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### **Paper:**

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# MISSION POSSIBLE: USING UBIQUITOUS SOCIAL GOAL SHARING TECHNOLOGY TO PROMOTE PHYSICAL ACTIVITY IN CHILDREN

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## Abstract

**Objective:** The present study investigates the acceptability of a novel ubiquitous social goal-sharing intervention aimed at promoting physical activity (PA) in schoolchildren. **Methods:** Thirty children (18 boys; 10.1±0.3 years; 1.39±0.06 m; 19.85±4.03 kg·m<sup>-2</sup>) were randomly assigned to ten groups and outfitted with Fitbit monitors. Video-clips describing mission-based activities were shown on iPads each week, for four consecutive weeks. An LED lighting-strip provided visual feedback on daily group PA levels. Three semi-structured group interviews were conducted with 10 children (4 boys, 6 girls; n=2) and two teachers (n=1). Additionally, at baseline and post-intervention, seven-day accelerometry, cardiorespiratory fitness (CRF; 20m shuttle run test), anthropometrics and physical self-perceptions were assessed. Data were analysed using a mixed “between-within” analysis of variance (ANOVA). **Results:** Children stated that peers were positive role models and provided encouragement to accomplish their goals. Teachers noted that children’s fitness, teamwork and problem-solving skills considerably improved. Statistical analyses revealed no significant intervention effect (p>0.05), though BMI and waist circumference increased and CRF decreased. **Conclusion:** The integration of ubiquitous social goal-sharing technology in schools was well received among both teachers and pupils. Future studies should integrate a larger sample size encompassing numerous schools, comparison groups, and a longer intervention period with associated follow-up measurements, in order to ascertain the feasibility of this intervention as a low-cost way to promote children’s PA levels.

**Keywords:** Ambient display, gamification, intervention, visual feedback

## Introduction

Physical activity is associated with numerous physiological and psycho-social health benefits (Ahn & Fedewa, 2011). Physical inactivity and sedentary behaviour are attributable to many of the health risks associated with childhood obesity (Rowland, 2004). Specifically, healthy weight status and sufficient physical activity are positive health determinants associated with reduced cardiometabolic risks, such as lower blood pressure, healthy lipid profiles, and reduced risk of type II diabetes (Andersen, Riddoch, Kriemler, & Hills, 2011). Recent evidence suggests that the prevalence of obesity has plateaued both in the UK (Boddy, Hackett, & Stratton, 2010) and internationally (Rokholm, Baker, & Sørensen, 2010), however, there is no evidence of a decline and 30% of 5 to 12 year old children in the UK remain at risk of morbidity (Department of Health, 2011). Current physical activity guidelines recommend that children aged 5 to 18 years engage in at least 60 minutes moderate-to-vigorous physical activity (MVPA) every day (Department of Health, 2011). Despite well-established recommendations to increase daily physical activity levels, many children fail to meet the current recommendations (Hills, Andersen, & Byrne, 2011) and tend to engage in excessive sedentary behaviour (Ekelund et al., 2012).

Childhood is a critical period for developing favourable lifestyle behaviours that can continue into adolescence and adulthood. Thus, interventions that target low physical activity levels and poor weight status are imperative. Schools have been identified as an ideal setting to implement health-promoting interventions given their pre-established infrastructure and their pivotal role in health and education of communities

(Dobbins, Husson, DeCorby, & LaRocca, 2013). Children spend, on average, 40% of their waking time at school (Fox, Cooper, & McKenna, 2004). Despite this, school-based interventions have been conducted with varying success rates (van Sluijs, McMinn, & Griffin, 2007), which may be attributed to the different intervention strategies and variable methodological quality, such as lack of objective measurements of physical activity (Mountjoy et al., 2011). Furthermore, interventions targeting reduced sedentary behaviour tend to discourage highly valued behaviours, such as engagement with technology. Poole et al. (2011) integrated a school-based intervention in which wireless pedometers automatically uploaded data within range of a base station and fed back data via a website. However, children did not access their data regularly and, given the sporadic nature of children's movements, were unlikely to understand what movements the activity corresponded to.

Ambient displays, also known as glanceable displays, are peripheral, aesthetically pleasing displays of information that support awareness of some data, can be utilised to make information visible in an appealing and socially interactive manner. Glanceable displays are designed to be looked at occasionally without distracting people from other activities (Rogers, Hazlewood, Marshall, Dalton, & Hertrich, 2010). Consolvo et al. (2008a; 2008b) integrated an interactive mobile fitness application with a glanceable display, finding that those individuals utilising an awareness display maintained their physical activity levels better than those with no ambient display. However, such devices have inherent problems, such as monitor placement (Trost, McIver, & Pate, 2005), and have not been incorporated into a community-based setting like a school classroom. Therefore, the aim of the present study was to assess the acceptability of utilising ambient displays to provide near real-time visual feedback on physical activity levels during school time.

