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Exploring the use of gamification for encouraging physical activity in adolescents: A qualitative longitudinal study

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ABSTRACT

Objective: To explore the temporal changes of adolescents' views and experiences of participating in a gamified intervention to encourage physical activity behaviour, and associated processes of behaviour change.

Design: Longitudinal qualitative design. Focus groups were conducted with the same participants in each intervention school (n=3) at four time-points (baseline, end of each of two intervention phases and 1 year follow-up). The Framework method was used to thematically analyse the data.

Setting: Secondary schools (n=3), Belfast (Northern Ireland).

Participants: A sub-sample (n=19 at 4 time-points) of 12-14 year olds who participated in the StepSmart Challenge, a gamified intervention involving a pedometer competition and material rewards to encourage physical activity behaviour change.

Results: Three core themes were identified: 1) Competition; 2) Incentives and 3) Influence of friends. Participants indicated that a pedometer competition may help initiate physical activity, but suggested that there were a number of barriers such as participants finding it *"boring",* and feeling as though they had a remote chance of *"winning"*. ''Incentives" were viewed favourably, although there were participants who found not winning a prize *"annoying"*. Friends were a motivator to be more physically active, particularly for girls who felt encouraged to walk more when with a friend.

Conclusions: The intervention in general and specific gamified elements were generally viewed positively and deemed acceptable. Results suggest that gamification may have an important role to play in encouraging adolescents to engage in physical activity, and in creating interventions that are fun and enjoyable. The findings also suggest that gamified Behaviour Change Techniques align well with core concepts of Self-determination Theory, and that various game-elements may require tailoring for specific populations, for example, different genders.

Trial Registration Number: NCT02455986

Strengths and limitations

- A major strength of this study was the novel use of a longitudinal design, using the same participants in repeated focus groups. This enabled the investigation of how participants' views, experiences and PA behaviour evolved over time.

- In addition, having a number of researchers involved in the data collection and analyses reduces selectivity and researcher bias.
- However, only three focus groups participated in the study, and all were single sex schools.

BACKGROUND

Physical activity (PA) levels in children and adolescents around the world are low. [1] As patterns of PA are established during this time and tend to track into adulthood, [2 3] this is a crucial period which can affect lifelong health and habits. To date, PA programmes for this population have shown limited effect, [4 5] stressing the need for innovative approaches to initiate and maintain PA behaviour. [6]

Programmes such as Pokémon GO illustrates the potential of gamified interventions (i.e. the application of elements of game playing, such as scoring points, competing against others, to change behaviour) for encouraging PA behaviour [7] and can provide useful insights into how to reach and engage the most inactive in PA behaviour. [8] Elements of gamification are incorporated into many commercial PA promotion apps, such as Pokémon GO, Fitocracy and 'Zombies, Run!', which include the collection of points for undertaking a targeted behaviour, completing challenges, or competing against others in virtual games. [9] Interventions that have applied gamification elements suggest it could be possible to make a routine activity such as travelling to school into a game that promotes active travel modes, and that is engaging and fun.[10 11]

Some key gamification strategies, including feedback on players' performance to allow them to set goals and monitor progression, competing with others, and use of incentives, are all evidence-based Behaviour Change Techniques (BCTs).[12] Further, research has demonstrated that other core aspects of gamified interventions such as opportunities for socialisation, self-evaluation, and rewarding positive behaviour are key to providing an enjoyable experience [13 14] and enjoyment has been identified as a significant predictor of PA behaviour.[15] However, gamification interventions have rarely been grounded in well-established theoretical frameworks and we know little about the views and experiences of participants.

The aim of this study was to explore the views and experiences of adolescents who participated in a gamified PA intervention based on Self-determination Theory, and the temporal changes of these views and experiences over the 1-year study period. The temporal analyses also enabled the investigation of potential behaviour change processes.

METHODS

Context

The StepSmart Challenge was a 24-week primarily school-based intervention utilising team, and individual competitions in five schools in Belfast, Northern Ireland. The school recruitment process is detailed elsewhere (Best et al; under review). An independent trial statistician randomly allocated the five schools to the intervention (three schools) or control (two schools) group. School characteristics are shown in Table 1; two were all-boys schools, two all-girls schools, and one was a co-educational school. All intervention schools were single sex (boys (n=1), girls (n=2)). Students (n=224) from Year 9 classes (aged 12-14 years) were invited to participate in the trial. The main results from the feasibility trial are published elsewhere (Best et al; under review). Briefly, the results demonstrated that the StepSmart Challenge was acceptable to young people for encouraging PA, and there was a trend in increasing light-intensity PA and improving mental wellbeing.

The StepSmart Challenge

The StepSmart Challenge was a gamified intervention designed according to Self-determination Theory (SDT),[16] using distinct intervention phases aiming to move participants along the motivation continuum from extrinsic motivation towards intrinsic motivation and encouraging PA behaviour change. The theory is grounded in three psychological needs – autonomy, competence, and relatedness. [16] Those intrinsically motivated engage in PA for the enjoyment and satisfaction it provides. [17] This form of motivation is associated with improved quality of life, increased PA behaviour, [18] and long-term behaviour change. [19] Self-motivation is undermined when individuals feel less control over the activity, and the environment, and if they do not feel a sense of connectedness or belonging to others engaging in the same activity. [20]

Table 2 details the various intervention components and links to BCTs. The intervention consisted of two phases. Phase One involved a multi-level (competition at the school, team and individual level) pedometer competition lasting for 8-weeks. Team selection was determined by the research team and took account of current PA levels and friendship networks measured at baseline; this was to ensure a mixed ability team (4-5 participants per team) with at least one friend in the team. The team competition comprised of social incentives such as publication of the results on the website, a trophy awarded to the leading team (i.e. the team with the highest number of total steps) in each school at competition end, and a prize to the winning school (£1000). During the individual competition in Phase One, incentives (approximate value of £10 – see Table 2 for details) were awarded weekly in

each school to two participants (participant who accumulated the most steps that week ('Walker of the Week'); and the participant who increased his/her step count the most from the previous week ('Most Improved')). Phase Two (14 weeks) focused on an individual level competition, in which the three participants that had accumulated the most steps in each school during this phase were awarded a 'goody bag' (approximate value of £30 for each participant and consisted of an assortment of those used in Phase One).

Qualitative longitudinal research

To elicit the temporal views and experiences of participants in the StepSmart Challenge a qualitative longitudinal research (QLR) design was used involving repeated semi-structured focus groups with the same participants over four data collection periods. This enabled qualitative charting of the perceived behaviour change process over a one-year period, and the opportunity to further understand potential mechanisms of behaviour change, and how perceptions and experiences of the intervention changed over time (pre, during and post-intervention). [21] Understanding why certain choices were made can produce more insightful and considered interpretation of behaviour change. [22] Such approaches are particularly valuable in providing a different perspective in assessing interventions or as part of process evaluations. [23]

Focus group participants

Baseline focus groups were conducted in each intervention school with a sub-sample of trial participants using a purposive sampling strategy whereby teachers identified potential participants with a range of PA levels from low to high to ensure data saturation. Those interested in taking part were given a study information sheet explaining the purpose of the focus groups, to read themselves and then give to their parent(s)/guardian(s). Parental (or guardian) opt-out consent and participant consent was sought from all participants. [24] Ethical approval was granted by the School of Medicine, Dentistry and Biomedical Science Research Ethics Committee (Queen's University, Belfast) (Ref: 15.09).

The focus groups were repeated during the study, following the same participants on their journey through the trial. This provided rich contextual data to explore the views and experiences of participants over time. Data were collected one-month pre-intervention (T0); at the end of the team competition (8 weeks) (T1); end of the individual competition (post-intervention) (24 weeks) (T2); and at 12-month follow-up (T3). Focus groups were conducted

on school premises and were audio recorded. The researchers verbally reaffirmed consent to participate at the beginning of each focus group. No other participants were present at the time of the focus groups.

Focus groups were semi-structured, based on topic guides (see Supplementary Material I) exploring core concepts at each time point. The topic guide was not piloted but developed iteratively reflecting on the data gathered from the focus groups from previous time points. Thus, emerging themes were explored across time points to chart changing views, experiences and PA behaviour. During all focus groups, the researcher summarised information at the end of each section and questioned understanding as a form of participant verification. [25]

Core concepts explored included:

1. General views and experiences of the intervention and intervention components;
2. Motivation to be active and to maintain being active long-term;
3. Extrinsic motivators including a) competition e.g. Does the competition motivate you to walk?; b) Material incentives e.g. Was the opportunity to win a prize something that motivated you?; c) Motivation for PA e.g. What motivates you to be active?;
4. SDT concepts including a) Autonomy e.g. What new ways have you found to be active?; b) Perceived competence e.g. How did it make you feel when you compared your steps to those of the class?; c) Relatedness e.g. Do you think friends are important in terms of how active you are?

Focus groups were conducted by RC (Male, PhD student), PB (Male, Post-doctoral Researcher) and RO'N (Female, Post-doctoral Researcher). PB and RO'N are experienced qualitative researchers and have facilitated focus groups with adolescents previously. RC had undergone a number of formal training courses in the facilitation of focus groups and thematic analysis methods. RC was accompanied to the focus groups by either RO'N or PB. No field notes were made during the focus groups. Saturation of the data was discussed between PB and RC. None of the researchers had any relationship with the participants.

