Design for Balanced Engagement in Mixed Level Sports Teams

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Abstract
Most interactive sports-oriented products that are commercially available focus on individual athletes. The ones that focus on team sports rarely go beyond performance monitoring. Therefore, in this case study we focus on team dynamics in secondary school sports teams. These teams typically have to deal with unbalanced engagement due to skill level differences. This can impede the goals of these PE-classes; to raise young people's enthusiasm for a variety of sports and to teach them how to work together as a team. In this project we explore a design solution aimed at balancing engagement in these mixed level sports teams, through an intelligent system of connected light jerseys. The jerseys, iteratively developed through experiential prototypes that were used during secondary school basketball games, were able to measure ball possession and give feedback through a series of light stripes. In this paper we describe two iterations of this case study and our quantitative and qualitative findings of team engagement.

Keywords
Interaction Design; Prototyping/Implementation; Games/Play; Sensors; Wearable Computers; Behavior Change; Schools/Educational Setting; Field Study; Empirical study that tells us about how people use a system

1. Introduction

The largest share of commercial interactive sports products focuses on boosting the performance of an individual athlete. Products of this type aiming at the sports category seem to pay little attention to the team and group dynamics of team sports. Some examples that clearly illustrate this individualistic approach, even for sports that are mostly played in teams, are the Wilson X [9] i.e., a connected basketball that tracks your shooting accuracy during practice and the FWD Powershot [5] i.e, ice hockey stick swing analyzer. The team oriented products that are available have a clear performance focus and are virtually always aimed at elite sports clubs. Examples here are the Adidas' miCoach Elite Team system [7] and the Polar Team system [8].

Most products focus on improving individual skills, some to ultimately improve team performances. We see teams as more than a collection of individuals and the drivers to practice sports reach far beyond being better, faster or stronger. Through sports, children (already at a young age) learn to play together to develop their social skills. Through teamwork, they learn how to cooperate and to value both individual and collective goals.

In this case study, we address secondary school sports teams, as we see opportunities for design to enhance the social interactions during group PE lessons. The goal of the study is to design for balanced engagement in mixed skill level sports teams.
What follows is an introduction to the design space:

Friday 3pm, the last hour of the school week just started: PE class; with basketball on the schedule. Although I like it, I am terrible at it. The first game starts, and I am in the best team. I am trying to get to the ball, but others easily ignore me. In the heat of the game they do not see I get excluded.

The presented situation is a much occurring one in teams with high skill level differences such as secondary school sports teams. Skilled players often don't involve less skilled players. They look for the option that is resulting in the highest chance of winning. We are intrigued by the social nature of this phenomenon and see opportunities for design to change this behavior. Please note that this case study is situated in the Netherlands, where secondary school students have approximately two hours of compulsory PE lessons each week.

According to the Self Determination Theory [3] students' motivation can be influenced through nurturing three basic psychological needs: the need for competence, autonomy and relatedness. Several studies have shown a number of positive outcomes, such as skill development and motivation for PE and sports, among students in whom these needs are supported [1,4]. Frustrating these needs, in contrast, has a negative effect on students' motivation. Supporting these basic needs was considered as an important aspect of our design.

We take a research through design approach [6] and explore how to design for balanced engagement in mixed level sports teams. In the first iteration we describe how we came to our initial experiential design research prototype, a set of interactive basketball jerseys, and give insight in feedback from a first situated experiment. Next, we show in a second

iteration how we scaled up our experiments to get insight in the potential value of our concepts. We reflect on the results of both iterations and discuss our insights designing for balanced engagement.

2. Iteration 1

Following our research through design approach, the challenge was to design a research prototype that allowed secondary school students to experience different 'engagement interventions'. As we address complex social integrations we choose to explore these in their real context of use. At the same time this prototype had to allow for exploration of multiple concepts. By making the jerseys as interactive displays, we introduce various opportunities to add information and interaction possibilities during team sports. In a first version each jersey contained five light stripes and was wirelessly connected to all other jerseys to receive and transmit information (see figure 1). The way in which the light stripes behaved could be programmed in a variety of ways.

We choose to focus our explorations around basketball games during vocational school PE lessons, as the high game pace results in many passes to differently skills players. We hoped that by tracking ball possession percentages (i.e. which player has which percentage of ball contacts) we were able to get a good indication of engagement.