## **Materials and Methods**

### *Study Participants*

All Year 5 children (9-10 years) from one primary (elementary) school in South Wales were invited to take part in the study (n=32). Written informed parental consent and participant assent were obtained from all children (100% participation rate). The study protocol was approved by Swansea University Research Ethics Committee. The final sample size consisted of thirty children (18 boys, 12 girls;  $10.1 \pm 0.3$  years;  $1.39 \pm 0.06$  m;  $19.85 \pm 4.03$  kg·m<sup>-2</sup>).

### *Intervention Design*

The activity design and content were informed by iterative formative work with the children, whereby children were asked to work in groups to formulate ideas, thereby employing a user-centred design. Such work led to the descriptions of missions based around a "secret agent" theme. For example, mission one evolved around an assault course: "Captain Cybernetic wants you to infiltrate Dr. Tempus's lair. However, Dr. Tempus has placed various obstacles in your path. Navigate the obstacles to get to his lair as fast as possible." The intervention consisted of four, one-week long, missions, shown via an iPad, as their "Monday Mission". A DVD outlining the various missions, together with a Teacher's Guide and Mission Pack, was provided to the teacher, and the mission videos were copied onto a set of tablet devices. Children were divided into ten groups (n=3), with each group being assigned a team colour, and associated Fitbit Zip (Fitbit, Inc., San Francisco, CA) activity monitors.

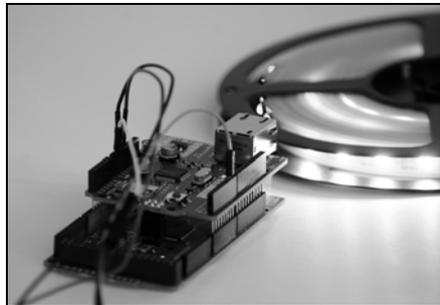
The Fitbit Zip has been shown to be valid and reliable (Noah, Spierer, Gu, & Bronner., 2013). It contains a tri-axial accelerometer to record time-stamped physical activity data, including number of steps and physical activity intensity according to four levels: sedentary, lightly active, fairly active and very active. Participants were asked to wear the monitor on their right hip. The Fitbit Zip is designed to be small and unobtrusive, making it more acceptable for use by children than other activity monitors, which are often large and bulky.

Ambient displays located in a person's environment have been shown to change their behaviour by providing live feedback (Fan, Forlizzi, & Dey, 2012; Harries, Eslambolchilar, Stride, Rettie, & Walton, 2013). These displays serve as decorative visual art pieces intended for reflection. An ambient display prototype, consisting of a 4m-long flexible lighting strip with 240 individually controlled LED lights was constructed and installed along the front of the classroom. As the children returned from the mission, data from the Fitbit

Zip monitors were uploaded automatically to Fitbit's servers, via a Bluetooth Low Energy (BLE) dongle connected to a computer in the classroom. Data was accessed using the Fitbit API. Results were analysed and stored on the university's server. The results were then downloaded by an Arduino microcontroller (Figure 1) connected to the internet via the school's network. The ambient display used uniquely distinguishable moving colour segments to visualise team performance. The speed of the segment represented the number of steps, and the teams colour would start to flash if they spent more time being active than the previous day. Each colour segment had a speed between 0 and 10, based on the group's performance. The following formula was used to calculate speed:

$$v = 5 \frac{x}{y} + 1$$

where  $v$  is the speed at which the segment is moving,  $x$  is the accumulated number of steps taken that day, and  $y$  is the number of steps taken on the previous day. On the first day of each mission,  $y$  was set to 1000 as a default value. To provide additional encouragement, the number of minutes the children spent in 'very active' to complete the mission on that day was compared with that of the previous day. If the amount of very active physical activity was greater than the previous day, their group's colour segment would start pulsating.



**Figure 1:** Arduino Microcontroller

### *Outcome Measures*

Group interviews (n=3) were conducted with two teachers (n=1) and 10 children (n=2; 4 boys, 6 girls). One child was randomly selected from each group. Each child focus groups was conducted with five children (Morgan, Gibbs, Maxwell, & Britten, 2007) given that such a method is deemed viable for exploring perspectives if groups are small in composite number (Porcellato, Dugdill, & Springett, 2002). The semi-structured interview was informed by enabling, reinforcing and predisposing factors from the Youth Physical Activity Promotion (YPAP) Model (Welk, 1999) to explore the physical activity engagement and identify barriers with particular focus on Mission Possible. Prior to data collection, the interview guide was examined by other researchers and teachers to ensure face validity and determine whether tone and structure format were appropriate. Minor modifications were made following this consultation process. Open-ended questions were used to allow exploration of detail, expression of opinion and examples, where appropriate. As such, the interview was responsive to the participants allowing time for explanation of any words that the participant did not understand. All interviews took place in an appropriate quiet area within the school and lasted between 30 and 35 minutes. Interviews were audio recorded using Garage Band (Apple Inc., USA) and all data were transcribed verbatim. All interviews were conducted by the first author, who has considerable experience in conducting focus groups with both adults and children.