Data analysis

Focus group recordings were transcribed verbatim and anonymised. Data were imported into NVivo (Version 10, QSR, Southport, UK) to manage and analyse the transcripts. Analysis

was undertaken using the Thematic Analysis Framework at the semantic level. [26] Initially researchers (RC and PB) familiarised themselves with the data. A sample coding frame was developed by the researchers independently, and refined iteratively with subsequent discussions. As a result, three coding frameworks were generated, one for each core theme. Illustrative quotes supporting emerging themes were highlighted and agreed by researchers. Transcripts were not returned to participants for comment, and they did not provided feedback on findings.

The dataset was systematically coded using an inductive approach and codes were generated to give a summary of elements of analytic interest. Once coded researchers identified potential themes from clusters of codes of similar meaning as well as patterns of responses across codes. Three central themes were identified at T0 and developed at subsequent time points. The coding frame was then discussed with ME and further refined. RC and ME then met multiple times to discuss and refine codes until a final coding frame was applied to all data. These themes consisted of (1) incentives; (2) competition; (3) influence of friends on PA. The temporal changes in the views and experiences of participants, and the influence of these components on the process of behaviour change were explored under each theme. Researchers (RC and ME) analysed the data together to further refine sub-themes to ensure assertions were accurately reflected.

RESULTS

Table 3 details the characteristics of participants in the focus groups, and demonstrates that the purposive sampling strategy was successful in recruiting participants of mixed gender, SES, from different teams, those who won prizes and those who didn't win, and PA levels. Table 3 displays a breakdown of the focus groups conducted. Twelve focus groups were conducted (mean duration 33 minutes; range 21–41 minutes). Focus group participants present at each time point varied due to participant absences (mean 6 participants; range 2–7 participants). No participants refused to participate or dropped out.

The following section details the themes and sub-themes identified from the thematic analysis.

Theme 1: Competition

Three sub-themes were identified including: a) usefulness of competition for PA behaviour change; b) self-competition for PA behaviour change; c) experiences of the team and individual competition.

Sub-theme A: Usefulness of competition for PA behaviour change

At T0, participants suggested the competition would motivate them to work harder and it was generally viewed as a motivating factor to become more physically active:

> *"that's what motivates me"* (School C, Male 5, T0).
> *"that's what pushes people on"* (School C, Male 6, T0).
> *"if I was actually in a competition I'd actually walk everywhere"* (School D, Female 6, T0).

Throughout the intervention, there appeared a sub-sample of participants in all schools who were motivated by more than just the desire to compete; the goal of winning was paramount:

> *"we like the winning but we don't like the losing"* (School E, Female 3, T0).
> *"to try and win like every week after that"* (School C, Male 6, T3).
> *"yeah, because you just wanted to win"* (School D, Female 6, T3).

For some participants, the competition was viewed as encouraging at the start but over time it became monotonous or 'boring':

> *"I think that's boring you know, who would want to know how many steps you're taking?"* (School D, Female 2, T2).
> *"at the start like, like you were quite motivated and then it just got more on and then you just forgot to wear it some days and it just got quite boring"* (School C, Male 4, T3).
> *"It was just like the same thing every day"* (School C, Male 4, T3).

Participants in School D (all girls) perceived their chances of winning the competition as remote, which suggests a lack of confidence in their capability in the competition.

> *"whenever you found out that you're actually losing there's just no point"* (School D, Female 2, T1).
> *"it's just sort of cause you knew you probably weren't going to win so you're just like there's really no point in wearing it [pedometer]"* (School D, Female 6, T2).
> *"well I just really gave up whenever X just won everything. I really did. I just stopped"* (School D, Female 3, T3).

Sub-theme B: Perceptions of the usefulness of self-competition for PA behaviour change

The potential use of the pedometer for self-directed goals, or 'self-competition' (competing against oneself) was considered promising at T0:

> *"if its showing you how many steps you're taking then you could challenge yourself to take more every day. So if you took 2000 steps one day you could try like try take more the next day. So it's like challenging yourself"* (School D, Female 1, T0).

Self-competition was shown to be a motivating factor throughout the intervention for most participants. One participant (School D) viewed 'getting better' and improving step counts as meaningful, reducing the negative effect of not winning prizes.

> *"trying to beat your day before target"* (School C, Male 5, T1).
> *"I loved to see like how many steps you were actually taking like when you're beating your scores as well like you check it one day and then the next day your gonna try and beat it"* (School E, Female 1, T2).
> *"No, it's alright because I was getting more each day so I was getting better; so it was alright"* (School D, Female 6, T3).

Sub-theme C: Experiences of the team and individual competition

The intervention incorporated two formats of a pedometer competition: a team-based competition (8 weeks duration), and an individual competition (14 weeks duration). During

the individual competition, participants competed against others from their school. At T0 the team-based competitions were seen to have the potential to better encourage PA:

> *"you can work together as a team"* (School D, Female 4, T0).
> *"if you were in like a group with more active people like you'd be sad that you're not as good as them but it would kind of push you to be as good as them"* (School E, Female 7, T0).

When asked to compare the individual with the team-based competition at T2, many participants from School C (all male) were more motivated by the team-based competition. This was due to the support provided by the team or peer pressure from not wanting to let *"your team down*":

> *"I'd probably say it's easier with the support rather than individually"* (School C, Male 6, T2).
> *"you didn't want to let your team down"* (School C, Male 6, T2).

Reflecting on the intervention at T3, there were clear differences regarding experiences of the competition. School C (all boys) participants continued to feel positive about the team competition.

> *"the team's a lot better. Like its more… you are just like together"* (School C, Male 1, T3).
> *"The individual is quite boring"* (School C, Male 4, T3).

The girls' schools (School D and E) tended to favour the individual competition, as they did not have to rely on their team members, or for logistical reasons, such as the inability to meet up and 'organise stuff'.

> *"you don't have to depend on anyone else"* (School D, Female 3, T3).
> *"you know like sometimes you don't live close to your friends so you can't always organise stuff, which is a problem. So I think the individual one"* (School E; Female 7, T3).

One disadvantage of the team competition was the issue of free-riding team members (i.e. a member of a team that obtains benefits from membership but is not seen to contribute a fair share of the work needed to accrue the benefit). [27] In School D (all girls), free-riding was evident.

> *"well in the group you didn't really have to do anything cause the rest of them could do it but like by yourself like I don't know you just lose it altogether cause you don't walk"* (School D, Female 2, T2).
>
> *"we didn't really have to worry about it cause like the rest of them would've like walked anyway"* (School D, Female 2, T2).

Theme 2: Incentives

Two sub-themes were identified including a) type of incentive; and, b) perceptions of usefulness on incentives.

Sub-theme A: Type of Incentive

The provision of material incentives in this study was contingent on doing well in the competition, rather than being contingent on PA behaviour change. The types of incentives suggested and discussed by participants included recognition-based incentives (e.g. trophies) and material incentives (e.g. vouchers). Males tended to favour recognition based incentives, whereas material incentives with a higher monetary value were largely proposed by females. When asked what type of prizes they would like, male participants suggested:

> *"a medal or a trophy"* (School C, Male 5, T0).
>
> *"rugby ball"* (School C, Male 4, T0).

In contrast, females often suggested the use of material incentives.

> *"vouchers for clothes"* (School D, Female 6, T0).
>
> *"Topshop"* (School D, Female 1, T0).
>
> *"money"* (School E, Female 7, T0).

Sub-theme B: Perceptions of usefulness of incentives

At T1 and T2 many participants viewed incentives favourably. Participants suggested that the incentives were desirable and encouraged them more during the intervention.

> *"Every week cos you know it's like running out of time for like the prizes, just really want to get one"* (School C, Male 6, T1).
>
> *"that they weren't just like wee rubbish prizes they were really good ones"* (School E, Female 4, T2).

At T3, when reflecting on the intervention, participants still viewed the incentives as a motivating factor as they were 'good' prizes and provided acknowledgement for achievement:

> *"yeah, they look good. Like the prizes were really good"* (School C, Male 4, T3).
>
> *"yeah, I think [it] was good actually. Just to keep people motivated* (School E, Female 7, T3).
>
> *"like you know you are being acknowledged, like when you get prizes"* (School E, Female 3, T3).

Some participants did not win any prizes over the course of the intervention. When these participants discussed the instances when their peers won prizes there was a clear sense of disappointment, with a number stating that it was *"annoying":*

> *"kinda annoyed you when people like brought out their ten pound of cinema tickets and yeah it's like kinda annoying"* (School C, Male 3, T2).
>
> *"like it annoyed me that I didn't get one"* (School E, Female 6, T2).
>
> *"It just made me sad"* (School E; Female 2, T2).

Theme 3: Influence of friends

Two sub-themes emerged, including: a) the role of friends in general for encouraging PA behaviour, and b) the role of friends in team competition.

