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KIJANI: Designing a Physical Activity Promoting Collaborative Augmented Reality Game

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Abstract. Background: There is an increased need for physical activity among children and adolescents. KIJANI, a mobile augmented reality game, is designed to increase physical activity through gamified exercises. Objectives: The primary aim of this study is to get feedback on the design and implementation of potentially physical activity-increasing features in KIJANI. Methods: A mixed-method study (n=13) evaluates newly implemented game design features quantitatively through measuring physical activity and qualitatively through participant feedback. Results: Preliminary results are limited and need further studies. Participants' feedback shows a positive trend and highlights the game's potential effectiveness. Conclusion: KIJANI shows potential for increasing physical activity among children and adolescents through gamified exercise. Future work will refine the game based on user feedback and findings presented in related work. The game's long-term impact is to be explored.

Keywords. Physical Activity, Augmented Reality, Mobile Applications, Video Games, Child

1. Introduction

The World Health Organization (WHO) recommends that children and adolescents (aged 5 to 17) do at least an average of 60 minutes of moderate-intensity physical activity (PA) per day. Additionally, they recommend vigorous activity on three days per week. Time spent being sedentary, particularly recreational screen time, should be limited [1]. Research has shown that activity levels during childhood and adolescence correlate with sedentary behavior, activity, and the rate of illnesses and diseases as adults, making it important to start being active as early as possible [2, 3]. It is recommended that children move at least 60 minutes per day [1, 4], and a 2008 review suggests that setting and monitoring PA goals can positively impact children's activity [5]. The review suggests that parents should do this, but games could also take that control role. PA can be done in many ways, with a common concept being to increase the daily step count [6]. Tabata

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[7] classifies walking as a non-exercise PA. They differentiate between regular and "brisk walking". They also suggest increasing walking or bicycling time as a good start to increasing PA. A common way of measuring PA is by counting steps. Doing so manually isn't feasible, which is why step-counting devices have become common. In addition to standalone step counters, modern smartphones and smartwatches also support counting steps during everyday activities.

Counting steps is commonly considered part of the "quantified self" movement [8, 9], with the idea of tracking metrics of one's life to quantify different aspects of everyday life. As such, step counts are used to measure PA. Given that research suggests that wearable step trackers increase the steps walked by individuals [10], this offers an opportunity to gamify the experience to increase PA.

According to the WHO's 2020 catalog of PA recommendations, sedentary behavior in children can be associated with various health issues: "increased adiposity; poorer cardiometabolic health, fitness, behavioural conduct/pro-social behaviour; and reduced sleep duration" [4]. Usually, smartphone usage is classified as sedentary behavior [10, 11], and children are suggested to limit their screen time. Location-based games that promote outdoor activities (like KIJANI, the game proposed in this research) could change that narrative.

Through a thorough investigation, Arsenault analyzed two lists of video game genres and discussed their rigidness and history [12]. As an ever-expanding market, it is important to note that such lists are often incomplete. An often overlooked genre of video games is location-based (LB) games. LB games are not limited to being digital, with an example of a non-video LB game being *geocaching*. In *geocaching*, players roam the physical world to find hidden caches. This concept is fundamental for most LB games, especially those that have arisen in the last few years, such as Pokémon Go. A 2012 review of LB educational games categorizes them into three categories: ludic, pedagogic, and hybrid approaches to learning [13].

Most video games are based on extrinsic motivation [14], meaning that players aren't motivated by themselves (intrinsic motivation) but rather through other people or external factors like gameplay-related goals. When discussing goals, a duration-based distinction must be made between short-and long-term goals. In video games, short-term goals should be achievable in a few days. Consequently, long-term goals refer to several days to week-long goals. Research suggests that "achievable short- and long-term goals" are relevant for successful activity-based video games [15]. According to a 2014 study by Staewen et al. [16], different player types get different motivation levels depending on the goal duration. People who play to avoid boredom prefer quick and easily achievable goals, while those players who enjoy difficulty are less likely to pursue short-term goals. True long-term goals in video games often include streaks (repeating a behavior for several consecutive days) and immersive experiences that allow players to shape the game through their actions. Immersive experiences include AR, which directly allows manipulation of the perceived reality.

