Pathomon: A Social Augmented Reality Serious Game

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***Abstract*—The release of *Pokémon GO* attracted a huge player base ranging from children to adults, thereby establishing augmented reality (AR) on the mass market. In this paper, we present *Pathomon*, a social AR serious game which combines the location-based game mechanics of *Pokémon GO* with the benefits of using AR in a serious context. We describe the concept of the game which is based on cooperatively scanning QR codes, enabling the players to work together towards their common goal of eradicating viruses in their environment, while at the same time acquiring knowledge about these viruses. Furthermore, we present a first user study suggesting favorable results with respect to game experience, yet indicating room for improvement concerning the social game aspects. Finally, we outline the opportunity of the game to serve as a starting point for the development of a more versatile social AR platform capable of including arbitrary contents beyond the context of virus infections.**

***Index Terms*—Educational technology, Mobile learning, Mobile applications, Augmented reality, Games, Biological information theory, Information sharing.**

I. Introduction

The release of the 2016 blockbuster title *Pokémon GO* granted its developing company Niantic an unprecedented success. Due to the popularity of its brand, the game was downloaded more than 30 million times within the first two weeks after its release [1]. Along with that, it targets a huge and diverse audience ranging from children to adults alike [2]. Furthermore, by making use of location-based AR, *Pokémon GO* represents the first game to have popularised this technology among global mainstream [3].

In this paper, we present *Pathomon*, a serious game which integrates *Pokémon GO's* main game mechanics into the serious context of infectious diseases. Following the basic concept of *Pokémon GO*, three main reasons lead to selecting the domain of virus transmission as context of the game: First, education in the field of contagious diseases is a fundamental prerequisite to reduce their spreading [4]. Second, since *Pathomon* targets the same diverse audience as *Pokémon GO*, we wanted to pick a domain which children and adults can be educated on alike. Third, the location-based structure and mechanics of *Pokémon GO* qualify excellently for adaptation in the serious context of diseases, mimicking the ubiquitous and path-dependent characteristics of virus transmission.

Furthermore, like *Pokémon GO*, our game *Pathomon* also emphasises the social aspect between players by encouraging and rewarding collaboration in different ways. Accordingly, the contribution of our work is two-fold: On the one hand, we have transposed the *Pokémon GO* game mechanics to a serious, educative context. On the other hand, this work paves the way for developing a general set of game mechanics and linking them to serious contents beyond our target domain.

In the following section, we will give a brief overview on related work concerning the usage of AR in learning environments. In section III, we present *Pathomon's* concept and functionality in further detail and discuss the results of a user study. Eventually, we conclude with a summary and give an outlook on future work in section IV.

II. Related Work

The use of AR provides several affordances for educational purposes in comparison to non-AR environments. According to [5], AR provides the possibility of (1) presenting learning content as three-dimensional representation, (2) ubiquitous, collaborative and situated learning, (3) the invocation of the learners' senses of presence, immediacy and immersion, (4) visualising the invisible and (5) bridging formal and informal learning. As summarised in [6], these affordances can lead potential advantages like (1) better learning of spatial structures among various domains (e.g. astronomy [7], chemistry [8] or anatomy [9]), (2) higher long-term memory retention as well as (3) improved collaboration and motivation. These findings portray the usage of AR technology as a promising opportunity to convey knowledge in an effective and collaborative way.

Aside from this, studies suggest that it could be beneficial to integrate education within the learner's lifeworld, e.g. by incorporating learning into everyday life, and thus making the learned content more authentic and applicable [10]. To achieve this, the use of games for learning tasks appears to be a suitable way [11]. Therefore, combining the benefits of AR technology with gamified environments which refer to the player's lifeworld seems like a promising approach for education. An example for the integration of such a game-based approach into everyday life is the 2007 AR game *Outbreak @ The Institute* [12]. The game put students in different roles in which they had to prevent the spread of an infectious disease. However, as the hard- and software of handheld devices was still limited at that time, the use of AR was limited to location-based information and did not include augmenting the real world with real-time virtual 3D models.

