FitBirds: Designing Heart Rate Feedback for Playful and Social Physical Education

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ABSTRACT

Participating in physical activity at a moderate-and-vigorous-intensity-level is recommended for teenagers to advance in health benefits. However, due to the fitness differences, the amount of physical activity to reach the recommended intensity varies among teenagers. Therefore, tailoring the physical intensity of each teenager's fitness level is meaningful in physical education. In this paper, we present FitBirds, a multiplayer fitness game to encourage teenagers in physical activity at a recommended intensity level, which is calibrated by their real-time heart rate. The FitBirds game leverages both competition and cooperation game mechanics to enhance teenagers' playful experiences and social engagement, which could further contribute to their physically active participation in the physical education context.

CCS CONCEPTS

• **Human-centered computing**; • **Visualization**; • **Visualization application domains**; • **Information visualization**;

KEYWORDS

Physical education, Heart rate, Teenagers, Feedback

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1 INTRODUCTION

Participating in physical activity (PA) can benefit teenagers' physical and mental development [4], and also prevent childhood obesity and cardiovascular diseases [24]. To yield these health benefits, the World Health Organization recommends teenagers to do 60 minutes of PA at a moderate-and-vigorous-intensity level on a daily basis [16]. However, to achieve the recommended intensity level, a different amount of PA is required for each teenager because of the differences in individuals' biological development [21], and physical fitness. Therefore, a personalized PA recommendation or guidance helps each teenager to do PA at a recommended intensity level (moderate-and-vigorous).

In the Human-Computer Interaction domain, heart rate (HR) has been proven as a valid indicator for an individual's physical status, exercise intensity [13], and energy expenditure [7] during PA. With the popularity of fitness tracking devices, HR data becomes increasingly accessible and widely used to adapt to the difficulty level in fitness games for teenagers [8, 9, 19]. However, HR data collected by fitness tracking devices are rarely used in the teenagers' physical education (PE). We argue the HR data can be used in PE for educating and motivating teenagers to achieve a recommended level of PA intensity. However, an appropriate way to utilize the HR data in PE is yet to be explored. For instance, how to represent physiology data in a playful way to increase teenagers' motivation for participation? How to promote social engagement among teenagers having different fitness status? And how to display personal data in a public classroom while having concerns on data privacy?

In PE, besides developing students' physical fitness, teaching students physical literacy [23], for instance, getting knowledge about PA related physiological indicators (i.e., HR) is required as

an essential educational goal for their lifelong fitness and well-being [10]. Thus, developing teenagers' ability to identify their own fitness needs on achieving the recommended intensity level will be beneficial for their well-being [2]. Meanwhile, physical fitness differentiation has challenged teenagers' motivation and affected their enjoyment and social engagement [25] in group PA. For all these reasons, we assume a well-designed HR feedback in PE will help teenagers to: 1) increase their interests in being physically active; 2) be socially engaged in PA together with teenagers having different fitness status; and 3) gain a better understanding of the recommended intensity of PA for individuals.

In this design study, we explore integrating HR data into the PE context with the focus of teenagers' special needs on *playful experiences, social engagement*, and *data privacy*. We first present the design of FitBirds, a fitness game representing teenagers' HR through anonymous birds in a game scenario. The game explores both competition and cooperation mechanisms to enhance *playful experiences* and *social engagement*, aiming to further promote teenagers' PA in PE. Next, we describe a preliminary user study to gather both PE teachers' and teenagers' feedback, summarized as a set of implications for future design and deployment.

2 RELATED WORK

2.1 Effects of HR measurements in PA intervention

HR data can be used to adapt to the difficulty level in fitness games to engage the players in the flow status of their fitness and gameplay. For instance, Plunder Planet [9], Designable Sports Field [19], Pulse Masters Biathlon [15], and the Boxercise [12] are adaptive fitness games which adjust both the difficulty level of the fitness game and the needed amount of physical exercise to adheres to the players' target HR zone. Meanwhile, in collective fitness games, HR data can also be used as a mediator for balancing the gameplay between players having different fitness status. For instance, Jogging Over a Distance provides a balanced exertion experience between two remotely located joggers by representing their HR value through the spatialized sound [14]. The Open Heart Helmet explored a social interplay experience between pairs of cyclists by presenting each HR at the backside of their bicycle helmet [26]. The Heart Burn game implemented a heart rate scaling mechanism within a truck racing game to support competition among players having disparate abilities [22]. These examples show the potential of HR data as an intervention to mediate both personal and social engagement in PA. We believe HR feedback can also be integrated into PE classes to provide personalized information and improve teenagers' social engagement in PA.