Sub-theme A: Role of friends in general for encouraging PA behaviour

At T0, participants suggested that PA was more enjoyable with friends, and the social support provided by friends encouraged participation in PA:

> *"it's about encouraging each other to do stuff"* (School C, Male 5, T0).
> *"if they want to go for a run you will want to go for a run with them"* (School C, Male 4, T0).
> *"Yeah, because you want to be doing it with them so you can enjoy yourself"* (School C, Male 6, T3)
> *"Good friends will help you yeah"* (School D, Female 6, T0).
> *"X only lives up the street so we go for runs most days after school"* (School E, Female 3, T0).

Participants in School E discussed the continued positive influence of friends on PA motivation at T1 and T2. Feeling 'scundered' (colloquialism for embarrassed) when walking alone is offset when provided the social support of friends:

> *"Make you feel like I'm going to be scundered [embarrassed] walking about alone but when you have your friend with you like you'd be more encouraged to do more walking if you're like walking with your friend"* (School E, Female 2, T2).
> *"hardly just like go a walk about yourself about the street like a big loner"* (School E, Female 4, T2).

Sub-theme B: Role of friends in team competition

Participants suggested that the influence of friends and a sense of connectedness was necessary within teams in order for them to work together and be competitive. Although, some participants in School C felt it would be *"good to have at least one friend or two"* (School C, Male 6, T3), they did not want to pick their own teams as they believed this might produce unbalanced teams with the more physically active individuals going into the same team. For these participants, the combination of friends within a team and homogeneity between teams was important:

> *"No cause then they could get really unfair"* (School C, Male 1, T2).

"Cause all the active people could go in one team and then the inactive so it wouldn't work out" (School C, Male 1, T2).

In contrast, participants in Schools D and E wanted the opportunity to choose team members; preferring to be in teams composed of their friends:

"I wanted to choose my own team" (School D, Female 4, T1)

"no I think it should just be like your own group like friends like five of each of them" (School E, Female 3, T1).

"because like [if] you don't like people in your team you're just going to be like 'nah not even going to talk to you'" (School E, Female 6, T2).

DISCUSSION

Participant's generally had positive experiences and views of a gamified PA intervention. Results suggested that the gamified design may have an important role to play in encouraging adolescents to engage in PA, and in creating interventions that are fun and enjoyable. The findings also suggested that core concepts of SDT are compatible with gamified BCTs, and that some game-elements may require tailoring for specific populations, for example, different genders.

In general, the use of a gamified pedometer competition was viewed favourably by participants. However, the goal of winning was very important for some and was key to sustaining their motivation to be active. This could be linked to the provision of material incentives which was contingent on 'winning' the competition. Over the course of the intervention, material incentives continued to motivate some participants, suggesting that intrinsic motivation and autonomy were not undermined. A possible mechanism could be that positive feedback provided by winning prizes and doing well in the competition, helped develop an individual's intrinsic motivation by improving feelings of competence. [28] The positive effect of material incentives for health behaviour change with children and adolescents has also been shown in previous studies. [29-32] and Corepal et al (under review).

The long-term effect is less clear with some studies showing that positive effects dissipates over time. [33] This could be due to habitation to the extrinsic motivators being offered [34] or a

'crowding out effect' of intrinsic motivation [35] once extrinsic incentives are removed. However, to date this hypothesis has not been tested or supported in 'real world' interventions. [28 36-38]

Other participants suggested feeling de-motivated from the outset as they felt they had no chance of winning. Some became less enthusiastic about the competition if other participants consistently had a greater number of steps, and were disappointed at not winning a prize. Previous work has suggested that competition can affect participants' self-evaluation of their competence to perform the task. [39 40] If a participant loses, and their loss is attributed to low ability, this can negatively impact behaviour. [41] Therefore, as a preventative measure, participants may choose not to compete, or not engage in the competition with maximum effort. [42] This helps to provide some explanation for the loss, other than low ability, and thus preserving the participant's self-esteem and self-efficacy.

Some participants indicated that they became gradually less interested because of the repetitive nature of the pedometer competition. These findings are supported by a large body of literature which suggests that extrinsic motivators can have a short-term positive effect on motivation which is not maintained. [33 36 37 43] Extrinsic motivators such as competition and material incentives could be used to initially stimulate the interest of participants, especially those with lower levels of PA. [44] However, a key learning point would be to transition to more intrinsically motivating forms of PA and thus the incorporation of BCTs that focus on these behaviours would be useful. [45 46]

The competition had various levels: rewards could be offered to the highest achieving team, the highest achieving individual, or to anyone on the basis of achieving some personal goals (self incentive). The findings showed distinct perceptions regarding the value of each. For example, males tended to prefer the team competition and suggested they would try harder to contribute to the team, and found the team environment supportive and enjoyable. Maculada [47] suggested that males find team affiliation important, and a way to be accepted by peers and to feel a sense of belonging with the group. Team-based PA interventions have been shown to be effective, [10 11] and may be less harmful than individual competitions. [48] Conversely, females favoured individual competition; how well a participant did in the competition was not dependent on the effort of others, mitigating to the problem of free-riding. [49] One solution may be to distribute incentives equitably (ie proportionate to effort

and contribution) to team members rather than distributing them equally, [50] thereby reducing free-riding and increasing effort. [51 52]

Self-competition [53] was seen as a prominent positive influence of PA. Participants often used the pedometers for feedback, to self-monitor, and set personal step goals. Creating achievable personal goals may also play a part in mitigating the potential negative effects of extrinsic motivators by emphasising competence (by meeting goals and receiving positive feedback), autonomy (as participants are free to choose which activities they pursue to increase step counts), and maintaining self-efficacy. Self-competition with the use of intrinsic goals was enjoyed by all participants in the focus groups, regardless of success in the overall competition. Self-competition allowed participants to be autonomous, and to create achievable challenges such as walking more steps than during the previous day. Therefore, self-competition could be a way to develop autonomous identified or integrated regulation, which has been shown to have benefits for PA motivation. [54 55] Autonomy-supportive elements such as self-competition could consequently stimulate the development of habit formation. [56]

The significance of friends for influencing PA behaviour has also been frequently cited in the literature. [57-59] The participants' feelings on team composition and the influence of friends reinforce the physiological need for relatedness, a core construct of SDT. Participants from all schools felt that a sense of connectedness to the group was important for an effective team competition. Other research shows that adolescents value opportunities for social interaction, [39] and so team membership could have a positive effect on PA motivation. Participants stated that friends provide support, encouragement, and help with the enjoyment of PA.

Strengths and limitations

A major strength of this study was the novel use of a longitudinal design, [21 60] using the same participants in repeated focus groups at baseline, post-intervention and 1-year follow-up. This enabled the investigation of how participants' views, experiences and PA behaviour evolved over time. The findings are robust as assumptions, views and experiences can be tested and re-tested in subsequent sessions, and researchers build relationships with participants due to the repeated exposure which can encourage disclosure. In addition,

having a number of researchers involved in the data collection and analyses reduces selectivity and researcher bias.

Focus groups were chosen as an appropriate approach as they provide opportunity for the group to discuss issues amongst themselves and reach consensus, gathering multiple viewpoints and representing 'everyday' conversation. However, they have been criticised for lacking depth, particularly when conducted with young people as they tend not to elaborate on points. It may also have been useful to combine this approach with 1:1 interviews to reduce peer pressure and ensure coherency of responses at different schools. Finally, only three focus groups participated in the study, and all were single sex schools. Consequently the purported gender differences may be an artefact of differences in socio-economic status as well as or in addition to gender differences.

Conclusions

Preferences for gamified elements including team or individual competitions, and the influence of friends on PA behaviour were highlighted. The use of a longitudinal qualitative design enabled exploration of temporal changes in participants' views and experiences, and exploration of potential mechanisms of behaviour change. This study suggests that the three core constructs for self-motivation in SDT could be important factors for motivating PA in adolescents via competition and the use of material rewards delivered through gamification. This supports previous research which proposes benefits in providing opportunities for autonomy, perceived competence, and relatedness. [61]

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Table 1: Characteristics of schools included in the StepSmart Challenge feasibility study

	Intervention or Control Group	Single Sex or Co-educational	Free school meal entitlement (%)
School A	Control	All Male	63.7%
School B	Control	Co-Educational	7.2%
School C	Intervention	All Male	8.0%
School D	Intervention	All Female	56.5%
School E	Intervention	All Female	54.6%

Table 2: Intervention Components and Behaviour Change Techniques (BCTs)