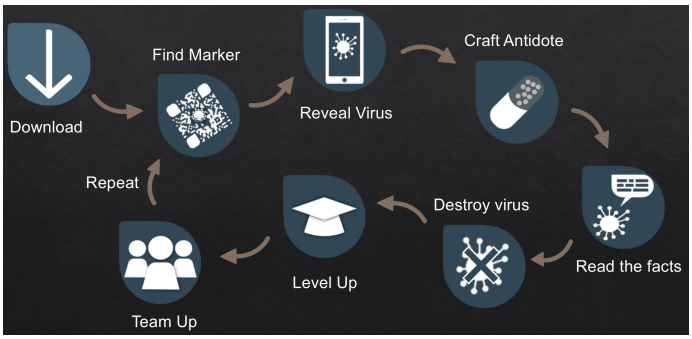

Fig. 1. Game Procedures of *Pathomon*, showing the repeatable game loop

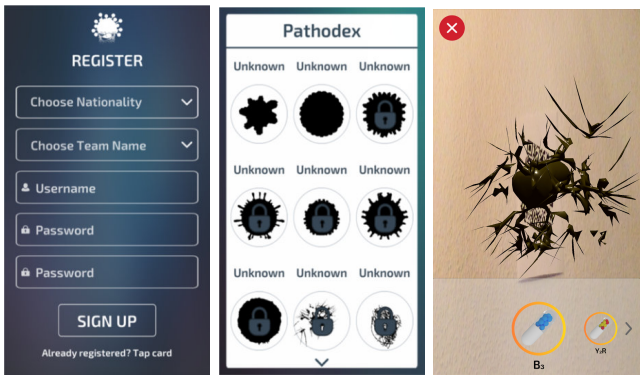

Fig. 2. Login (left), *Pathodex* (center) and AR view (right)

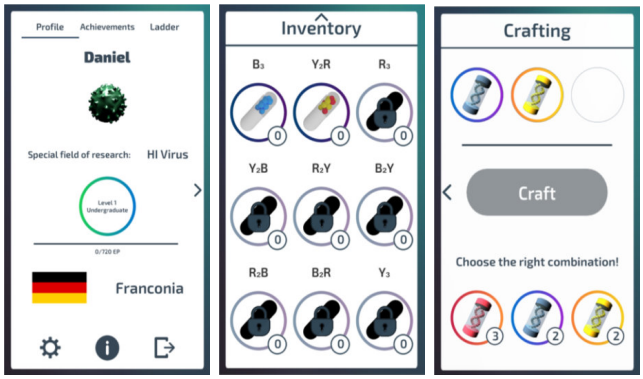

Fig. 3. Profile (left), Inventory (center) and Crafting (right)

Apart from these positive aspects, there are also problems associated with AR learning: Learners might experience issues with the technology in use [13]. Moreover, the use of AR can lead to attentional tunneling or cognitive overload [14]. According to [15], users might also "lose sight of where the game ends and reality begins". These shortcomings have to be carefully considered when creating an AR learning experience.

III. Methodology

As outlined in the previous section, new forms of technology, especially AR, might improve learning environments. However, such systems are yet to be fully established. *Pathomon* aims at transforming information into a system using the discussed benefits of AR and gamification.

A. Concept

1) Story: Pathomon takes the real world and the real issues of spreading diseases and transforms it into a journey: players dive into the role of young scientists and have to fight viruses. In order to do that, the players soon realize that they have to find the right ingredients to craft antidotes that are then used to eradicate the viruses. However, killing them at one (real-world) location does not completely erease them. Players need to team up with others to share knowledge and fight stronger viruses in the hope of finally erasing them completely.

2) Game Procedures: The game procedures are depicted in Figure 1. Players first have to find QR codes which can be located within the play area. The player will be presented an AR real-time virtual animation of either a virus or an ingredient after scanning a code. By collecting ingredients and subsequently crafting (Figure 3) antidotes, players can attack the viruses and earn experience points (XP). Some highly resistant viruses make it necessary for players to team up with others in order to fight them. Other ways of social engagement are sharing knowledge about QR code, and hence, antidote and virus locations. Finally, progress is tracked and summed over all players, leading to the uniting aim to eradicate all viruses.