Physical activity at baseline and post-intervention was objectively assessed for seven consecutive days using ActiGraph GT1M accelerometers (ActiGraph LLC, Pensacola, FL). The ActiGraph is a common tool used to assess the volume and intensity of physical activity and has previously been validated with children (Trost et al., 1998). To distinguish between wear time and sleep time children also completed a log sheet to record when the ActiGraph was put on in the morning and removed at night before bed, and any other times when the monitor was removed (e.g., showering, contact sports, swimming, and so on). These log sheets were checked and initialled by parents at the end of each day. During the monitoring period, physical activity was recorded using 5 second epochs (McClain, Abraham, Brusseau, & Tudor-Locke, 2008). Sustained 20 minute periods of zero counts were considered non-wear time (Catellier et al., 2005). Children were included in the

data analysis if they wore the monitors for at least 600 minutes for a minimum of 3 days in total (Mattocks et al., 2008). These inclusion criteria have previously shown acceptable reliability in similarly-aged children (Mattocks et al., 2008).

Two participants (6.7%) at baseline, and eight (26.7%) at post-intervention, did not meet wear-time criteria and were consequently excluded from the analyses. There were no significant differences in descriptive characteristics between children included and excluded at baseline ( $p=0.11-0.85$ ) or post-intervention ( $p=0.12-0.91$ ). Evenson et al. (2008) cut-points were used to classify counts per minute into light physical activity (LPA), moderate physical activity (MPA), vigorous physical activity (VPA) and sedentary behaviour (SED). These cut-points have been identified as the most valid and reliable for the age group under consideration (Trost, Loprinzi, Moore, & Pfeiffer, 2011).

In addition, children completed the Physical Self-Perception Profile for Children (PSPP-C; Whitehead, 1995). Stature and sitting stature to the nearest 0.01 m (Seca Ltd., Birmingham, UK) and body mass to the nearest 0.1 kg (Seca Ltd., Birmingham, UK) were measured using standard techniques (Lohman, Roche, & Martorell, 1988). Body mass index (BMI) was calculated and BMI z-scores were assigned to each participant (Cole, Freeman, & Preece, 1990). Waist circumference was measured to the nearest 0.01 m using non-elastic anthropometric tape (Seca Ltd., Birmingham, UK) and measurements were taken at the narrowest point between the bottom of the ribs and the iliac crest. All measurements were undertaken by the same trained researcher. The 20m shuttle run test, which has been widely used in children of a similar age (EUROFIT, 1998; Stratton et al., 2007; van Mechelen, Hlobil, & Kemper, 1986), was conducted to estimate cardiorespiratory fitness (CRF).

#### *Data Coding and Analyses*

Focus group data were transcribed verbatim, for a total of 71 pages of typeset data with Arial font, size 12, double-spaced. Unique identification codes were used throughout all transcripts to ensure confidentiality. The researchers read each transcript several times in order to familiarise themselves with the data. Transcripts were deductively and inductively analysed by each researcher independently using a manual cut and paste technique. The transcripts were reduced to identify quotes indicative of meaningful themes and discard irrelevant quotes with no meaning. Comparing and contrasting the meaningful quotes enabled the researcher to unite quotes with similar meaning and to separate quotes with different meanings, clustering quotes into categories and essentially highlighting common themes between participants' experiences. A frequency count was then conducted for the meaningful quotes, noting how many participants noted respective points. The outcomes of the analysis process were then represented as pen profiles. Pen profiles are considered appropriate for representing analysis outcomes from large datasets via a diagram of composite key emergent themes, frequency data and verbatim quotations and have been used previously as a representative tool in formative research (Boddy et al., 2012; Mackintosh, Knowles, Ridgers, & Fairclough, 2011; Ridgers, Knowles, & Sayers, 2012). Methodological rigour was demonstrated using 'trustworthiness criteria' (Ridgers et al., 2012) in which researchers responsible for data collection determine that the findings were firstly worthy of attention to other researchers not directly involved in the process (Hardy, Jones, & Gould, 1996). Verbatim quotations were initially presented and critically questioned through analysis and the data were cross-examined in reverse, from the pen profiles to the transcripts. This process was repeated, allowing the authors to offer alternative interpretations of the data, until an acceptable consensus had been reached. Verbatim transcription of data and triangular consensus procedures afforded credibility and transferability, with comparisons of pen profiles and verbatim citations accentuating dependability.