Component	Activity/Task	Behavioural Change Technique
Competition	Competition was designed to take place across three levels during Phase one (April – June 2015). 1. School level - £1000 prize for winning school 2. Team level – trophy for the winning team in each school 3. Individual level – weekly prizes for highest steps and most improved within each school During Phase two (July – Sept 2015) there were individual prizes for the top three participants in each school achieving the highest average number of steps across the 14-week period. This two-phased tapered approach was designed to encourage med-long term PA behaviour change (i.e. extrinsic to intrinsically motivated PA behaviour)	-Set graded tasks -Provide rewards contingent on successful behaviour -Provide feedback on performance
Material Rewards/Prizes	Material rewards included coloured stickers, selfie sticks, completion certificates, cinema tickets and £10 sports vouchers. Individual prizes were awarded on a weekly basis under two categories, 'outstanding performance' and 'most improved'.	-Prompt rewards contingent on effort or progress towards behaviour
Teams	A team based competition was developed alongside the main school competition to encourage peer support. Ten teams were created within each school (4-5 participants per team). Team captains were selected based on baseline PA data to ensure balance between teams and peer nominations to identify those 'most looked up to'. The highest placed team within each school at the end of Phase One was awarded with a trophy.	-Plan social support/ social change -Facilitate social comparison -Prompt identification as role model/ position advocate
Pedometers	Participants were given a Fitbit Zip pedometer and asked to wear throughout every day of the intervention (Phase One	-Goal setting (outcome) -Prompt self-monitoring of behavioural outcome

	and Two). Pedometers provided participants with feedback on daily steps and were uploaded to the study website via the Fitbit App or using a wireless dongle located at designated areas within schools.	-Provide feedback on performance
Website	Pedometer data was uploaded to the StepSmart Challenge website and participants could review their daily/weekly scores and view the competition leader board. The website included the provision of motivational messages, weekly challenges and links to other PA resources	-Goal setting (outcome) -Prompt self-monitoring of behavioural outcome -Provide feedback on performance
Workbook	A short workbook was given to participants at the start of the intervention. This included 'fun-facts', tips and challenges to promote PA behaviour as well as a section for the participant to record weekly step target (individual and team).	-Provide information on consequences of behaviour in general -Goal setting (outcome) -Prompting generalization of a target behaviour

Table 3: Characteristics of focus group participants

			Average steps per day (measured using accelerometers)		
Participant		**Team**	**Baseline**	**Post-intervention**	**12 Month Follow Up**
1	**School C**	C10	9,949	8,576	No valid data
2	**School C**	C6	No valid data	No valid data	No valid data
3	**School C**	C6	8,815	13,127	No valid data
4	**School C**	C7	9,325	4,099	4,099
5 Winner of 'Most Improved'	**School C**	C1	9,264	6,687	14,246
6 Winner of 'Walker of the Week' Winner of Summer Competition	**School C**	C5	13,326	9,563	8,039
1 Winner of 'Walker of the Week' Winner of Summer Competition	**School D**	D2	10,940	10,684	11,784
2	**School D**	D9	2,787	No valid data	No valid data
3 Winner of 'Most Improved'	**School D**	D6	9,737	7,160	7,160
4	**School D**	D5	6,555	No valid data	4,088
5	**School D**	D5	2,782	No valid data	5,426
6 Winner of 'Most Improved'	**School D**	D7	9,253	No valid data	No valid data
1	**School E**	E7	6,495	13,080	6,129
2	**School E**	E7	7,330	No valid data	9,440
3	**School E**	E2	6,583	No valid data	No valid data
4	**School E**	E9	5,915	No valid data	No valid data
5 Winner of 'Walker of the Week' Winner of Summer Competition	**School E**	E6	14,153	13,998	8,179
6 Winner of 'Most Improved'	**School E**	E3	14,113	No valid data	9,988
7 Winner of 'Walker of the Week' Winner of Summer Competition	**School E**	E3	11,330	No valid data	5,909

* No valid data = Unreturned accelerometer or no valid three-day measurement of data

Table 4: Overview of the number of participants in (and duration of) each focus group at each time point

	Time points of each focus group			
Intervention schools	*Baseline (T0)*	*8 weeks (T1)*	*24 weeks (T2)*	*52 weeks (T3)*
School C (All Boys)	6 (35 mins)	6 (21 mins)	5 (38 mins)	5 (35 mins)
School D (All Girls)	6 (34 mins)	5 (37 mins)	6 (40 mins)	2 (31 mins)
School E (All Girls)	7 (36 mins)	7 (41 mins)	6 (24 mins)	7 (24 mins)

Supplementary Material I: Topic Guide

Topic Guide			
Pre-intervention	**End of phase one (External regulation; Introjected regulation)**	**End of phase two (Introjected regulation; Identified regulation)**	**12 months post-baseline follow up (Integrated motivation)**
Explore the barriers and facilitators to PA What stops you from being physically active? (Relational support) Role of parents/friends in your PA? (Autonomy support; Relational support) Any ideas to increase PA? (Autonomy support) Opportunities for PA within school/community? (Autonomy support; Relational support)	**Explore the experiences of StepSmart** How easy is it to find ways in which to be more active? (Autonomy support) Did completing the StepSmart Challenge with friends make it easier? Or more pressure? (Autonomy support; Relational support) Do you enjoy telling people about your success in terms of PA (e.g. showing others your steps)? (Perceived competence; Relatedness)	**Explore the how participants felt about the different competition elements** How did the team competition compare to the individual competition? (Relational support) Some of the class were more/less active than you. How did you feel when you compared your steps to the class? (Perceived competence) Did team members encourage you to be active or not? (Autonomy support) How did you feel if you didn't contribute to the team/school's step count? (Perceived competence)	**Explore if there has been a change in PA (formation of habit)** One year on: how active are you now (compared to before you took part)? Did you make changes to your PA? Why/why not? *(changes to routine ... active travel, walking with friends etc.)* If you did make any changes, which are you still doing? What strategies helped? (Autonomy support)
Explore the acceptability of the intervention components Have you ever heard of…or used a pedometer? What is it you (dis)like about them? Feelings on writing down your own daily steps goals in a workbook.	**Explore the attitude towards PA** Do you enjoy PA? What are your main reasons for being active? (i.e. role of the prizes and other elements?) Do you enjoy finding new	**Explore how the StepSmart Challenge instigated any changes in participants PA** How do you feel about PA since the StepSmart Challenge? What have you enjoyed? Has the StepSmart Challenge increased your PA? If not, what would motivate you	**Explore how participants felt about the StepSmart Challenge** Why did you choose to participate? Good/not so good aspects of the competition? Did the competition motivate – no/at beginning/all throughout?

(Perceived competence; Autonomy support) What features of a website would you find appealing? How do you feel about entering a school-based competition? Any advantages/disadvantages to team vs individual competitions What prizes would motivate young people to take part?	ways of becoming more active? (Autonomy support) Do you think your motivation towards PA has changed?	to be more active? Since the StepSmart Challenge, what new opportunities have you found to be active? (Autonomy support) Anything outside your control stopping you from being active? (e.g. park proximity, family, other) (Autonomy support; Relational support)	
	To explore the consequences of PA Do you find yourself having more energy? Do you feel more confident in being able to achieve things? (Perceived competence) How do you feel after you've completed some PA? Do you think you are more active now than when you started? Why?	**Explore how participants felt about the use of the pedometer** How often did you use the pedometer? What did you like/dislike about it? (e.g. Feedback) (Perceived competence; Autonomy support) How many of you are still using the pedometer? Why?	**Explore how participants felt about the team/individual competition** Class vs school, was one enjoyed more? (Autonomy support; Relational support) Influence of friends on being active? (Autonomy support; Relational support) Opportunity to make new friends? (Relational support) Feelings about not contributing to the team/school step count? (Perceived competence) More motivated if friends wanted to do well in the competition? (Relational support)

		Explore how participants felt about the rewards/prizes What did you think of the prizes? Tell me how well they worked to motivate you? How did you feel if you didn't win a prize? (Perceived competence) If no prizes, but still a competition, would you still be as active? Why?	**Explore how participants felt about the rewards/prizes** Type of prizes preferred, including ttrophy or a certificate? Not competing against others, but beating your own goal? (Autonomy support; Perceived competence)
		Explore how the website and Facebook group were used Things you liked/didn't like about the website? What did you think of Facebook group? (Autonomy support; Relational support) Which way would you prefer to get your information from? (Autonomy support)	**Mood/motivation did these change at different stages of the intervention?** Feelings if didn't make as many steps as others? Did that affect your mood? (Perceived competence; Relational support) If you did/didn't do well - did that motivate/demotivate you? (Perceived competence; Relational support) If felt like don't have a good chance to win would that make you stop trying? (Perceived competence; Relational support)

Red text illustrates how items in the topic guide are linked the concepts of self-determination theory

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

Developed from:
Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

No. Item	Guide questions/description
Domain 1: Research team and reflexivity	
Personal Characteristics	
1. Inter viewer/facilitator	Which author/s conducted the interview or focus group? **PB, RO'N, RC**
2. Credentials	What were the researcher's credentials? E.g. PhD, MD **PhD (PB), PhD (RO'N), MPH (RC)**
3. Occupation	What was their occupation at the time of the study? **PB: Research Fellow, UKCRC Centre of Excellence for Public Health/Centre for Public Health** **RO: Research Fellow, UKCRC Centre of Excellence for Public Health/Centre for Public Health** **RC: PhD Student**
4. Gender	Was the researcher male or female? **Male (PB), Female (RO'N), Male (RC)**
5. Experience and training	What experience or training did the researcher have? **PB: Qualified social worker, training in thematic analysis, Computer Assisted Qualitative Data Analysis (CAQDAS) packages** **RO'N: Experience in the design, conduct and analysis of a photo elicitation and focus group based qualitative research. Training in focus group facilitation and the NVivo** **RC: MPH with a focus on health services research comprising training on qualitative research methods. Formal training in NVivo during PhD**
Relationship with participants	None
6. Relationship established	Was a relationship established prior to study commencement? **No**
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research **PB recruited interviewees to the study**
8. Interviewer characteristics	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic **None**
Domain 2: study design	