3) Mechanics: First, players create their personal account (Figure 2). Then, they obtain a profile which designates them as expert for one particular virus (Figure 3). Due to the proximity to a viral specimen, the player has the possibility to leave the virus with QR codes he interacts with, forcing subsequent players to attack them. Progress is achieved through various game mechanics: First, players earn XP that transform into levels (Figure 3). Higher levels allow the crafting of new antidotes and therefore to fight higher-level viruses. Players can also compare themselves on a score ladder, which is accessible through their in-game profile. Additionally, achievements can be earned. Concerning the viruses, each player is decorated with a personal success rate in their *Pathodex*, a collection of viruses this player has fought so far (Figure 2). Players earn progress and unlock information about defeated viruses and thereby increase their rates. Additionally, all players share a global rate. This leads to the fact that the whole player base is working together to eradicate viruses by fulfilling personal rates in order to take the global rate to its maximum.

The main interactions in the game are collecting, crafting and fighting. Players can scan QR codes to find ingredients, which are then stored in their inventory (Figure 3). They can cooperate by sharing their knowledge about the locations of the codes. In the next step, players combine ingredients into antidotes using the crafting option (Figure 3). They need to discover the right combinations first or ask other players about them. Finally, players fight viruses by using antidotes in the AR view (Figure 2). Resistant viruses can only be killed by coordinating attacks with other players.

4) Conveying Knowledge: Three different strategies are used to convey knowledge about viruses within *Pathomon*:

First, each virus contains facts that can be unlocked and are explicitly attached to those viruses. This textual information includes size, time of discovery, lethality, type of vaccination, symptoms, incubation time, method of transmission and outbreaks. Some "fun facts" like "swine flue is not transmitted by swines" are also stated. Second, players learn about the appearance of the viruses, since models with realistic shapes are used. Third, the game mechanics implicitly relate to the characteristics of viruses, like players who can spread (drop) them (onto QR codes).

All in all, the game closely bridges between its knowledge information and game mechanics, since "specific game mechanics require gaming skills which are then mapped to general physiological as well as cognitive and social human skills" [16], allowing players to learn this knowledge in an entertaining way.

B. Implementation

Unity3D was used for development in order to achieve multi-platform support. For the AR aspects of the game, the Kudan framework was used. The server-side implementation and API was hosted on an Amazon AWS EC2 instance attached to an Amazon AWS RDS database instance. *Pathomon* was published both on iOS and Android.

C. User Study

Pathomon was first played and evaluated at the 2017 *International Genetically Engineered Machine (iGEM) Conference* in Boston, MA. By the end of the conference, 162 players had downloaded and tried out the game. We conducted a user study with a subset of these players to evaluate on the general game experience. Due to the social features of the game, the extent of social involvement with respect to other players was examined as well. However, this study should not be seen as a summative evaluation since other important aspects, like the effectiveness of learning, have not been tested yet.

1) Participants: By the end of the conference, players were selected at random and asked to take part in the study. However, only data of players that had gained XP were analysed in order to make sure they had at least some experience with the game. A total of 23 people participated, of which 10 were female, 9 were male and 4 did not state their gender. All of the subjects were attendees of the 2017 *iGEM Competition* and thus came from a variety of different countries. On average, the participants were 22.00 years old (SD = 1.98). The subjects stated that they had played the game for 44.47 minutes on average (SD = 27.10 minutes).

2) Instruments: For quantitative data collection, two modules of the *Game Experience Questionnaire (GEQ)* [17] were used. (1) The *Ingame Questionnaire* allowed us to raise data about experience components such as immersion or challenge. (2) By means of the *Social Presence Module*, we examined the psychological and behavioural involvement during the game. Answers were collected in an online questionnaire with a 5-point Likert scale (ranging from 0 (not at all) to 4 (extremely)). The participants were also asked to express open coded qualitative feedback. Finally, additional qualitative feedback was provided by the iGEM competition's judges via the *iGEM* website [18].

3) Procedure: At the beginning of the conference, the required QR codes were distributed at the conference venue. Simultaneously, the game was promoted to the participating teams by approaching them at their exhibition booths and asking them to try it out with their private smartphone during the conference days. Playing took mostly place during poster sessions and was not monitored. At the end of the conference, players were approached again at random and asked to take part in the study. The participants filled out the online questionnaires using their smartphones.

