]. Under the term "Educaching" the application also found its way into libraries [25].

Ingress Ingress [10] is also a location-based game where two teams play against each other and try to "capture" distinctive objects, like statues, in the real world using their mobile phone. Ingress recently introduced the possibility to create scavenger hunts that also tell you something about the history of those objects

LMAC In a previous project, we introduced a location- based mobile application creator [26, 27], which allows the creation of scavenger hunts for users that they can complete with their smart phone and learn something about the surroundings using geodata. This app did not include any gamification issues, but simply guided users through the environment. In a first study the educational value of such an application was shown, however, elements such engagement were noted as elements for potential improvement.

Additionally, security issues due to a strong focus on the mobile app and losing awareness of the environment (e.g. traffic) was noted. Nasar et al. however show that there are also disadvantages when using smart phones in public [28]. The number of injuries due to distraction by mobile phone use is strictly increasing since 2005. One should be aware of this risks especially when creating a location-based learning application.

In the following section the design and the implementation of a location-based scavenger hunt application, which additionally included gamification features, which gives users more freedom to explore the environment and tell stories, in order to raise engagement and fun. that motivates students to learn using the gamification methods is described. We conclude with a discussion on risks and issues and how these can be minimized.

3 Myth Hunter

Myth Hunter was designed to create an interactive, flexible, and expandable mobile location-based application with focus on enhanced user engagement. Thus, a traditional location-based scavenger hunt principle is combined with playful design and story-based exploration experiences. Users should not only be able to experience such location-based explorations, but should be also able to create own story-based experiences for other users.

The main idea of Myth Hunter is to create playful learning experiences for users: learning and exploring should be perceived as an adventurous quest. This can be used to attract students, to learn more about specific places (e.g. historic parts of a city), for tourists to learn about the city by exploring it, or for users, who are simply engaged by the app to explore the own region. Due to the diversity of the target group in terms of background, motivation, and also age, the design of the apps needs to support flexible and adaptable design and the user interface should be user-friendly and intuitive. This should assure that they can focus on exploring and learning about their surroundings rather than facing usability issues.

Another important goal is to make it easy and attractive to build individual quests for non-programmers while still giving creators the freedom to create quests of their choices. The first prototype of *"Myth Hunter"* prototype was designed to take into account (1) usability, (2) exploratory experience, and (3) flexibility.

It is designed to support all these design requirements by consisting of (1) a web-based editor to create and edit quests and (2) a mobile application for playful mobile learning experience for students. The following sections will introduce the editor and the Android application by focusing on their designs and functionality followed by an overview of the architecture of the whole project.

3.1 The Editor

The software presented in this paper depends on users to create new content for the application. This has the advantage that not all of the quests have to be created by the development team itself, but users can also create their own quests and challenges. However, this decision of relying on externally-created content comes with some challenges. The editor has to be as simple to use as possible so that even users that are not very technically experienced are encouraged to build quests for the application. This section describes the Web-based editor for creating new content for the application and analyses the design decisions for making it as user-friendly and fast as possible.

The quest creation follows some simple steps. First, quest creators name the quest and provide an overall description of the quest. After confirming their input users can use a screen-sized map (illustrated in Figure 1) providing a search bar. In this search bar, user can look for locations, which should be added to their quest and place a marker on the map by just clicking on it. The newly added marker appears in a menu on the left hand side of the screen. The quest creators

can now add additional tasks to the quest, by simply adding additional markers to the map. They can choose from three different types of tasks:

1. **Info-task:** Gives information about the quest to the user (simple task)
2. **Quiz-task:** This tasks challenges the users to answer question such as multiple-choice or fill-in-the-blank questions. This question should involve aspects from the current locations (e.g. using hints hidden at the location)
3. **Invisible-task:** The user has to find a hidden location by following the hints given in the task description

Fig. 1: Map interface of the Web-based editor showing different locations of the quest as markers

Figure 2 illustrated the interface for creating a task (a quiz task in this case). The creator can e.g. add multiple-choice questions by simply selecting the quiz-options. Media elements such as images can be added to tasks as well.

3.2 The Mobile App

The Myth Hunter application is the mobile game-application. It is built with the Unity Game Engine [29] which allows to develop the game once and build it for various mobile operating systems like Android, IOS, or Windows Phone 8. The development process is designed ad iterative development approach. So the current version is used as first prototype to get an understanding of the user experience and will be constantly redesigned and updated based on the feedback.