2.2 Representing physiological data through the game scenario

Many design researchers have explored a form with virtual avatars and game interfaces to represent physiological data, especially for school-age children. For instance, the American Horsepower Challenge [17] represents students' step counts in a horse race game scenario where each student has their customizable cartoon horse controlled by their data. Schäfer et al. have presented personalized feedback on children's PA levels through two cartoon figures [20]. The FitBit Garden illustrates a virtual garden environment with virtual plant avatars that represent children's increased physical activity [1]. These researches show the advantages of game scenarios in increasing children's motivation, and the possibility of anonymously presenting data through virtual avatars.

3 DESIGN FEATURES OF FITBIRDS

We designed a fitness game (see Figures 1 and 2), which integrates teenagers' real-time HR data into the game control. The FitBirds game is presented on a large TV screen, with the background graphics of the game indicating five levels of physical intensity: rest, light, moderate, vigorous, and strenuous. The height of the bird avatar represents the player's level of physical intensity, which is calibrated by his or her HR data. Through gamified feedback, FitBirds can increase the teenagers' understanding of their PA intensity level and teach them to regulate their HR to keep the PA intensity in a recommended moderate-and-vigorous-level. Specifically, we acquire teenagers' HR through a wireless HR sensor (Scosche Rhythm24 [18]) attached to the teenagers' lower arm. According to the Karvonen formula [6], the PA intensity level of each teenager is estimated by mapping their real-time HR to a personalized HR range, calibrated by one's age and resting HR.

The game scenario of FitBirds is inspired by the story of Icarus in Greek Mythology [5]. Using this well-known story aims to help teenagers better understand the game rules and be immersed in it. During the gameplay, the birds start from the sea-level (rest) and fly up into the white-colored cloud (light-intensity). Teenagers are encouraged to keep the birds flying between the two-layer blue-colored clouds (moderate-and-vigorous-intensity), which is the goal of the game. They are also told to avoid flying too low to drop into the sea (rest) nor too high to be burned by the sun (strenuous-intensity). The design features of FitBirds are summarized and presented below.

It presents teenagers' real-time HR as anonymous birds in the game. The recommended moderate-and vigorous-intensity-level is visualized as a flying "safe zone" for the birds. As shown in Figure 2, each teenager is represented by a bird avatar of different colors, and the changes in their HR controls the birds' height in real-time. The direction of the bird's shadow indicates the rise or fall of the current HR compared to the previous data. The white, light blue and blue-colored clouds represent the flying "safe zone", where the bird stays in for 5 seconds will gain 0, 2, and 4 points (reward), respectively. Besides, if the birds fly too high, they will be burned by the sun and lose 0.5 points (warning). If the birds fly too low, they will drop into the sea and lose one point (punishment). To account for data privacy in collective PE-class, each teenager is only informed about their bird, without knowing which one of the other birds belongs to whom. But they can also share their identity with others. PE teachers and teenagers can see the overall performance of the class.

It equalizes the contribution of teenagers with different physical abilities and fitness status. Teenagers with different physical abilities and fitness status often have difficulty participating in the PA requiring the same intensity. Instead of tracking motion and activity [11], FitBirds measures HR as an indicator of

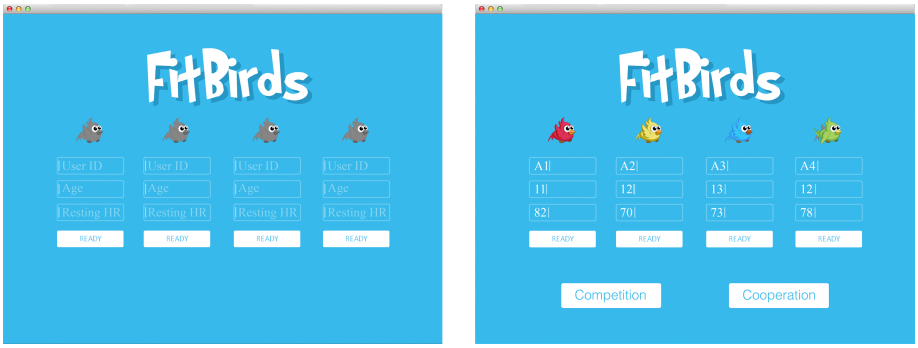

Figure 1: The login interface of the FitBirds game. The game uses the inputs of age and resting HR to calibrate a tailored intensity recommendation. After login, users can choose competition or cooperation mode to start the game.