4) Results: The results of the *Ingame Questionnaire* can be found in table I. The components 'Sensory and Imaginative Immersion', 'Positive Affect' as well as 'Competence' showed relatively high values, whereas the game does not seem to evoke negative affects or tension. The components 'Flow' and 'Challenge' are on a moderate level.

TABLE I
RESULTS *GEQ Ingame Questionnaire*

Component	***n***	***M***	***SD***
Sensory and Imaginative Immersion	22	3.07	1.00
Flow	19	1.95	1.19
Competence	20	2.51	1.11
Positive Affect	18	2.90	0.89
Negative Affect	21	0.70	1.09
Tension	19	0.86	0.89
Challenge	22	2.29	1.09

The results for the *Social Presence Module* are depicted in table II. Players experienced empathy on a moderate level and did not have many negative feelings towards others. The relatively low value of 'Behavioural Involvement' indicates that they experienced only little to moderate influence of their actions on the actions of the others.

TABLE II
RESULTS *GEQ Social Presence Module*

Component	***n***	***M***	***SD***
Psychological Involvement – Empathy	17	2.28	1.10
Psychological Involvement – Negative Feelings	18	1.60	1.46
Behavioural Involvement	20	1.55	1.28

The qualitative feedback contained several positive statements, but also a couple of critical mentions. Among these were technical issues, especially with the Android version. The latter seemed to have a less stable performance compared to the iOS version. In addition, the participants of the game provided suggestions to improve the game concept as well. Some players for example perceived the start and progress of the game as too hard. The judges' qualitative feedback was very positive, stating i.a. the "AR game Pathomon is a wonderful way to engage others".

5) Discussion: The results of the *Ingame Questionnaire* are quite favorable as the game seems to evoke feelings of immersion and positive affects while not being tensioning or bringing out negative emotions. The high values for 'Competence' however contradict the qualitative expressions stating that the start of the game was too hard. A possible explanation for this is that the players felt competent with respect to understanding the game controls and rules, but were overwhelmed by the difficulty in the initial phase of the game. Additionally, the players did not have the feeling that their actions would influence the actions of the others in a considerable way according to the the low values for Behavioural Involvement'. An explanation for this could be that the players might have focused on their own progress, thereby overlooking their influence on the others. It should therefore be investigated in what way a better perception of this impact can be evoked in order to strengthen the game's social aspect.

Aside from this, it must be noted, that the study itself is subject to a couple of limitations as well. First and foremost, it only considered the experience of the player during the game. An evaluation of the effectiveness of the game for learning about viruses has not been conducted yet. Second, neither the game-playing nor the collection of the data could be done in a uniform way under laboratory conditions due to the circumstances at the conference. This might have led to undesired deflections. Third, the number of participants was relatively low. For more reliable results, a follow-up study with a larger number of participants should be carried out.

IV. Conclusion

This paper presented the mobile social AR serious game *Pathomon*. An analysis of related work focusing on the usage of AR within the context of learning deems this technology as a promising approach. Concordantly, *Pokémon GO* used this technology effectively to attract a huge player base.

Pathomon resembles a combination of the location-based game mechanics of *Pokémon GO* with scientific knowledge about viruses. By grouping up, players can help each other with sharing QR code locations, fighting together against very resistant viruses and work towards the common goal of eradicating all viruses.

A first user study conducted at the 2017 *iGEM* conference, revealed several positive aspects of the game as well as suggestions for improvement. These include, for example, the wish for a smoother and easier progress in the game.

While knowledge about viruses is a good start, the game mechanics developed in this paper could be used in various other contexts, as long as well-defined, localised interactions between the AR contents and the player can be established. With respect to *Pokémon GO* and *Pathomon*, these interactions are, for instance, finding, collecting, fighting, crafting, and spreading. More systematically speaking, it makes sense to provide game mechanics that contribute to a socially and spatially distributed game setting that involves local interactions, combination and transport. Therefore, a possible step in the future might be the further development of the game towards a versatile platform whose content for learning can be exchanged easily.

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