Research also highly suggests that social features are a significant driver of motivation to play a specific video game. Research by Shameli et al. and Zielinski et al. suggests that in-game competitions can increase PA in players [17, 18]. Shameli et al. found that players participating in a competition increase their daily step count by 23% [17]. One of the simplest forms of competition in video games (aside from player vs. player game modes) is ranking. Such a leaderboard also provides another way of instant feedback for competitive players. As existing research suggests, only some enjoy having that public comparison enabled through a leaderboard [19].

It is suggested that video game players often prefer gaming over socializing with friends in real life and might even sacrifice real-life social interactions to be able to play video games [20, 21].

This research describes KIJANI, a location-based mobile augmented reality game that aims to promote PA in children and adolescents through gamification. The game promotes moderate PA by incentivizing players to walk outside to unlock in-game content through external motivational factors hidden behind a game. Step counts are used as a measure of PA. KIJANI can also be categorized as a hybrid educational game, as increasing PA is merely a side effect of completing in-game challenges. In KIJANI, players can create block-based buildings in an AR environment (Fig. 1). Blocks can be unlocked with coins earned through real-life fitness challenges.

This paper explains KIJANI's strategy to increase PA, game design, and user experience decisions and presents preliminary results from a chair-internal study.

2. Methods

2.1. KIJANI's Goals

KIJANI has a high-level goal of making the player go outside, move around, and have fun. The game tries to motivate its players to increase their PA while enjoying time in nature, a common concept in the literature around active games [22, 23]. KIJANI aims to increase step counts in children and adolescents, as that metric is used to approximate player PA in the context of this research.

2.2. Requirements

In addition to common video game requirements regarding usability, user experience, and ease of use, specific requirements for the KIJANI game and application were defined:

R1: KIJANI should be played at specific real-world locations suitable for children and adolescents.
R2: KIJANI should reward exploration and movement.
R3: KIJANI should increase players' motivation to interact with the game through long- and short-term goals.
R4: KIJANI should promote social interactions and communication in the physical world.

2.3. KIJANI Overview

KIJANI is a collaborative AR game built for iOS devices. It combines location-based gameplay with a focus on the gamification of PA. In KIJANI, players place virtual blocks to create buildings in augmented reality (Fig. 1). This can happen solo or in a group of players. More blocks can be unlocked with coins. Fitness challenges reward the player with KIJANI coins upon completion of PA tasks. Currently, walking a certain number of steps is used as a PA measure for fitness challenges. KIJANI aims to increase PA both while playing and outside of gameplay.