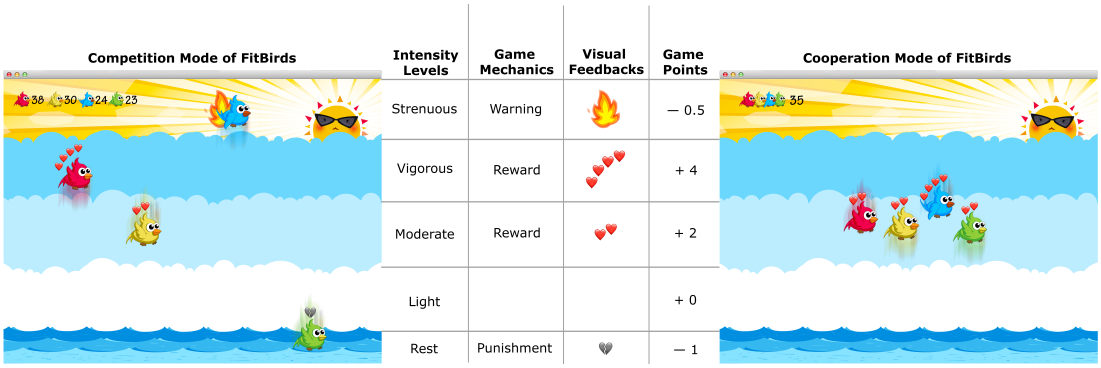

Figure 2: FitBirds in competition and cooperation modes. The game interface with its' corresponding intensity levels, game mechanics, visual feedbacks, and game points.

teenagers' physical intensity. During PA, changes in HR are related to an individual's fitness status. To achieve the same change in HR, the ones with a strong physical ability need to do more amount of PA than teenagers with a weak ability. Therefore, the HR-mediated game could adjust the game's difficulty for different fitness status players.

It utilizes a game scenario and game mechanics to elicit teenagers' interests and increase their enjoyment and social interactions. We illustrate the potential of FitBirds to facilitate team collaboration (see Figure 2). In this cooperation game mode, a team has a flock of birds, where the total height of the bird flock represents the average HR of the team as a collaborative result. Within the flock, the different height of each bird indicates the rank of the HR among teams. This cooperation game mode encourages team members to be aware of each other's fitness status and negotiates a game strategy.

4 PRELIMINARY USER FEEDBACK

In the preliminary study, we evaluate the design concept of FitBirds by demonstrating the prototype to 6 teenage students (named S1-S6, age range 10-13, 6 females) and 3 secondary school PE teachers (named T1-T3, 1 male and 2 females, teaching experience from 6 to 10 years). We explained the purpose, functions, and design features of FitBirds to 9 respondents and collected their feedback through one-on-one interviews. We performed a content analysis [3] on the transcribed interviews and the results are summarized as follows.

A clear PA intensity recommendation: The teenagers indicated that the game could instruct them to be physically active at the right pace. *"The game ensures that you are doing at exactly the right pace (S4)."* They believe PE teachers could monitor class performance through FitBirds and avoid exercise overload. Similarly, PE teachers believe that applying FitBirds in their classes could help them quickly know the fitness level of the entire class and adjust the PA intensity in time. *"I think it can stimulate teachers to reflect the physical intensity of your lessons (T2)."* Besides, the PE teachers liked the recommended "safe zone" in the game as it takes away their concern that students will focus too much on achieving the highest HR and thus compete with each other in a harmful way. *"It's good that the game recommends a 'safe zone' and not directly shows the numbers of HR. Otherwise, I am afraid students will just be fighting for the highest HR (T3)."*

Appealing visual design with the concern of data privacy: The teenagers said the visual design of the game attracts their attention and makes them feel more about playing a video game than doing PA. *"I think it's nice for gym class. It looks like a fun and educational video game. I am interested in playing it because I want to win (S6)."* They also think the anonymous avatar and the game scenario can help them feel less embarrassment if they perform

poorly in PA. *"I like that if you are doing PA badly, you don't really need to worry. Because you are just a bird (S3)."*

Future explorations: The teenagers expect the game can be used for different types of PA, or offer a variety of game scenarios to maintain long-lasting attractiveness. *"I certainly think it's nice in the beginning, but after a long time, it will become less fun. So, you can add more animals or more activities (S2)."* PE teachers also expect the game to provide freedom to decide when, for how long, and for which PA to use the game in their PE-class. *"It could be a tool to organize my class, but I would like to use it in different ways to meet the learning goals of each lesson (T1)."*

5 CONCLUSION AND FUTURE WORK

We presented the conceptual design of FitBirds, a fitness game that facilitates teenagers to regulate their PA at the recommended intensity level in the PE-class. The design features meet teenagers' special needs in PE context: *playful experiences, social engagement*, and *data privacy*. The preliminary user feedback from PE teachers and teenagers supports our design considerations and shows the possibility to integrate physiological data and digitally augmented feedback into the PE context. For future study, the design of FitBirds will be iterated and improved. Then we will evaluate FitBirds game in a real-life PE context to explore the effects of augmented HR feedback on teenagers' experiences in PE, such as *playfulness, social engagement*, and *learning experiences*.

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