#### *Statistical Analyses*

Data were analysed using a mixed "between-within" analysis of variance (ANOVA), with time as a within-participant factor. Statistical significance was accepted at  $p<0.05$ . All statistical analyses were conducted using IBM Statistics 21 (SPSS, Chicago, IL). All data are presented as means  $\pm$  SD.

## **Results**

### *Pen Profiles*

Data were initially analysed through a deductive process using some aspects of the YPAP model (Welk, 1999) as a thematic framework, reflecting the underlying study objectives. Additionally, an inductive process also enabled additional emergent themes to be further explored. Children’s and teachers’ data are presented separately (Figure 2 and 3, respectively) and structured in terms of the positives and negatives of Mission Possible. Figure 4 incorporates both children’s and teachers’ future recommendations.

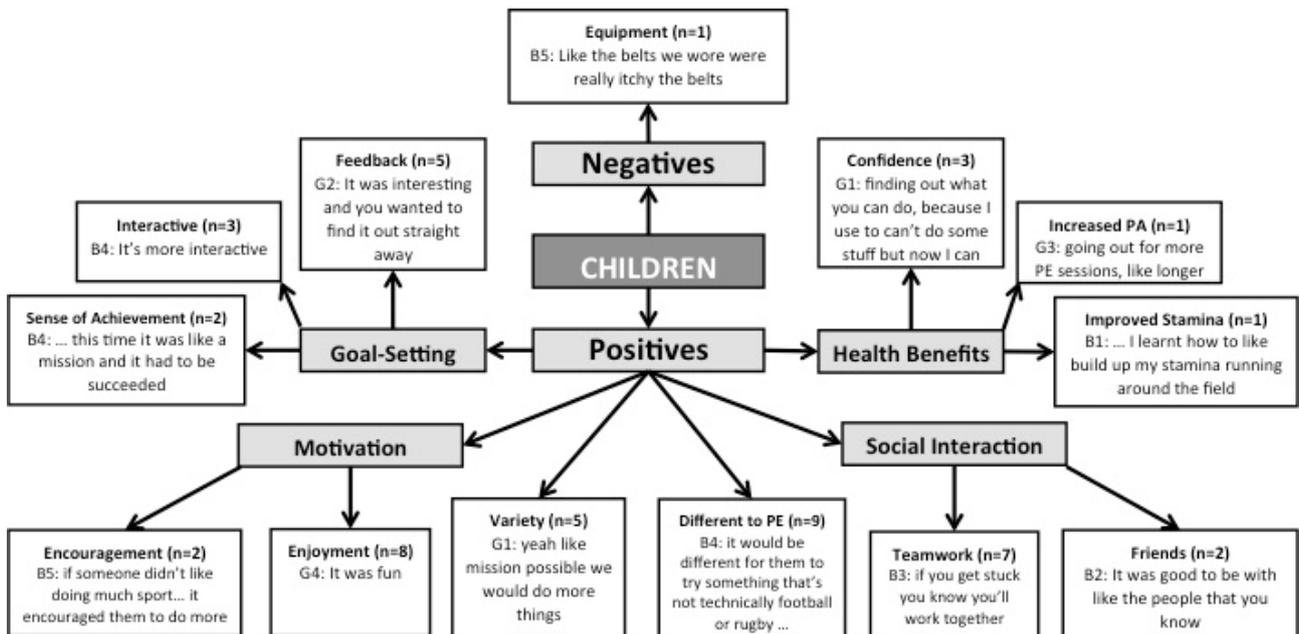
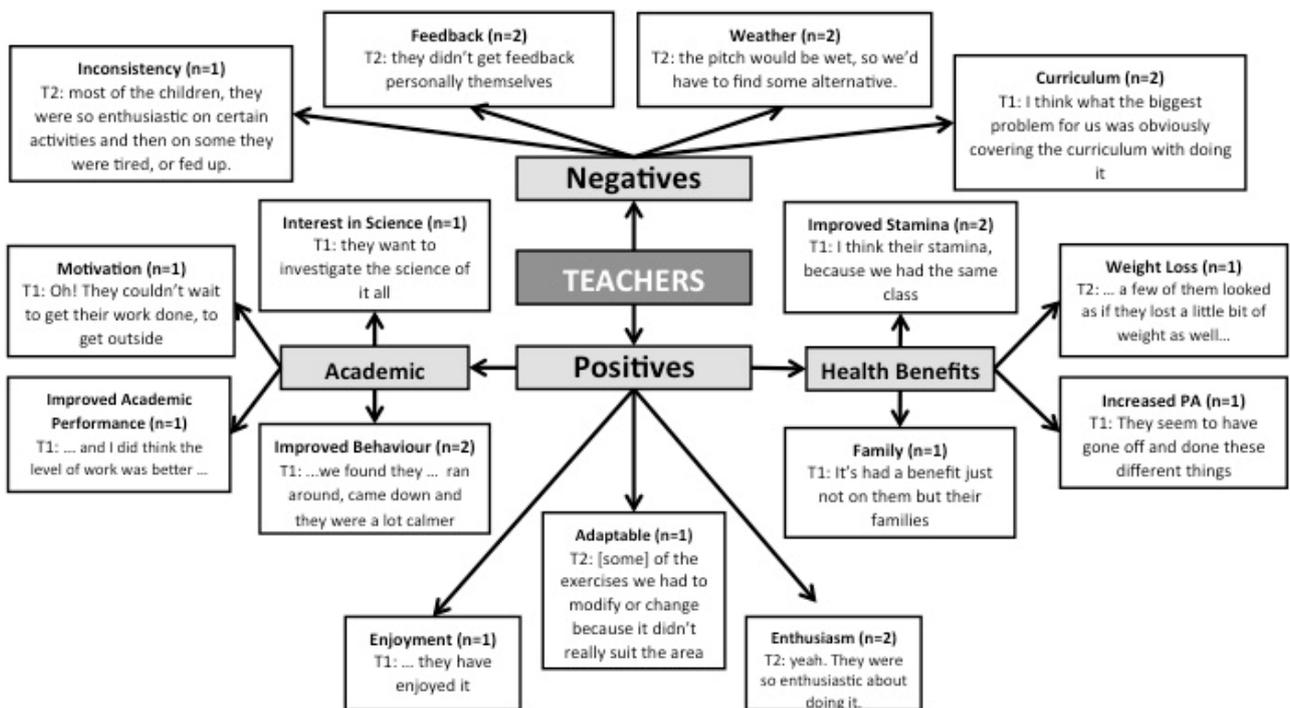