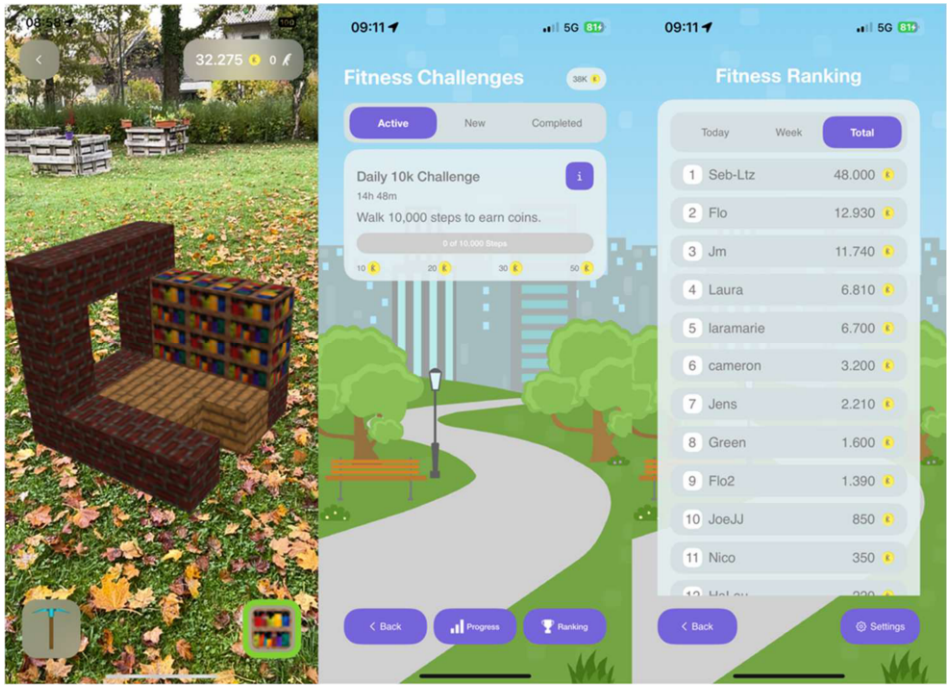

Figure 1. AR Building; Fitness Challenge; Fitness Ranking

2.4. KIJANI Features

2.4.1. Locations

KIJANI is designed to be unusable at home and in most public places except for specific outdoor locations. In their 2017 review, Licoppe found that the LB game "Mogi" sometimes made players go to "strange, unanticipated, and sometimes risky places" [24]. KIJANI doesn't promote visiting such places in the context of the game, as the set of available locations is finite and pre-selected. They were chosen based on several criteria and mostly represent public parks or playgrounds in the greater Munich metropolitan area (and other selected areas in Germany) with sufficient space and safety to allow children to play. These physical locations are limited in space. Because of that, they are eventually filled with blocks, disallowing players to continue building. To circumvent this issue, the concept of servers was introduced. Like other games' concepts of servers, KIJANI servers offer the option to play in the same physical location while accessing a different digital world. As such, players can construct multiple space-filling buildings at the same location, making it feasible to play KIJANI at the same place over a prolonged time. Servers can be configured to be private, and players can set a list of visitors, builders, and admins. This eliminates a set of potential misuse issues regarding inappropriate behavior among players. This setup allows for a distinction between private and group building without changing physical location, which might be infeasible in certain areas (due to lack of parks and playgrounds).

2.4.2. Fitness Challenges

Fitness Challenges are KIJANI's main tool to increase players' motivation to play and, thus, their PA. Fitness Challenges are of varying duration and intensity, ensuring a mixture of short-term and long-term goals. There are three kinds of fitness challenges: the daily 10k challenge and other non-recurring, manually created, challenges that might last longer than a day (e.g., weekend or week-long) are visible to the user and can be completed through PA. The third challenge type is a hidden background challenge that automatically tracks the players' PA while running studies. This system is a backup to the manual data collection described in the study overview. The daily 10k challenge automatically gets activated when players open KIJANI for the first time on any day. On the technical side, fitness challenges are implemented as a modular system, allowing for full customization of rewards, sub-goals, and metadata such as the title and description. They are fetched from a remote server and managed through a separate app, allowing the KIJANI team to update and change challenges without the user needing to update their app. An in-app notification system was added to KIJANI to keep players updated about their challenge progress without opening the respective screen (Fig. 1). The fitness challenges collect progress even while the app is in the background, using Apple's HealthKit as the data source.

2.4.3. Friends

KIJANI players can add each other as in-game friends by sending and accepting a friend request. Doing so enables them to play on the same server and inspect each other's fitness challenge progress on a leaderboard. KIJANI servers allow players to specify who can explicitly visit, build, and administrate a server. This setup ensures that no uninvited players destroy buildings or interfere with the fun of others.

A leaderboard (Fig. 1) was added to improve motivation toward the fitness challenge feature described in the next section. The leaderboard has two participation options: global and friends. This means that both players who want to compare their progress with everyone and those who only want to compare themselves to their friends can do so by changing the setting. Given that no significant correlation between access to the leaderboard and fitness challenge progress could be found in the thesis study, a more prominent placement for the leaderboard should be considered.

2.5. Study Overview

To get the first results regarding the effectiveness of both KIJANI and the impact of social features in the game and an overview of the game's core concept, an exploratory study was conducted as part of a master's thesis at our chair. The study was based on a randomized controlled design (albeit noted that familiar participants could have interacted), with the participants split into two groups. The first group had a basic, stripped-down version of the game without social features (friends, leaderboard, and multiplayer servers), while the second group had those social features enabled. Two questionnaires were included: At the beginning and at the end of the study duration. The questionnaires contained free-text feedback questions and recorded the participants' PA, based on HealthKit metrics, during the study duration. Participants were instructed to record their PA in the first week while following their usual routine. In the second week, participants received access to KIJANI and were instructed to play for at least 30 minutes during at least two sessions to ensure at least one return to the game. The cohort contained

predominantly students and was completed by scientific staff. Both male (n=12) and female (n=1) players were included, with most people (n=11) 20 to 25 and a minority (n=2) 30 to 31 years of age.