After logging in, the user will see an overview of his/her profile including the number of completed quests and tasks and other motivating statistics as well as information to all his/her active quests (see Figure 3). It is possible to directly

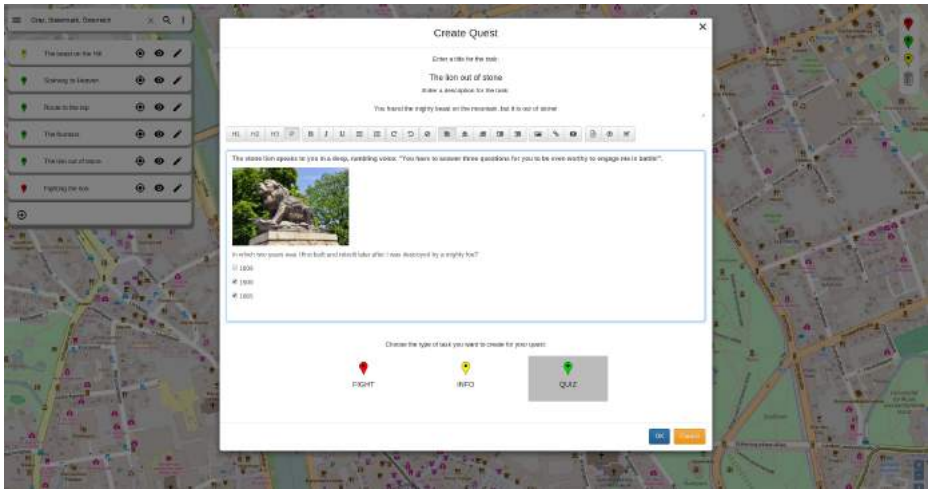

Fig. 2: Interface for creating tasks such as multiple-choice questions, which are triggered at specific locations

navigate to one of these quests on a map view (Figure 4) which is the primary screen when executing a quest. A quest in the map view consist of a series of markers of which usually only a few are displayed at once on the map depending on the quest progress. Each of this marker represents a certain task a user has to fulfill by clicking on the marker. This opens a HTML page within the app (Figure 5) which tells the user what to do next, e.g. reading some information, watching a video, answer questions or find a hidden location. After a Task is completed, the following task becomes visible on the map and an arrow from the users position towards the new marker indicates in which direction the user has to go.

Additionally this screen features a compass to indicate in which cardinal direction the user is heading. The orientation of the map automatically follows the orientation of the user meaning if one looks, e.g. at a street straight ahead the map will also show the street heading upwards on the screen. This makes it easier, especially for kids, to navigate to a given point on the map. However, the orientation-following can be stopped at any point by tapping on the compass which allows the user to freely turn the map in any direction. The functionality of the compass itself stays the same in both modes. This gives the user the opportunity to either focus entirely on the quest and easily navigate from one target to the next or discover how to navigate with an ordinary static map and a compass.

On the right-hand side of the map a menu is placed which provides features like centering the map on the users location or filter all the shown quest-markers by various criteria. It also contains an "Active Quests" view which shows a list of all the quests a user has started. Upon a click on one of these quests it expands and lists the next tasks of this quest as shown in Figure 6. Furthermore, the map

Fig. 3: The profile overview showing statistics and active quests.

Fig. 4: Map view featuring a compass and several filter options

automatically shifts and zooms in order to show the position of the tasks relative to the users position. Clicking on a task causes blinking of the corresponding marker on the map to indicate which list entry represents which marker. In this menu it is also possible to make the already finished markers visible again which allows the user to recap what he/she has accomplished so far. In the next chapter the general architecture and the communication between editor and application is explained.

3.3 Architecture

Figure 7 illustrates the basic architecture of the Myth Hunter prototype. The server-side implementation consists of a Java Webservice Application which is launched on an Apache TomEE Webserver [30]. Via the Java-Hibernate ORM Framework [31] a PostgreSQL [32] database is connected to the Webservice Aplication. Within this Database all the information regarding quests and users are stored.

The Web-Editor Interface is HTML5 based and implemented using the Javascript framework AngularJS [33] in combination with OpenLayers 3 [34] for displaying map data from an OpenStreetMap [35]-Tileserver within the web browser.

For the Implementation of the mobile application the GameEngine Unity3D [29] is used. This allows to implement most of the application platform-independent meaning that even though we focus our attention on Android right now the porting to e.g. IOS will not be a big issue. Furthermore the Unity community provides a lot of useful plugins like PowerUI [36] which we use to display the user-generated quest and task description stored in HTML5 format. UnitySlippyMap [37] is another Unity plugin used to display and manipulate OpenStreetMap tiles.