Figure 2: Children’s Pen Profile

The majority of children expressed a sense of enjoyment (n=8), stating that it was different to physical education (PE; n=9) and provided variety (n=5). For example, one child stated, “...if someone like, didn’t like football or something, it would be different for them to try something that’s not technically football” (B4), with another participant agreeing and adding further, “Yeah. Like Mission Possible we would do more things.” (G1). Additionally, both teachers specifically highlighted the children’s enthusiasm levels for the intervention.



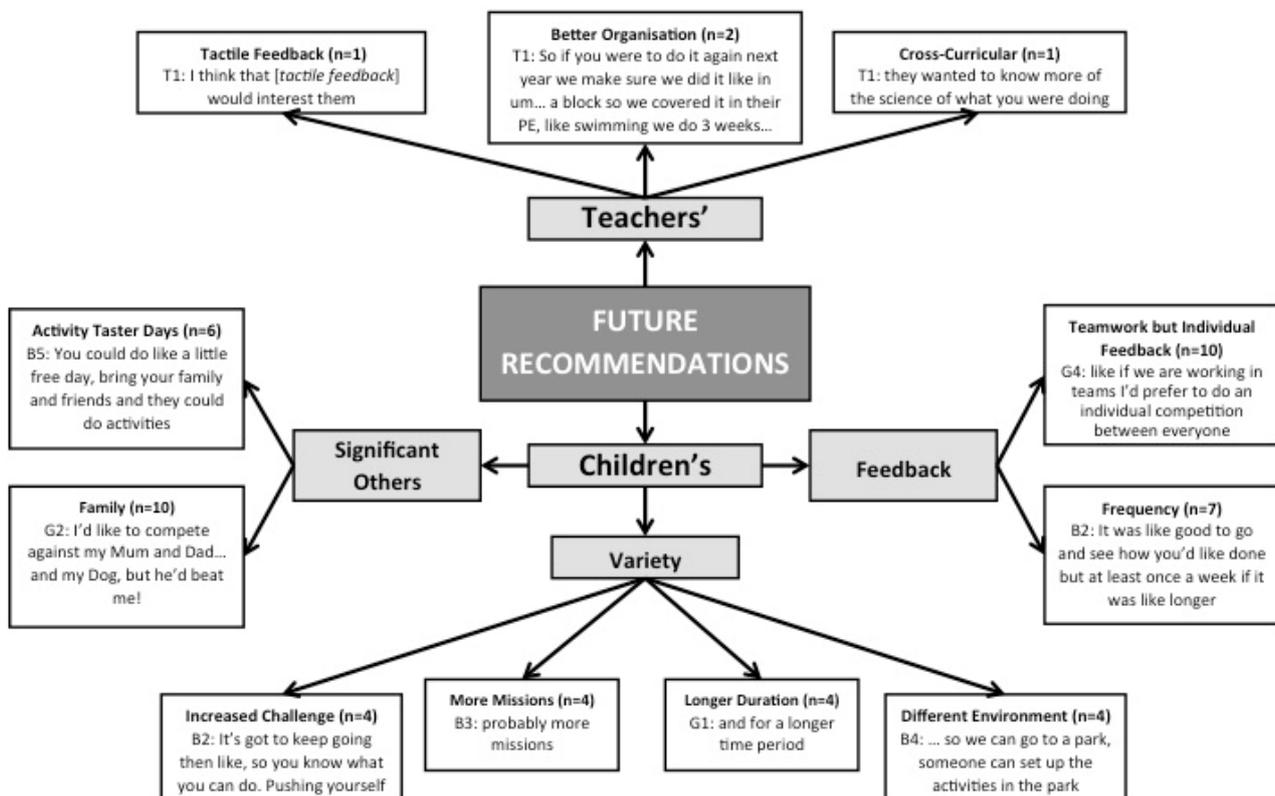
**Figure 3: Teachers Pen Profile**

Several children (n=5) reported motivation to participate and engage in Mission Possible due to the visual feedback provided. As such, seventy percent of children (n=7) stated that teamwork was an important factor: “If you get stuck you know you’ll work together.” (B3)

Not only did working as a team provide a form of support, children stated that it provided peer encouragement (n=2) and that it was good to work with friends (n=1). Children felt that participating in the missions provided them with a sense of achievement (n=2), specifically stating that they experienced more confidence (n=3), increased their physical activity opportunities (n=1), and had improved stamina (n=1). Conversely, teachers noted other health benefits, such as weight loss, family benefits, increased participation in physical activity out of school, as well as improved stamina.

Only one child related a negative perception, which concerned the physical activity monitoring analyses, rather than the intervention itself: “...the belts we wore were really itchy...” (B5). Conversely, both teachers identified barriers in terms of weather, lack of individual feedback, and the impact on the curriculum. As such, teachers suggested that if the intervention were to be conducted again, it would need to be implemented in blocks to align with the curriculum (Figure 4). Moreover, one teacher felt that some children became bored during some of the tasks. Despite teachers’ highlighting the impact the intervention had on curriculum time, qualitative data revealed that the intervention resulted in improved behaviours and academic performance, as well as acting as motivation to finish work. Teachers’ also identified increased interest in science, resulting in a Mission Possible themed science project. Interestingly, the teachers felt that the intervention was easily adaptable to their schools’ needs.