Theoretical framework	
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis **Underpinned by Self-determination theory. Framework Method was used for qualitative data analysis**
Participant selection	
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball **Purposive sampling used for participant focus groups**
11. Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email **Face-to-face**
12. Sample size	How many participants were in the study? 19 participants **School C (n = 6); School D (n = 6); School E (n = 7)**
13. Non-participation	How many people refused to participate or dropped out? Reasons? **None**
Setting	
14. Setting of data collection	Where was the data collected? e.g. home, clinic, workplace **Data was collected in each intervention school (n = 3)**
15. Presence of non-participants	Was anyone else present besides the participants and researchers? **No**
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date **Year 9 classes from 3 schools over 2015-2016** **School C: All male aged between 12 to 14 years** **School D: All female aged between 12 to 14 years** **School E: All female aged between 12 to 14 years**
Data collection	
17. Interview guide	Were questions, prompts, guides provided by the authors? **Yes** Was it pilot tested? **No**
18. Repeat interviews	Were repeat interviews carried out? If yes, how many? **Four were carried out in total**
19. Audio/visual recording	Did the research use audio or visual recording to collect the data? **Audio recordings were made during each focus group**
20. Field notes	Were field notes made during and/or after the interview or focus group? **No**
21. Duration	What was the duration of the interviews or focus group? **Average length of focus groups = 33 minutes (range = 21-41 minutes)**
22. Data saturation	Was data saturation discussed? **Yes**
23. Transcripts returned	Were transcripts returned to participants for comment

	and/or correction? **No**
Domain 3: analysis and findings	
Data analysis	
24. Number of data coders	How many data coders coded the data? **Three**
25. Description of the coding tree	Did authors provide a description of the coding tree? **N/A**
26. Derivation of themes	Were themes identified in advance or derived from the data? **Derived from data**
27. Software	What software, if applicable, was used to manage the data? **NVivo (Version 10, QSR, Southport, UK)**
28. Participant checking	Did participants provide feedback on the findings? **No**
Reporting	
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number **Yes**
30. Data and findings consistent	Was there consistency between the data presented and the findings? **Yes**
31. Clarity of major themes	Were major themes clearly presented in the findings? **Yes**
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes? **No**

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Exploring the use of a gamified intervention for encouraging physical activity in adolescents: A qualitative longitudinal study in Northern Ireland

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Exploring the use of a gamified intervention for encouraging physical activity in adolescents: A qualitative longitudinal study in Northern Ireland

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ABSTRACT

Objective: To explore the temporal changes of adolescents' views and experiences of participating in a gamified intervention to encourage physical activity behaviour, and associated processes of behaviour change.

Design: A Qualitative Longitudinal design was adopted whereby focus groups were conducted with the same participants in each intervention school (n=3) at four time-points (baseline, end of each of two intervention phases and 1 year follow-up). The Framework method was used to thematically analyse the data.

Setting: Secondary schools (n=3), Belfast (Northern Ireland).

Participants: A sub-sample (n=19 at 4 time-points) of 12-14 year olds who participated in the StepSmart Challenge, a gamified intervention involving a pedometer competition and material rewards to encourage physical activity behaviour change.

Results: Three core themes were identified: 1) Competition; 2) Incentives and 3) Influence of friends. Participants indicated that a pedometer competition may help initiate physical activity, but suggested that there were a number of barriers such as participants finding it *"boring",* and feeling as though they had a remote chance of *"winning"*. ''Incentives" were viewed favourably, although there were participants who found not winning a prize *"annoying"*. Friends were a motivator to be more physically active, particularly for girls who felt encouraged to walk more when with a friend.

Conclusions: The intervention in general and specific gamified elements were generally viewed positively and deemed acceptable. Results suggest that gamification may have an important role to play in encouraging adolescents to engage in physical activity, and in creating interventions that are fun and enjoyable. The longitudinal approach added additional depth to the analysis as themes were refined and tested with participants over time. The findings also suggest that gamified Behaviour Change Techniques align well with core concepts of Self-determination Theory, and that various game-elements may require tailoring for specific populations, for example, different genders.

Trial Registration Number: NCT02455986

Strengths and limitations

- A major strength of this study was the novel use of a longitudinal design, using the same participants in repeated focus groups. This enabled the investigation of how participants' views, experiences and PA behaviour evolved over time.
- In addition, having a number of researchers involved in the data collection and analyses reduces selectivity and researcher bias.
- However, only three focus groups participated in the study, and all were single sex schools.

BACKGROUND

Physical activity (PA) levels in children and adolescents around the world are low. [1] As patterns of PA are established during this time and tend to track into adulthood, [2 3] this is a crucial period which can affect lifelong health and habits. To date, PA programmes for this population have shown limited effect, [4 5] stressing the need for innovative approaches to initiate and maintain PA behaviour. [6]

Programmes such as Pokémon GO illustrates the potential of gamified interventions (i.e. the application of elements of game playing, such as scoring points, competing against others, to change behaviour) for encouraging PA behaviour [7] and can provide useful insights into how to reach and engage the most inactive in PA behaviour. [8] Elements of gamification are incorporated into many commercial PA promotion apps, such as Pokémon GO, Fitocracy and 'Zombies, Run!', which include the collection of points for undertaking a targeted behaviour, completing challenges, or competing against others in virtual games. [9] Interventions that have applied gamification elements suggest it could be possible to make a routine activity such as travelling to school into a game that promotes active travel modes, and that is engaging and fun.[10 11]

Some key gamification strategies, including feedback on players' performance to allow them to set goals and monitor progression, competing with others, and use of incentives, are all evidence-based Behaviour Change Techniques (BCTs).[12] Further, research has demonstrated that other core aspects of gamified interventions such as opportunities for socialisation, self-evaluation, and rewarding positive behaviour are key to providing an enjoyable experience [13 14] and enjoyment has been identified as a significant predictor of PA behaviour.[15] However, gamification interventions have rarely been grounded in well-established theoretical frameworks and we know little about the views and experiences of participants.

The aim of this study was to explore the views and experiences of adolescents who participated in a gamified PA intervention based on Self-determination Theory, and the temporal changes of these views and experiences over the 1-year study period. Study objectives included;

1. To explore key aspects of a gamified PA intervention over a 1-year period using a Qualitative Longitudinal Research method.
2. To discuss key issues relating to the intervention, such as PA opportunities/barriers, the value of competition and types of rewards etc.
3. To explore the key influences of PA and to determine who benefitted from the intervention, how and why it worked for them;
4. To qualitatively chart changes in behaviours, opinions or views as a result of participating in the intervention.

METHODS

Context

The StepSmart Challenge was a 24-week primarily school-based intervention utilising team, and individual competitions in five schools in Belfast, Northern Ireland. The school recruitment process is detailed elsewhere (Best et al; under review). An independent trial statistician randomly allocated the five schools to the intervention (three schools) or control (two schools) group. School characteristics are shown in Table 1; two were all-boys schools, two all-girls schools, and one was a co-educational school. All intervention schools were single sex (boys (n=1), girls (n=2)). Students (n=224) from Year 9 classes (aged 12-14 years) were invited to participate in the trial. The main results from the feasibility trial are published elsewhere (Best et al; under review). Briefly, the results demonstrated that the StepSmart Challenge was acceptable to young people for encouraging PA, and there was a trend in increasing light-intensity PA and improving mental wellbeing.

The StepSmart Challenge

The StepSmart Challenge was a gamified intervention designed according to Self-determination Theory (SDT),[16] using distinct intervention phases aiming to move participants along the motivation continuum from extrinsic motivation towards intrinsic motivation and encouraging PA behaviour change. The theory is grounded in three psychological needs – autonomy, competence, and relatedness. [16] Those intrinsically motivated engage in PA for the enjoyment and satisfaction it provides. [17] This form of motivation is associated with improved quality of life, increased PA behaviour, [18] and long-term behaviour change. [19] Self-motivation is undermined when individuals feel less control over the activity, and the

environment, and if they do not feel a sense of connectedness or belonging to others engaging in the same activity. [20]

Table 2 details the various intervention components and links to BCTs. The intervention consisted of two phases. Phase One involved a multi-level (competition at the school, team and individual level) pedometer competition lasting for 8-weeks. Team selection was determined by the research team and took account of current PA levels and friendship networks measured at baseline; this was to ensure a mixed ability team (4-5 participants per team) with at least one friend in the team. The team competition entailed social incentives such as publication of the results on the website, a trophy awarded to the leading team (i.e. the team with the highest number of total steps) in each school at competition end, and a prize to the winning school (£1000). During the individual competition in Phase One, incentives (approximate value of £10 – see Table 2 for details) were awarded weekly in each school to two participants (participant who accumulated the most steps that week ('Walker of the Week'); and the participant who increased his/her step count the most from the previous week ('Most Improved')). Phase Two (14 weeks) focused on an individual level competition, in which the three participants that had accumulated the most steps in each school during this phase were awarded a 'goody bag' (approximate value of £30 for each participant and consisted of an assortment of those used in Phase One).