Fig. 5: The HTML page of an Information-Task

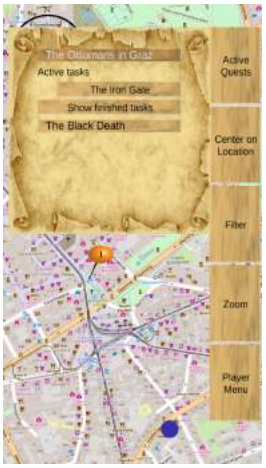

Fig. 6: Map with active-quest overview showing the next task on the map

4 Field Study

In order to get first in sights on the prototype for its applicability for students and learning scenarios (e.g. international students learning the abroad location) based on the design and experience goals described earlier we conducted a first qualitative study including eight participant (7 female) between 20-35 years old (M=24.63, SD=3.46) with different professional backgrounds. They all had only a little experience with mobile games and next to no experience with location-based games. On a Likert scale between 1 (not at all) and 5 (very strong) they rated their experience with mobile games with a mean of 2.88 (SD=0.83) and their experience with location-based mobile apps (mainly Google Maps) with 2.25 (SD=0.89). Asking them about their skills to navigate with a map/compass the average mean was 3.5 (SD=0.93). All participants had to complete the same quest, as described in the next section, and answer a survey afterwards. The questionnaire was designed to assess (1) usability, (2) the exploratory experiences, and (3) engagement with the app (game).

4.1 Scenario

The quest for our field study takes place in the Austrian city Graz and guides the user around parts of the old town up to the peak of the "Schlossberg". To complete the whole quest the users have to walk approximately 1,5 km. The quest consists of seven tasks in total including three Quiz-tasks and one Invisible-task. The answers to the questions of the Quiz-tasks are hidden in the surroundings of the marker's location. Therefore our test-users had to walk around, read information-signs and take a close look at buildings and structures

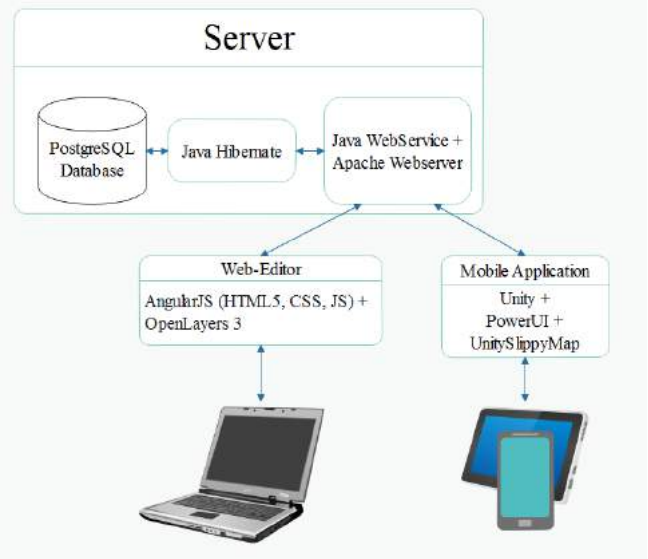

Fig. 7: Myth Hunter architecture

to find the answers. While executing the quest the participants learned facts about the area either by reading the signs or as part of the task descriptions. After completing the quest, each participant had to fill out a survey consisting of two sections:

- **Background:** age, sex, professional and their experience with mobile games and location based apps.
- **Experience with the app:** Experience with elements such as fun, motivation, learning effect, easy use and safety risk.

4.2 Observations

Following, we discuss the results of the study with focus on looking an elements which were noted as engaging, ideas for applications, and flaws and issues.

Engagement The overall Feedback was very positive: 75% of the participants answered the questions about the fun of the game and the motivation to finish the quest with five out of five points. Especially exploratory and narrative story-based elements were noted as motivating and important aspect they liked: "*[I liked] the funny story. I felt very motivated to finish the task as I wanted to know the story.*"; "*I liked the story a lot and I think that the app - especially if one is not familiar with the city an entertaining way to get to know the city.*"; "*[I liked] the system, the idea I did like how involved I felt and caught by the story.*" Only 12.5% of our testers answered that they would rather read a book about the history of Graz than learning with our app.

Learning with the app Regarding the learning effect we got very mixed results mostly depending on how familiar the participants already were with the area. 87.5% answered with four or more points out of five when asked how easy it was to navigate with the app and if they always knew where to go next.

Application scenarios When asked to estimate how children would react to the application all participants answered that they would expect kids to have fun executing such a quest and preferring it over reading about the same content in a school book. As shown in figure 8 they were rather unsure though if pupils would use the application in their free time as well resulting in an arithmetic mean of 3.38 points of five. Additional comments to this question suggested that parents or teachers would need to initiate or propose specific quests to them. For us this is an indicator that the gamification elements implemented so far are not enough to keep players motivated. At the end of this section of the survey we again raised the question about safety risks, but this time especially for children who lead to quite a different result (see figure 9): 75% rated this question with three or more points of a total of five indicating that the risk of children forgetting about their surroundings, e.g. traffic is perceived significantly higher than of adults.