2.1 The Research Prototype

The custom developed system consists of two main components: (1) the interactive light jersey (figure 1) and (2) the dashboard: a central computer giving (real-time) insight in data collected (figure 3).

Figure 1. Interactive light jersey prototypes

2.1.1 The Interactive Light Jersey

The challenge was to integrate clearly visible light stripes in a jersey, which would be robust, battery powered and wirelessly connected to the other jerseys.

For the positioning of the stripes we explored various positions. Because of the social nature of the concept, we aimed to have maximum visibility for other players and less visibility of the player wearing the jersey. Therefore, the stripes are placed on the lower part of the jersey, on the side.

To prevent wearing large battery packs we designed a simple light stripe, maximizing visibility. Using two single white LED's the whole stripe could be lit diffusely (figure 2). The stripes were connected through a flat cable, running through the sleeve, to an Arduino Fio [2]. This Arduino was placed in a stretch fabric wristband and was able to control each light stripe individually. By adding a wireless radio (i.e., an Xbee [10]) the shirt was able to receive and transmit data.

In total we built 6 jerseys, 3 for team red and 3 for team blue, which allowed us to play 3 versus 3 games.

Jerseys and wristbands were visibly labeled with characters from A to F on front and back side.

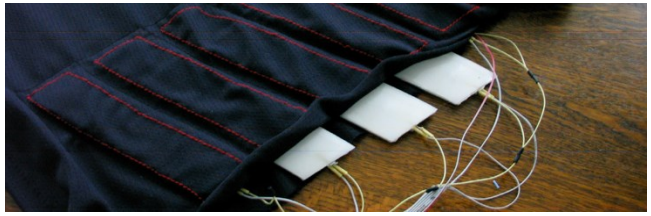

Figure 2. The light stripes were embedded into the fabric of the jersey

Figure 3. The dashboard, showing team ball possession and engagement

2.1.2 The Dashboard

A laptop on the courtside was used both as a wizard of Oz type of control and to get insight in the ball possession percentages through real-time data visualization. As we had no means to track ball contact automatically, we would score this manually by pressing keyboard keys corresponding to labels on the jerseys (i.e. A to F).

In the first version of the dashboard a graph would show the progress of ball possession percentage over time for both teams and the amount of (absolute) ball contacts per player (see figure 3).

2.2 Experiment

So far our design decisions were based on intuition and assumptions on what might work. The goal of this in-context design experiment was twofold: (i) getting feedback on the initial direction, based on situated experiences, and (ii) to get insight in the potential of two concept directions.

(1) No Additional Rules

The first direction aims to balance engagement in a subtle manner, simply by visualizing the percentage of ball possession on the stripes. More stripes light up at higher percentages. To make the system respond to small and large variations in ball possession we set the following thresholds for the stripes. The set thresholds below are based on 3 player teams:

Stripe 1: 15 – 22 % - Stripe 2: 22 – 29 %

Stripe 3: 29 – 38 % - Stripe 4: 38 – 48%

Stripe 5: 48 – 100%

(2) Additional Rules

The second direction strongly builds on the first but adds some additional game rules: The player with the highest number of stripes lit is not allowed to score points. Moreover, if a player in the team has no stripes lit (under 15 percent), the player with the highest number of stripes has to leave the court for 1 minute.

By visualizing otherwise hidden game statistics, we aim to address the social responsibility of the students. We hope to motivate less skilled players to be more involved and hope to see that the more involved players start to care more about the less involved ones.

In this first experiment, 6 students played three 3 versus 3 games of ten minutes each. Participants were aged between 15 and 17 years and were all male students. In the first game, the interactive light jerseys were not used, as a warmup and reference game. Besides, the Wizard of Oz spectators had to practice the real time registration of ball contacts through the dashboard. The second and third game are played with the interactive jerseys that are deployed in the Additional Rules mode (2) during game two and No Additional Rules mode (1) in the third game (figure 4).

2.3 Results of Iteration 1

As expected from a complex system of handmade prototypes, there were some initial flaws. Four out of six jerseys functioned properly. The other two stopped working occasionally, but could easily be repaired.