Qualitative longitudinal research

To elicit the temporal views and experiences of participants in the StepSmart Challenge a qualitative longitudinal research (QLR) design was used involving repeated semi-structured focus groups with the same participants over four data collection periods (recurrent cross-sectional approach). This enabled qualitative charting of the perceived behaviour change as well as changes in attitudes and opinions over a one-year period. This presented an opportunity to further understand potential mechanisms of behaviour change, and how perceptions and experiences of the intervention changed over time (pre, during and post-intervention). [21] Understanding why certain choices were made can produce more insightful and considered interpretation of behaviour change. [22] Such approaches are particularly valuable in providing a different perspective in assessing interventions or as part of process evaluations. [23]

Focus group participants

Baseline focus groups were conducted in each intervention school with a sub-sample of trial participants using a purposive sampling strategy whereby teachers identified potential participants with a range of PA levels from low-to-high as well as those with mixed educational ability. To reduce selection bias, the researchers discussed the importance of having a range of views within focus groups before participants were selected. However, it was considered that teachers were best placed to make these judgements as researchers did not know any of the participant's backgrounds and would not be aware of hidden conflicts or instances of bullying which may have influenced the group dynamic and quality of data. Those interested in taking part were given a study information sheet by the teacher explaining the purpose of the focus groups, to read themselves and then give to their parent(s)/guardian(s). Parental (or guardian) opt-out consent and participant consent was sought from all participants. [24] Ethical approval was granted by the School of Medicine, Dentistry and Biomedical Science Research Ethics Committee (Queen's University, Belfast) (Ref: 15.09).

The focus groups were repeated during the study, following the same participants on their journey through the trial. This provided rich contextual data to explore the views and experiences of participants over time. Data were collected one-month pre-intervention (T0); at the end of the team competition (8 weeks) (T1); end of the individual competition (post-intervention) (24 weeks) (T2); and at 12-month follow-up (T3). Focus groups were conducted on school premises and were audio recorded. The researchers verbally reaffirmed consent to participate at the beginning of each focus group. No other participants were present at the time of the focus groups.

Focus groups were semi-structured, based on topic guides (see Supplementary Material I) exploring core concepts at each time point. The topic guide was not piloted but developed iteratively reflecting on the data gathered from the focus groups from previous time points. Thus, emerging themes were explored across time points to chart changing views, experiences and PA behaviour. During all focus groups, the researcher summarised information at the end of each section and questioned understanding as a form of participant verification. [25]

Core concepts explored included:

1. General views and experiences of the intervention and intervention components;

2. Motivation to be active and to sustain activity long-term;
3. Extrinsic motivators including a) competition e.g. Does the competition motivate you to walk?; b) Material incentives e.g. Was the opportunity to win a prize something that motivated you?; c) Motivation for PA e.g. What motivates you to be active?;
4. SDT concepts including a) Autonomy e.g. What new ways have you found to be active?; b) Perceived competence e.g. How did it make you feel when you compared your steps to those of the class?; c) Relatedness e.g. Do you think friends are important in terms of how active you are?

Focus groups were conducted by RC (Male, PhD student), PB (Male, Post-doctoral Researcher) and RO'N (Female, Post-doctoral Researcher). PB and RO'N are experienced qualitative researchers and have facilitated focus groups with adolescents previously. RC had undergone a number of formal training courses in the facilitation of focus groups and thematic analysis methods. RC was accompanied to the focus groups by either RO'N or PB. Saturation of the data was discussed between PB and RC. None of the researchers had any relationship with the participants.

Data analysis

Focus group recordings were transcribed verbatim and anonymised. Data were imported into NVivo (Version 10, QSR, Southport, UK) to manage and analyse the transcripts. Analysis was undertaken using the Thematic Analysis Framework at the semantic level using a recurrent cross-sectional approach. [26] Initially researchers (RC and PB) familiarised themselves with the data. A sample coding frame was developed by the researchers independently, and refined iteratively with subsequent discussions. As a result, three coding frameworks were generated, one for each core theme. Illustrative quotes supporting emerging themes were highlighted and agreed by researchers. Transcripts were not returned to participants for comment, and they did not provided feedback on findings.

The dataset was systematically coded using an inductive approach and codes were generated to give a summary of elements of analytic interest. Once coded researchers identified potential themes from clusters of codes of similar meaning as well as patterns of responses across codes. Three central themes were identified at T0 and developed at subsequent time points. The coding frame was then discussed with ME and further refined. RC and ME then met multiple times to discuss and refine codes until a final coding frame

was applied to all data. These themes consisted of (1) incentives; (2) competition; (3) influence of friends on PA. The temporal changes in the views and experiences of participants, and the influence of these components on the process of behaviour change were explored under each theme. Researchers (RC and ME) analysed the data together to further refine sub-themes to ensure assertions were accurately reflected. Codes were not validated with study participants due to the time commitment that they had already provided due to the qualitative longitudinal design. However, given the nature of the QLR design core concepts that were apparent at T0 were revisited at subsequent time points to test the validity of the theory.

RESULTS

Table 3 details the characteristics of participants in the focus groups, and demonstrates that the purposive sampling strategy was successful in recruiting participants of mixed gender, SES, from different teams, those who won prizes and those who didn't win, and PA levels. Table 3 displays a breakdown of the focus groups conducted. Twelve focus groups were conducted (mean duration 33 minutes; range 21–41 minutes (Table 4)). Focus group participants present at each time point varied due to participant absences (mean 6 participants; range 2–7 participants). No participants refused to participate or dropped out.

The following results section details the themes and sub-themes identified from the thematic analysis. This includes a diagrammatic representation (see figure 1) of how themes continued to evolve as new data emerged at each time point.

Theme 1: Competition

Three sub-themes emerged under this theme: a) usefulness of competition for PA behaviour change; b) self-competition for PA behaviour change; c) experiences of the team and individual competition.

Sub-theme A: Usefulness of competition for PA behaviour change

At T0, participants suggested the competition would motivate them to work harder and it was generally viewed as a motivating factor to become more physically active:

> *"that's what motivates me"* (School C, Male 5, T0).
>
> *"that's what pushes people on"* (School C, Male 6, T0).

"if I was actually in a competition I'd actually walk everywhere" (School D, Female 6, T0).

As interviews progressed (across time points) these early conceptualisations were developed further. For example, it was clear from T1 onwards that for a sub-sample of participants in all schools the desire to compete was not sufficient; the goal of winning was paramount:

"we like the winning but we don't like the losing" (School E, Female 3, T0).
"to try and win like every week after that" (School C, Male 6, T3).
"yeah, because you just wanted to win" (School D, Female 6, T3).

Yet while this sub-sample was extremely motivated during Phase 1, when the competitive elements (against others) lessened during Phase 2, the intervention became monotonous or 'boring':

"I think that's boring you know, who would want to know how many steps you're taking?" (School D, Female 2, T2).
"at the start like, like you were quite motivated and then it just got more on and then you just forgot to wear it some days and it just got quite boring" (School C, Male 4, T3).
"It was just like the same thing every day" (School C, Male 4, T3).

For others, the benefits of competition related to their perceived their chances of winning. If this was believed to remote then motivation lessened. This became clear at T1 as the researcher reflected upon earlier (T0) responses given by participants.

"whenever you found out that you're actually losing there's just no point" (School D, Female 2, T1).
"it's just sort of cause you knew you probably weren't going to win so you're just like there's really no point in wearing it [pedometer]" (School D, Female 6, T2).
"well I just really gave up whenever X just won everything. I really did. I just stopped" (School D, Female 3, T3).

Sub-theme B: Perceptions of the usefulness of self-competition for PA behaviour change

The potential use of the pedometer for self-directed goals, or 'self-competition' (competing against oneself) was considered promising at T0:

> *"if its showing you how many steps you're taking then you could challenge yourself to take more every day. So if you took 2000 steps one day you could try like try take more the next day. So it's like challenging yourself"* (School D, Female 1, T0).

Self-competition was shown to be a motivating factor throughout the intervention for most participants. One participant (School D) viewed 'getting better' and improving step counts as meaningful, reducing the negative effect of not winning prizes. This aligns closely with SDT and shows possible progression towards intrinsically based motivated for PA.

> *"trying to beat your day before target"* (School C, Male 5, T1).
> *"I loved to see like how many steps you were actually taking like when you're beating your scores as well like you check it one day and then the next day your gonna try and beat it"* (School E, Female 1, T2).
> *"No, it's alright because I was getting more each day so I was getting better; so it was alright"* (School D, Female 6, T3).

Sub-theme C: Experiences of the team and individual competition

The intervention incorporated two formats of a pedometer competition: a team-based competition (8 weeks duration), and an individual competition (14 weeks duration). During the individual competition, participants competed against others from their school. At T0 the team-based competitions were seen to have the potential to better encourage PA:

> *"you can work together as a team"* (School D, Female 4, T0).

"if you were in like a group with more active people like you'd be sad that you're not as good as them but it would kind of push you to be as good as them" (School E, Female 7, T0).

When asked to compare the individual with the team-based competition at T2, many participants from School C (all male) were more motivated by the team-based competition. This was due to the support provided by the team or peer pressure from not wanting to let *"your team down"*:

"I'd probably say it's easier with the support rather than individually" (School C, Male 6, T2).

"you didn't want to let your team down" (School C, Male 6, T2).

Reflecting on the intervention at T3, there were clear differences regarding experiences of the competition. School C (all boys) participants continued to feel positive about the team competition.