3. Results

According to the first questionnaire, participants did sports an average of 3.43 times per week, which decreased to 3 times per week in the second questionnaire. The average amount of steps walked in the first week was 46556, which increased to 47269. 5 participants had an increased step count in the second week (Fig. 2). Before joining the study, participants averaged 4.35 hours of weekly game-playing time, including about 1.06 hours of mobile games. The average gameplay duration of KIJANI was 24.85 minutes (min: 12 min, max: 40 min). 5 participants played for >= 30 minutes, 9 for >= 20 minutes, and 4 for < 20 minutes.

During the second week of the study duration, two fitness challenges were available: A week-long challenge with the goal of 35000 steps and a reward of 1600 coins total, and a 3-day challenge with a goal of 10000 steps and a cumulative reward of 650 coins. The only study participant who completed a fitness challenge was part of the social feature group. A total of 4 (2 from each group) of the 13 study participants completed at least one sub-goal of a fitness challenge. 10 participants took on at least one fitness challenge. One of them took on both available challenges.

In their final questionnaire, 3 study participants mentioned liking KIJANI's approach to promoting a healthy lifestyle through walking challenges. Two study participants explicitly mentioned that they liked the multiplayer aspects of KIJANI's gameplay. Another participant mentioned that there wasn't enough to offer for solo players, which underlines the importance of social interactions. One of the non-social-feature participants also mentioned that they wanted more social aspects to the game. It was also mentioned that adding friends should be easier than entering an ID.

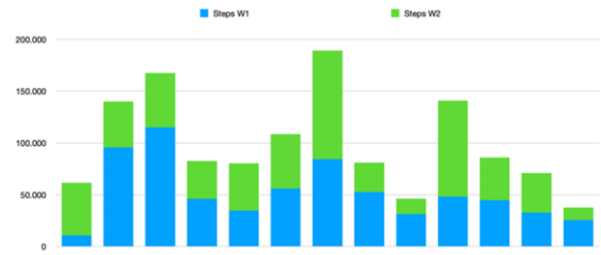

Figure 2. Step count results from the questionnaires

4. Discussion and Future Work

The location feature satisfies R1 partly and ensures KIJANI isn't considered sedentary behavior. It enforces gameplay at suitable real-world locations. R2 specified that KIJANI should reward exploration of the physical world. The current implementation has no incentive to play at unique locations, as staying at the same location is easiest for everyday gameplay. An exploration-focused route feature, rewarding players for walking

along a predefined route, would be a possible implementation that satisfies R2. To satisfy R3, the fitness challenge system was introduced. A positive effect on player motivation couldn't be recorded through the study. KIJANI promotes social interactions through the collaborative gameplay feature in the server system, as specified in R4. The positive impact on playing motivation that was expected wasn't found through the collected data.

Even though the data couldn't support the idea of social aspects increasing PA in KIJANI players, the collected feedback was still valuable, as several participants had positive feelings toward the game's social features. This supports our belief that an intervention like KIJANI can positively impact players' PA. HealthKit, the integration powering fitness challenges, is a secure health metric store that collects health data through phone movement, manual input, and peripherals like the Apple Watch [25]. An investigation into its data accuracy has shown that recorded step counts (using just an iPhone) are much more accurate than estimated distances walked [26]. An Apple Watch could be worn to further increase step-counting accuracy [27]. Since KIJANI directly reads health data using HealthKit, both approaches are suitable, and this could be explored further in the future.

We were able to implement a competitive social feature through the leaderboard. The preliminary study's sample size is limited and based on non-target-group participants, making it hard to interpret the findings w.r.t. the research's original goals.

More collaborative gameplay elements should be considered to improve the players' need to interact with each other further. Introducing collaboration and contest features, such as the possibility to attack other players' buildings, could allow for more direct real-world communication between players. Currently, KIJANI uses step counts as a proxy for PA. Other measurements, such as workout count, active minutes, heart rate, etc., could also be adapted. They could be added to the fitness challenge system, allowing users to narrow down on a specific area of activity they want to engage in. This would make the system more approachable and personalized. KIJANI's impact on PA should be evaluated in a study with a bigger sample size and a longer timeframe to reduce the impact of external factors on step counts.

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