Children, as opposed to teachers, had numerous suggestions on how the intervention should be taken forward. All children stated that they would like significant others involved in future interventions, with six children suggesting implementing family and friend’s activity taster day. Additionally, two children suggested that it would be good to have missions outside of the school environment. Although children enjoyed the teamwork aspect of the intervention, some children (n=3) stated that it would also be good to incorporate individual competition. Overall, the data revealed that children wanted a longer intervention (n=2), with more missions (n=4) of a progressive nature (n=2).



**Figure 4: Future Recommendations Pen Profile**

## Quantitative

**Table 1:** Descriptive Statistics.

	<i>n</i>	Age (years)	Height (m)	Waist Circumference (m)	BMI (kg·m <sup>-2</sup> )	Total Shuttles
Baseline	32	10.14 ± 0.27	1.39 ± 0.06	0.64 ± 0.09	19.85 ± 4.03	23.0 ± 12.3
Post	32	10.27 ± 0.27	1.40 ± 0.06	0.63 ± 0.09	19.60 ± 4.12	26.5 ± 16.8

Note: Values reported as mean ± SD

Descriptive statistics for the physiological parameters are shown in Table 1. There were no significant differences in any intensity of physical activity (Table 2) or physical self-perceptions (Table 3) or over time ( $p > 0.05$ ). Whilst there were no significant differences in BMI, waist circumference, or CRF ( $p > 0.05$ ), all three measurements decreased at post-intervention in comparison to baseline.

**Table 2:** Physical Activity Levels

	<i>n</i>	SED (mins)	LPA (mins)	MPA (mins)	VPA (mins)	MVPA (mins)
Baseline	23	488.9 ± 43.5	181.9 ± 28.1	42.4 ± 13.4	32.8 ± 13.7	75.2 ± 25.0
Post	18	494.3 ± 46.4	195.1 ± 27.2	43.0 ± 17.8	27.4 ± 12.7	70.4 ± 28.9

Note: Values reported as mean ± SD

**Table 3:** Physical Self-Perceptions.

	<i>n</i>	Sport Competence	Physical Condition	Body Attractiveness	Perceived Strength	Physical Self-Worth	Global Self-Esteem
Baseline	32	3.0 ± 0.1	3.0 ± 0.1	2.8 ± 0.1	2.9 ± 0.1	3.1 ± 0.1	3.3 ± 0.1
Post	32	2.9 ± 0.1	2.9 ± 0.1	3.0 ± 0.2	2.9 ± 0.1	3.1 ± 0.1	3.3 ± 0.1

Note: Values reported as mean ± SD

## Discussion

The present study used ambient displays to provide near real-time visual feedback on physical activity levels during school time. The primary aim was to assess the acceptability of integrating a technological intervention within a school environment and elicit children's and teachers views on the benefits and barriers to participation. Novel ubiquitous computing technology was successfully integrated into the school environment and provided children with near real-time visual feedback to promote physical activity levels.