"the team's a lot better. Like its more… you are just like together" (School C, Male 1, T3).

"The individual is quite boring" (School C, Male 4, T3).

The girls' schools (School D and E) tended to favour the individual competition, as they did not have to rely on their team members, or for logistical reasons, such as the inability to meet up and 'organise stuff'.

"you don't have to depend on anyone else" (School D, Female 3, T3).

"you know like sometimes you don't live close to your friends so you can't always organise stuff, which is a problem. So I think the individual one" (School E; Female 7, T3).

One disadvantage of the team competition was the issue of free-riding team members (i.e. a member of a team that obtains benefits from membership but is not seen to contribute a fair share of the work needed to accrue the benefit). [27] In School D (all girls), free-riding was evident.

"well in the group you didn't really have to do anything cause the rest of them could do it but like by yourself like I don't know you just lose it altogether cause you don't walk" (School D, Female 2, T2).

"we didn't really have to worry about it cause like the rest of them would've like walked anyway" (School D, Female 2, T2).

Theme 2: Incentives

Two sub-themes were identified including a) type of incentive; and, b) perceptions of usefulness on incentives.

Sub-theme A: Type of Incentive

The provision of material incentives in this study was contingent on doing well in the competition, rather than being contingent on PA behaviour change. The types of incentives suggested and discussed by participants included recognition-based incentives (e.g. trophies) and material incentives (e.g. vouchers). Males tended to favour recognition based incentives, whereas material incentives with a higher monetary value were largely proposed by females. While this was apparent at T0, the QLR approach enabled the researchers to revisit this at subsequent time points to test the validity of the theory. When asked what type of prizes they would like, male participants suggested:

"a medal or a trophy" (School C, Male 5, T0).

"rugby ball" (School C, Male 4, T0).

In contrast, females often suggested the use of material incentives.

"vouchers for clothes" (School D, Female 6, T0).

"Topshop" (School D, Female 1, T0).

"money" (School E, Female 7, T0).

Sub-theme B: Perceptions of usefulness of incentives

At T1 and T2 many participants viewed incentives favourably. Participants suggested that the incentives were desirable and encouraged them more during the intervention.

"Every week cos you know it's like running out of time for like the prizes, just really want to get one" (School C, Male 6, T1).

"that they weren't just like wee rubbish prizes they were really good ones" (School E, Female 4, T2).

At T3, when reflecting on the intervention, participants still viewed the incentives as a motivating factor as they were 'good' prizes and provided acknowledgement for achievement:

"yeah, they look good. Like the prizes were really good" (School C, Male 4, T3).

"yeah, I think [it] was good actually. Just to keep people motivated (School E, Female 7, T3).

"like you know you are being acknowledged, like when you get prizes" (School E, Female 3, T3).

Some participants did not win any prizes over the course of the intervention. When these participants discussed the instances when their peers won prizes there was a clear sense of disappointment, with a number stating that it was *"annoying":*

"kinda annoyed you when people like brought out their ten pound of cinema tickets and yeah it's like kinda annoying" (School C, Male 3, T2).

"like it annoyed me that I didn't get one" (School E, Female 6, T2).

"It just made me sad" (School E; Female 2, T2).

Theme 3: Influence of friends

Two sub-themes emerged, including: a) the role of friends in general for encouraging PA behaviour, and b) the role of friends in team competition.

Sub-theme A: Role of friends in general for encouraging PA behaviour

At T0, participants suggested that PA was more enjoyable with friends, and the social support provided by friends encouraged participation in PA:

"it's about encouraging each other to do stuff" (School C, Male 5, T0).

"if they want to go for a run you will want to go for a run with them" (School C, Male 4, T0).

"Yeah, because you want to be doing it with them so you can enjoy yourself" (School C, Male 6, T3)

"Good friends will help you yeah" (School D, Female 6, T0).

"X only lives up the street so we go for runs most days after school" (School E, Female 3, T0).

Participants in School E discussed the continued positive influence of friends on PA motivation at T1 and T2. This added additional depth to T0 findings by showing friends as providing a social acceptable context in which to be active. Feeling 'scundered' (colloquialism for embarrassed) when walking alone is offset when provided the social support of friends:

"Make you feel like I'm going to be scundered [embarrassed] walking about alone but when you have your friend with you like you'd be more encouraged to do more walking if you're like walking with your friend" (School E, Female 2, T2).

"hardly just like go a walk about yourself about the street like a big loner" (School E, Female 4, T2).

Sub-theme B: Role of friends in team competition

Participants suggested that the influence of friends and a sense of connectedness was necessary within teams in order for them to work together and be competitive. Although, some participants in School C felt it would be *"good to have at least one friend or two"* (School C, Male 6, T3), they did not want to pick their own teams as they believed this might produce imbalanced teams with the more physically active individuals going into the same team. For these participants, the combination of friends within a team and homogeneity between teams was important:

"No cause then they could get really unfair" (School C, Male 1, T2).

> *"Cause all the active people could go in one team and then the inactive so it wouldn't work out"* (School C, Male 1, T2).

In contrast, participants in Schools D and E wanted the opportunity to choose team members; preferring to be in teams composed of their friends:

> *"I wanted to choose my own team"* (School D, Female 4, T1)
>
> *"no I think it should just be like your own group like friends like five of each of them"* (School E, Female 3, T1).
>
> *"because like [if] you don't like people in your team you're just going to be like 'nah not even going to talk to you'"* (School E, Female 6, T2).

Figure 1 here

Figure 1 illustrates the various thematic pathways that developed during focus group interviews at T0 (red), T1 (yellow), T2 (orange) and T3 (green). Taking the first theme (competition) as an example, the researchers considered the emergence of two distinct groups at T0. These were (1) *physically active participants* who viewed a pedometer competition as a means of further increasing their active lifestyle and, (2) *less active participants* who viewed the pedometer competition as an opportunity to become more active.

At T0, physically active participants were particularly 'excited' about a pedometer-based competition, perceiving it as enjoyable process. Some of these participants appeared to engage regularly in competitions. The less active group were more cautious, but felt a pedometer based competition might provide an acceptable context through which PA may be enjoyable. As such, these early ideas/themes were represented at T0 (red).

As interviews progressed through T1 and T2, the research team observed changes in relation to participant's views of competition (both in a general sense as well as relating directly to StepSmart). Moreover the QLR approach enabled the research team to frame these changes within the context of data revealed at baseline (T0). For example, physically active members who regularly engaged in competitions (outside of the StepSmart Project) at T0 continued to enjoy the intervention at T1 and T2. However, for a sub-set of this group (where winning

was more important than competing) motivation lessened at T2. Figure 1 also illustrates that for participants who were less active, motivation and engagement decreased much sooner (at T1) and continued to decrease into T2 and T3. In some cases these participants appeared to have been motivated solely by the material incentives, thus the perceived failure of 'not winning a prize' was interpreted as negative feedback and reinforced negative schemas around PA.

Self-determination theory maintains that an activity that is stimulating is an important aspect of sustained motivation. Throughout the intervention, the importance of self-monitoring, and the importance of personal goals was prominent for all participants. The concept of self-competition provides an opportunity to challenge oneself and can be supportive of feelings of competence. Self-competition, provided an opportunity for all participants to receive positive feedback by meeting the goals they set for themselves, and could lessen the impact of not winning prizes. By adopting a QLR approach, themes generated in earlier focus groups evolved and could be tested as new data emerged. The same level of depth would have been difficult to achieve within a pre-post test design.

DISCUSSION

Participant's generally had positive experiences and views of this gamified PA intervention. Results suggested that the gamified design may have had an important role to play in encouraging adolescents to engage in PA, and in creating interventions that are fun and enjoyable. The findings also suggested that core concepts of SDT are compatible with gamified BCTs, and that some game elements may require tailoring for specific populations, for example, different genders.

In general, the use of a gamified pedometer competition was viewed favourably by participants. The goal of winning was very important for some and was key to sustaining their motivation to be active. This could be linked to the provision of material incentives which was contingent on 'winning' the competition. Over the course of the intervention, material incentives continued to motivate some participants. A possible mechanism could be that positive feedback provided by winning prizes and doing well in the competition helped develop an individual's intrinsic motivation by improving feelings of competence. [28] The positive effect of material incentives for health behaviour change with children and adolescents has also been shown in previous studies. [29-32]

The long-term effect is less clear with some studies showing that positive effects dissipate over time. [33] This could be due to habituation to the extrinsic motivators being offered [34] or a 'crowding out effect' of intrinsic motivation [35] once extrinsic incentives are removed. However, to date this hypothesis has not been tested or supported in 'real world' interventions. [28 36-38]

Other participants felt de-motivated from the outset as they believed they had no chance of winning. Some became less enthusiastic about the competition if other participants consistently had a greater number of steps, and were disappointed at not winning a prize. Previous work has suggested that competition can affect participants' self-evaluation of their competence to perform the task. [39 40] If a participant loses, and their loss is attributed to low ability, this can negatively impact behaviour. [41] Therefore, participants may choose not to compete, or not engage in the competition with maximum effort. [42] This helps to provide some explanation for the loss, other than low ability, thus preserving the participant's self-esteem and self-efficacy.