Issues, improvements Regarding safety risks when using our application we again got quite an unreliable result with an arithmetic mean of three out of five points.

Following, detailed statistics of this study are listed:

Table 1: Your caption here

	AVG	SD
I had fun doing the scavenger hunt.	4.75	0.46
I felt motivated to complete the whole quest	4.63	0.74
I learnt something about the history of the Schlossberg	2.50	1.20
I prefer to learn about the history of Graz using the app to reading a book about it	4.38	1.41
I think my ability to use a compass/map increased	1.38	0.83
At any point during the test I knew where I had to go next.	4.38	0.74
It was easy for me to navigate with the app	4.24	1.04
I think using the app can bring security risks with it	3.00	1.31
I lost the sense of my surroundings while using the app	2.13	1.36

Two of the participants (one with a degree in German studies and one studying to become a teacher) brought up another interesting point regarding our target group of children between seven and fourteen years. They suggested that on one hand the quest they performed with our application had too much text to read for younger children from seven to ten and on the other hand may be not challenging or interesting enough for the older children up to fourteen. We

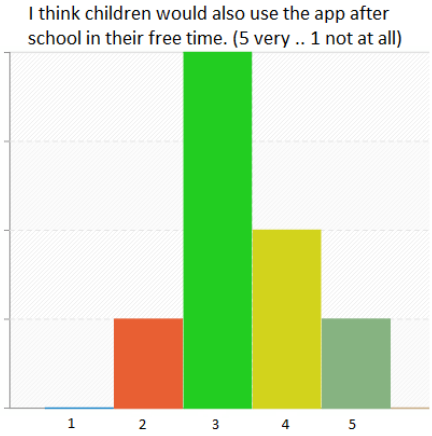

Fig. 8: Question results regarding after school usage of the app.

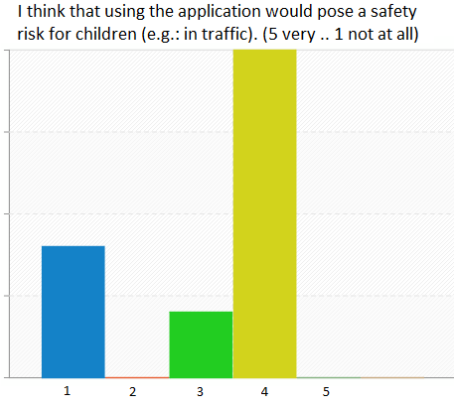

Fig. 9: Result of the question regarding safety risks for children

therefore decided to introduce a difficulty rating from easy, over medium to hard quests, where easy quests are more suited for the younger (more graphics, less text, content suited for younger children) and medium and difficult quest the older part of our target audience.

Limitations of the study This study is intended and design as first evaluation and proof of concept of the current prototype and game design. The design and development of MythHunter is an iterative process. Therefore, the study design is very limited in terms of trial-size and diversity (age, sex, and background) of participants and application domain. Future studies with a more elaborated prototype will be designed with a stronger focus on measuring engagement, learning progress, and usability.

5 Conclusion And Future Work

Summing up the results of our first study, the users had fun doing the multi-stage quest of the history of Graz and felt motivated to complete the whole quest. They think that children would rather use this application to learn about topics like history than reading the information from a book. The participants presume, however, that it is not very likely that children will use the application outside school. Thus, we will improve the application by adding more gamification elements and therefore make it more fun to use by children, even outside their school environment. Our study also shows that people think such application can pose safety risks especially for children. Therefore, we suggest not to let children use this application alone but, either in pairs or supervised by an adult.
This study was intended to improve the current prototype in an iterative design process. Important planned features are:

- **Fight-task:** We will add a fourth task type where players have to "fight" against, e.g. mythical creatures or historical characters. This "fights" will be decided by playing a trading-card-game where the players have the chance to win a new card representing the opponent for their deck.
- **Card-Editor:** When creating a quest the users will have the possibility to create special cards for this quest by using the new card-editor within the quest editor. They can choose between to types of cards, Magic- and Monstercards, and have a pool of various effects they can add to the card. More and stronger effects make a card more expensive to play in the game itself.
- **Quest-Rewards** Upon finishing a quest players will receive five random cards (booster) which they can afterwards add to their decks. If this quest included a fight there is a higher chance that the special opponent-card is within this booster. This adds extra motivation for completing a certain quest not only because it sounds interesting but also to collect special cards and strengthen the deck.
- **Quest difficulty rating** Addressing the point brought up by our survey participants we will introduce a rating system for our quests. Easy quests contain less text and more medial content like pictures or videos. These quests are targeted on younger children between seven and ten. Medium and hard quests contain more mature content, more text and pose more of a challenge to the older children.

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