The design of Mission Possible facilitated teamwork, with 70% of children suggesting that they succeeded as a result of working together to meet the set objective. Children felt that being part of a team provided an opportunity to work with friends, advancing previous research in which individual members of teams worked remotely via a digital medium rather than face-to-face (Consolvo, Everitt, Smith, & Landay, 2006; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006; Toscos, Faber, An, & Gandhi, 2006). Mission Possible breaks through this individualistic digital bubble phenomenon by allowing children to be more creative, playful and thoughtful of each other. However, despite children discussing the benefits of working as part of a team, some children identified the need for individual competition. Future research should consider the integration of both team and individual competition, which have shown to be successful approaches (Fujiki et al., 2007).

This fits with previous work by Young et al. (2006), who identified the need to maximise enjoyment and peer interaction within interventions. Children see these factors as reasons to be physically active (Allender, Cowburn, & Foster, 2006). Qualitative analyses revealed that not only was social support an essential aspect, but Mission Possible was fun and enjoyable. Specifically, playfulness and enjoyment have been found to be important for enhancing physical activity levels by stimulating positive emotional states to stimulate motivation (Blythe, Overbeeke, Monk, & Wright, 2005). Teachers felt that the children were not only motivated to participate in the intervention, but this also translated to academic motivation. However, conversely to the present study, research utilising a fish avatar whose growth, emotional state, and behaviour reflected the participants' recent physical activity levels found that rather than motivating enhanced physical activity, an unhappy avatar (i.e., sad or unhealthy) was related to discouraged app usage (Lin et al., 2006).

All children specified a desire to incorporate significant others. These results suggest that enhancing familial missions and how these could be incorporated into daily lifestyles should be the focus of future interventions. Previous research (Mackintosh et al., 2011) has suggested that inexpensive and fun activities accompanied with family members should be incorporated within children's physical activity in promoting interventions. However, congruent with Power et al. (2010) teachers believed that the school was an influential context to enhance children's physical activity levels' and the main intervention should remain focussed within the school environment. Qualitative data indicated that one of the key features of the intervention was structured around children's need to receive support from significant others, such as teachers and peers. This aligns with work by Portman (1995), who suggested that children need to receive support from teachers and parents in order to increase their perceptions of competence, self-efficacy, and enjoyment. Furthermore, peers as well as families have been shown to be major influences on children's physical activity participation (Evans, Wilson, Buck, Torbett, & Williams, 2006; Hesketh, Waters, Green, Salmon, & Williams, 2005). Familial influence (i.e., role modelling, social support, and sibling interaction) is considered to be more significant at weekends than at other periods of the week (King et al., 2011; McMinn, Griffin, Jones, & van Sluijs, 2013), and school-based interventions have shown to have relatively little impact. This consensus is in agreement with recent research stating that children are less active at weekends compared to weekdays when they are at school (Fairclough, Ridgers, & Welk, 2012). Parental concerns over child safety may also impact weekend physical activity through restrictions over children's local independent mobility (Carver, Timperio, Hesketh, & Crawford, 2010). Significant others, including a family-based component, may therefore be imperative to increasing children's physical activity levels, congruent with Mackintosh et al. (2011), despite the integration of visual real-time feedback. It has been previously advocated that such an approach could overcome potential conflicting messages between school and family-life (Mackintosh et al., 2011).

The ubiquitous nature of monitoring did not require children to enter any data, which has been shown to be a limitation in previous research (Slootmaker, Chin, Schuit, van Mechelen, & Koppes, 2009). Children were enabled to observe their progress on the ambient display without any additional effort. Specifically, focus groups revealed that the visual feedback allowed children to reflect on increasing their activity levels for each day of each mission in a playful way. As argued by Thaler and Sunstein (2009), behavioural feedback forms a part of the choice architecture which nudges behaviour. In the present study, the feedback from the ambient display can act as a nudge for the children to be more physically active than the previous day. Interestingly, 50% of children stated that their physical activity levels were motivated around the feedback rewards, though the intervention itself showed no significant increase in objectively assessed physical activity. Goal-setting is a key feature of technologies intended to promote physical activity (Consolvo et al., 2006). Formal goal-setting, training, and coaching are substituted in Mission Possible by users' engagement with the information on the ambient display in terms of how their team is performing and includes the performance of other teams. Children specifically emphasised that they enjoyed the interactive nature and coming back inside "to see if they had accomplished their mission" and "beaten their goal". As a result, rather than feeling that they were engaging in a formalised physical activity program, such as PE, children were allowed to respond to this information in whatever way they wish. This was evident from the children's views in the focus groups, with 90% of the children stating that it was different than performing in PE. It could be hypothesised that involving children in the development of Mission Possible provided them with a sense of autonomy, as conceptualised in Self-Determination Theory (Deci & Ryan, 1985), facilitating greater choice and variety of activity (Prusak, Treasure, Darst, & Pangrazi, 2004; Subramaniam & Silverman, 2007). However, it is noteworthy that the intervention was conducted over a short time-period; therefore, it is possible that the intervention was still associated with a novelty effect.