The overall concept and both directions were discussed in an informal group discussion. Initial responses were very positive. Participants liked to see the invisible statistics but indicated it was hard to pay attention to them while playing. However, they did indicate that at moments the game was at rest (e.g. scored points, ball outside court, free throw) they looked at the jerseys of others to evaluate the balance in the team and how they personally related to that.

Participants indicated they liked the No Additional Rules mode (1) far better than the Additional Rules mode (2). They unanimously agreed that the value of the concept is in bringing forward relevant game information that was otherwise invisible. The players choose for themselves whether or not to respond to this. Adding rules to the game changes the gameplay. "Basketball should stay basketball" as commented.

Unfortunately, it turned out that the 6 participating students were all of a comparable skill level. Because of this, the data showed little differences in the amount of ball contacts near the end of the games. (i.e., 37-35-33). Participants also indicated that in smaller teams it is more difficult to overlook players. A post analysis using ball contact time instead of the amount of ball contacts did not impact this distribution significantly.

Figure 4. Pictures of the jerseys during play

3. Iteration 2

As the *No Additional Rules* mode was received with large enthusiasm, it was decided to deploy the prototypes (with some updates) in a larger scale study to study the potential effect. Instead of 3 versus 3 games we aimed for 5 versus 5 games, to encompass for skill level variety within teams. Manually scoring ball contacts (with two spectators) was already difficult for the 6 players in the first experiment. Scaling to 10 players, and for more games, would give difficulties for a larger scale study. This would require both a large time investment and would not be beneficial to the experienced responsiveness of the system.

To allow for a larger scale study, the manual ball counting system was developed further into an automated tracking system. In this larger study we questioned whether a simple on-jersey visualization of ball possession percentages can influence the balance of engagement in that team. Simultaneously we aim to evaluate whether ball possession percentage is a viable measure to evaluate the teams' engagement balance.

3.1 Research System Prototype (update)

Based on experimental prototypes exploring different options to automate ball contact tracking (e.g., sound on catch, muscle tension, motion, ball conductivity) we selected wireless signal strength as the best option to proceed. By placing a wireless transmitter in the ball we were able to detect when the ball would come in close range of the wristband. A new ball contact for that player would then be transmitted to the laptop. This laptop recalculated all percentages in real time and updated the light stripes.

Next to the 6 jerseys with accompanying wristbands from the previous iteration, we build 6 stand-alone wristbands that could be used by the team that was not wearing the light jerseys.

3.2 Experiment

We aimed to evaluate the effect of the jerseys both quantitatively (i.e., through ball tracking sensor) and qualitatively (i.e., through questionnaires and informal on court conversations).

3.2.1 Participants

To optimize diversity and to have access to enough students for a larger scale study we choose to collaborate with 3 PE-teachers on two different secondary schools. In total 135 students participated during the experiment making a total of 27 teams. 11 teams played with interactive jerseys where 16 teams played only with wristbands. Participants were aged between 13 and 17. Their experience level in basketball was highly different.

3.2.2 Procedures and Measures

All experiments were carried out in the sports hall of the secondary schools. Where the remainder of the class played different sports outside the sports hall, 10 students were invited to participate in the experiment. Before entering the court all players received a wristband for ball detection. One team received the wearable display shirts, and it was explained that the number of stripes lit represented the percentage of ball possession during the game. The players of Team 1 are named A to E, the players of Team 2 F to J, for comparison with the questionnaires later on.

One game of the experiment consisted of a 5 versus 5 basketball game of 10 minutes on a full court where all normal rules applied (figure 5). The teams were randomly divided. After the game, all players were asked to fill in a questionnaire with more general and specific questions about the effect of the interactive light jerseys. Players were asked to rank the level of perceived engagement for all players inside their team. The game was recorded from two different angles to be able to have a continuous overview of the field. After every game, a short discussion with the team that was wearing the wearable display shirts was held to bring forward first thoughts and responses. After all sessions there was an evaluation with the involved PE-teachers.

Figure 5. Picture taken during the game.

3.3 Results

The largest part of all teams that participated (21 of 27) played with the automated tracker system. When that functionality gave in, because the glue used to seal the ball after placing the chip got loose and flattened the ball, the remaining games were scored manually. The possession percentages, of the teams playing without the jerseys that had no automated tracking, were later analyzed using the recorded videos.