Teachers demonstrated a sound understanding of the health-related benefits of children's enhanced physical activity levels, although contrary to previous research (Fairclough et al., 2013), it may have been better harmonised with the curriculum better. However, it was advocated that the children significantly enhanced their interest and understanding of science, resulting in a subsequent project surrounding Mission Possible, which was cross-referenced to the curriculum. Furthermore, converse to previous research (Davison & Lawson, 2006; Zabinski, Saelens, Stein, Hayden-Wade, & Wilfley, 2003), children did not perceive weather as a barrier to physical activity participation, only teachers. Importantly, the present study overcame numerous previously cited barriers to physical activity, including lack of money and transportation (Hesketh et al., 2005; Power et al., 2010).

Although quantitative analyses revealed no significant intervention effect, it is encouraging that over a four-week duration children's BMI decreased and CRF increased, suggesting the potential health benefits of implementing the intervention over a longer duration. That said, high data attrition at post-intervention may have substantially impacted the study findings. It is also noteworthy that 80.0% of the children met the current physical activity guidelines, engaging in  $75.2 \pm 25.0$  minutes of MVPA. It is therefore suggested that there would be less scope for increasing physical activity levels in the present population. Whilst it could be argued that these children engaged in sufficient physical activity, previous research has suggested that children meeting government guidelines may remain at risk of associated health detriments (Andersen et al., 2006). Furthermore, baseline physical activity levels were not established until consent was obtained from the school to be involved in the intervention. It is hypothesized that the intervention may have had greater impact on less active children. That said, the teachers and children's feedback were that all children exposed to the intervention enjoyed participating in the missions, regardless of whether they previously enjoyed physically active pursuits. Consequently, the study underscores the value of games in encouraging children to enjoy engaging in physically active pursuits and indeed be motivated to increase them. It is therefore postulated that such an approach may foster long-term behavioural change.

A major strength of the study is the integration of highly-valued and ubiquitous technology within a physical activity intervention and school environment. It has been frequently reported that high engagement with screen-based media can negatively impact on children's physical activity levels, with the range of available sedentary behaviours potentially being more reinforcing than physical activity, even when physically activity alternatives are available (Epstein & Roemmich, 2001). Mission Possible allowed children to engage in such highly valued behaviours, demonstrating promise for enhancing physical activity levels. Furthermore, group interviews with children provided insights into their thoughts, beliefs and experiences towards physical activity, respecting the expert knowledge of the participant (Kesby, 2007). Although there may be a risk that the data were influenced by sampling bias, it is noteworthy that all children approached did consent to take part and were randomly selected. Moreover, building on qualitative techniques previously implemented to inform interventions, the use of an emerging analyses technique endorsed a comprehensive evaluation of the presented intervention. Specifically, pen profiles enabled a visual representation of both children's and teachers' perceptions of Mission Possible while remaining a quantitatively based analysis procedure. Thus, it is postulated that dominant participants have less impact on key emergent themes (Mackintosh et al., 2011).

The authors acknowledge, however, that there are several limitations inherent to the nature of a feasibility study. Firstly, the results cannot be generalised due to being conducted with 9-10 year old children attending one primary school. However, this age group was targeted because pre-adolescence has been identified as a high-risk period for obesity development (Wardle, Brodersen, Cole, Jarvis, & Boniface, 2006), and research shows that children's physical activity levels decline markedly with age during elementary school (Troost et al., 2002). In addition, the intervention procedures, such as the setting of targets and use of ambient display feedback, were deemed to more developmentally appropriate for older children with the cognitive abilities to comprehend and complete such tasks. In order to ascertain a more accurate interpretation of the intervention effect, the study would need to run for longer, integrate a larger sample size incorporating a comparison group, and encompass numerous schools from a variety of socio-economic backgrounds. Future research should also determine the effects of the intervention on children of differing weight status, such as obese and overweight, and integrate a substantial follow-up period to determine long-term benefits.

## **Conclusion**

This study provides insight into the utilisation of novel ubiquitous social goal-sharing technology to provide real-time feedback on children's physical activity levels. Although results suggested that the integration of such technology within a school environment was well received by teachers and pupils, future research is warranted to ascertain the feasibility as a low-cost intervention to promote children's physical activity levels, as well as their understanding of government recommendations. Nonetheless, these findings may inform the development and implementation of a physical activity intervention incorporating ubiquitous technology.

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