First reactions about the shirt were positive. Some initial responses as "*nice I am lit*", "*this looks cool*", "*Are we going to be robots*" or "*Does it register my heartbeat*" show the point of view these students have on the newly introduced technology. The evaluations after each game gave mixed responses. Where some were more negative, as they indicated they paid little attention to the, others were more positive. "*During the game I am aware of how many stripes are lit on my shirt, but I also look at what scores the others have attained. If players get excluded from the game I can drag them back in".*

Younger students seemed more interested in how they perform individually and continuously look at their own score, to consecutively compare it to others. The jerseys got more attention in this younger group, possibly also because the game pace was lower there. The concept had a different impact there than with the older students. Most of the 13 and 14-year old's were excited to 'score more stripes', as an achievement in itself. A 13-year-old ran across the court with the ball in his hands shouting he needed more stripes.

The older students were more involved, calm and cared more about their social status in the group. Players with a higher level of ball possession replied they enjoyed seeing the distribution in the team. The less involved players, which we expected to be more negative, as the concept would put extra emphasis on their status, were surprisingly positive. *"Finally it is clear for everyone they should involve me more and I don't even have to say it"*. In a context where players care more about the social cohesion of a group the concept flourished.

We also investigated if ball possession percentages would be a viable measure to evaluate balanced engagement. Eventually, only for 8 games (16 teams) all students completed the questionnaires. In this questionnaire they were asked to rank the players in their team members based on engagement in the game. In over 80% of the rated players, the order of the ranking was close to the ball possession parameter (a maximum of 1 player was switched in order of hierarchy).

As our observations and experiences from interviews and discussions were positive, we hoped to verify some of these findings with the tracked data. Even though we managed to involve 135 participants, we only had 27

teams to analyze. Of these 27 teams, only 11 teams played with the interactive light jerseys, making it a rather small sample size. In our statistical analysis we attempted to find differences in the ball possession percentage of teams playing with and without the interactive jerseys. We compared the following situations: differences per student for students that played both with as without interactive jerseys, differences between all players with and without, differences in passes given from top ranked players to bottom ranked players with and without, and the differences in passes given bottom ranked players to bottom ranked players. Often results tended towards the positive side, but we never had a large enough sample size to give statistical evidence for transformed behavioral patterns.

4. Discussion

Students and teachers were enthusiastic about the interactive light jerseys. Their positivism was grounded in the fact that the new technology is not playing a dominant role. It is always present in the background; students can decide themselves whether to act on it or not. It does therefore not require any changes in the current ways schools organize their PE classes.

We started with the challenge to design an interactive system for team sports, that was not performance driven and focused on group dynamics. Through this case study we believe to have showed that a different approach to designing for teams can give outcomes that are widely different than the conventional performance of individually oriented sports solutions.

The results of our experiments provide some evidence for the potential effect of the designed interactive basketball jerseys on students' motivation for PE and sports. This can be related to the self-determination theory, as introduced [3]. The self-regulatory and social affordances of our designs addressed the fulfilment of the basic needs of autonomy (the system did not dictate what actions were required), relatedness (the system stimulated students experiencing connectedness with others through social responsibility of team play), and competence (individual differences were taken in to account). The results of this study suggest that the need supportive approach in our designs could play a role in supporting students in enjoying and persisting their exercising behaviour. However, in this study we did not examine the direct effect of our designs on students' motivations.

Next to this we challenged ourselves to design for balanced engagement. We found ball possession percentages to be a viable measure for engagement, when no additional rules are applied to a game. Where we initially saw more potential in developing specific games with the interactive light jersey, we found that a subtler approach was preferred.
By simply visualizing game information that was previously hidden, we appealed to a feeling of social responsibility within the groups. While the effect might have been less substantial on the short-term now, we believe that an intervention this subtle could have long term impact. Although a large number of students participated in our experiments, from a team perspective the sample size was not that large. Therefore, quantifying the behaviour effect of the jerseys was difficult. To further investigate this, we would like to further develop our research platform so that it is robust enough to be deployed to secondary schools for a more longitudinal study.

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