Some participants indicated that they became gradually less interested because of the repetitive nature of the pedometer competition. These findings are supported by a large body of literature which suggests that extrinsic motivators can have a short-term positive effect on motivation which is not maintained. [33 36 37 43] Extrinsic motivators such as competition and material incentives could be used to initially stimulate the interest of participants, especially those with lower levels of PA. [44] However, a key learning point would be to transition to more intrinsically motivating forms of PA and thus the incorporation of BCTs that focus on these behaviours would be useful. [45 46]

The competition had various levels: rewards could be offered to the highest achieving team, the highest achieving individual, or to anyone on the basis of achieving some personal goals (self incentive). The findings showed distinct perceptions regarding the value of each. For example, males tended to prefer the team competition and suggested they would try harder to contribute to the team, and found the team environment supportive and enjoyable. Maculada [47] suggested that males find team affiliation important, and a way to be accepted by peers and to feel a sense of belonging with the group. Team-based PA interventions have been shown to be effective, [10 11] and may be less harmful than individual competitions. [48]

Conversely, females favoured individual competition; how well a participant did in the competition was not dependent on the effort of others, mitigating to the problem of free-riding. [49] One solution may be to distribute incentives equitably (ie proportionate to effort and contribution) to team members rather than distributing them equally, [50] thereby reducing free-riding and increasing effort. [51 52]

Self-competition [53] was seen as a prominent positive influence of PA. Participants often used the pedometers for feedback, to self-monitor, and set personal step goals. Creating achievable personal goals may also play a part in mitigating the potential negative effects of extrinsic motivators by emphasising competence (by meeting goals and receiving positive feedback), autonomy (as participants are free to choose which activities they pursue to increase step counts), and maintaining self-efficacy. Self-competition with the use of intrinsic goals was enjoyed by all participants in the focus groups, regardless of success in the overall competition. Self-competition allowed participants to be autonomous, and to create achievable challenges such as walking more steps than during the previous day. Therefore, self-competition could be a way to develop autonomous identified or integrated regulation, which has been shown to have benefits for PA motivation. [54 55] Autonomy-supportive elements such as self-competition could consequently stimulate the development of habit formation. [56]

The significance of friends for influencing PA behaviour has also been frequently cited in the literature. [57-59] The participants' feelings on team composition and the influence of friends reinforce the psychological need for relatedness, a core construct of SDT. Participants from all schools felt that a sense of connectedness to the group was important for an effective team competition. Other research shows that adolescents value opportunities for social interaction, [39] and so team membership could have a positive effect on PA motivation. Participants stated that friends provided support, encouragement and help with the enjoyment of PA.

Reflections on the QLR approach

The authors acknowledge the difficulty in mapping temporal changes, especially in focus groups, where there may not be sufficient time or opportunity to explore individual's views in detail. Nonetheless, Figure 1 is a simplified, but useful, thematic illustration of general (group-level) consensus over a 1 year period.

The complexities contained within each pathway highlight the difficulty in developing a group-based PA intervention that will motivate all participants in a similar manner. It also illustrates the interrelated nature of the themes, and how experiences of one aspect of the intervention can influence other components. However, recognition-based incentives, the provision of feedback on performance, and opportunities for social connectedness were shown to be key gamification strategies with potential for motivating PA throughout the intervention period. This is in line with SDT which posits that supporting innate desires, competence and a sense of relatedness with others could help achieve a higher quality of motivation that is long-lasting.

Strengths and limitations

A major strength of this study was the novel use of a longitudinal design, [21 60] using the same participants in repeated focus groups at baseline, post-intervention and 1-year follow-up. This enabled the study of how participants' views, experiences and PA behaviour evolved over time. The findings are robust as assumptions, views and experiences can be tested and re-tested in subsequent sessions, and researchers build relationships with participants due to the repeated exposure which can encourage disclosure. In addition, having a number of researchers involved in the data collection and analyses reduces selectivity and researcher bias.

A focus group method was chosen as it provided an opportunity for the group to discuss issues amongst themselves and reach consensus, gathering multiple viewpoints and representing 'everyday' conversation. However, the approach has been criticised for lacking depth, particularly when conducted with young people as they tend not to elaborate on discussion points. It may also have been useful to combine this approach with 1:1 interviews to reduce peer pressure and ensure coherence of responses at different schools. Only three focus groups participated in the study, and all were single sex schools. Consequently the purported gender differences may be an artefact of differences in socio-economic status as well as or in addition to gender differences. Finally, there was good retention of participants in the qualitative longitudinal design, with the exception of T3 in which four (out of six) pupils were missing from School D owing to a timetable clash that was beyond the control of the research team.

Conclusions

Preferences for gamified elements including team or individual competitions, and the influence of friends on PA behaviour were highlighted. The use of a longitudinal qualitative design enabled exploration of temporal changes in participants' views and experiences, and exploration of potential mechanisms of behaviour change. This study suggests that the three core constructs for self-motivation in SDT could be important factors for motivating PA in adolescents via competition and the use of material rewards delivered through gamification. This supports previous research which proposes benefits in providing opportunities for autonomy, perceived competence, and relatedness. [61]

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Table 1: Characteristics of schools included in the StepSmart Challenge feasibility study

	Intervention or Control Group	Single Sex or Co-educational	Free school meal entitlement (%)
School A	Control	All Male	63.7%
School B	Control	Co-Educational	7.2%
School C	Intervention	All Male	8.0%
School D	Intervention	All Female	56.5%
School E	Intervention	All Female	54.6%

Table 2: Intervention Components and Behaviour Change Techniques (BCTs)

Component	Activity/Task	Behavioural Change Technique (Michie et al, 2013)
Competition	Competition was designed to take place across three levels during Phase one (April – June 2015). **1.** School level - £1000 prize for winning school **2.** Team level – trophy for the winning team in each school **3.** Individual level – weekly prizes for highest steps and most improved within each school During Phase two (July – Sept 2015) there were individual prizes for the top three participants in each school achieving the highest average number of steps across the 14-week period. This two-phased tapered approach was designed to encourage med-long term PA behaviour change (i.e. extrinsic to intrinsically motivated PA behaviour)	-Set graded tasks -Provide rewards contingent on successful behaviour -Provide feedback on performance
Material Rewards/Prizes	Material rewards included coloured stickers, selfie sticks, completion certificates, cinema tickets and £10 sports vouchers. Individual prizes were awarded on a weekly basis under two categories, 'outstanding performance' and 'most improved'.	-Prompt rewards contingent on effort or progress towards behaviour
Teams	A team based competition was developed alongside the main school competition to encourage peer support. Ten teams were created within each school (4-5 participants per team). Team captains were selected based on baseline PA data to ensure balance between teams and peer nominations to identify those 'most looked up to'. The highest placed team within each school at the end of Phase One was awarded with a trophy.	-Plan social support/ social change -Facilitate social comparison -Prompt identification as role model/ position advocate
Pedometers	Participants were given a Fitbit Zip pedometer and asked to wear throughout every day of the intervention (Phase One and Two). Pedometers provided participants with feedback on daily steps and were	-Goal setting (outcome) -Prompt self-monitoring of behavioural outcome -Provide feedback on performance

	uploaded to the study website via the Fitbit App or using a wireless dongle located at designated areas within schools.	
Website	Pedometer data was uploaded to the StepSmart Challenge website and participants could review their daily/weekly scores and view the competition leader board. The website included the provision of motivational messages, weekly challenges and links to other PA resources	-Goal setting (outcome) -Prompt self-monitoring of behavioural outcome -Provide feedback on performance
Workbook	A short workbook was given to participants at the start of the intervention. This included 'fun-facts', tips and challenges to promote PA behaviour as well as a section for the participant to record weekly step target (individual and team).	-Provide information on consequences of behaviour in general -Goal setting (outcome) -Prompting generalization of a target behaviour

Table 3: Characteristics of focus group participants

			Average steps per day (measured using accelerometers)		
Participant		**Team**	**Baseline**	**Post-intervention**	**12 Month Follow Up**
1	**School C**	C10	9,949	8,576	No valid data
2	**School C**	C6	No valid data	No valid data	No valid data
3	**School C**	C6	8,815	13,127	No valid data
4	**School C**	C7	9,325	4,099	4,099
5 Winner of 'Most Improved'	**School C**	C1	9,264	6,687	14,246
6 Winner of 'Walker of the Week' Winner of Summer Competition	**School C**	C5	13,326	9,563	8,039
1 Winner of 'Walker of the Week' Winner of Summer Competition	**School D**	D2	10,940	10,684	11,784
2	**School D**	D9	2,787	No valid data	No valid data
3 Winner of 'Most Improved'	**School D**	D6	9,737	7,160	7,160
4	**School D**	D5	6,555	No valid data	4,088
5	**School D**	D5	2,782	No valid data	5,426
6 Winner of 'Most Improved'	**School D**	D7	9,253	No valid data	No valid data
1	**School E**	E7	6,495	13,080	6,129
2	**School E**	E7	7,330	No valid data	9,440
3	**School E**	E2	6,583	No valid data	No valid data
4	**School E**	E9	5,915	No valid data	No valid data
5 Winner of 'Walker of the Week' Winner of Summer Competition	**School E**	E6	14,153	13,998	8,179
6 Winner of 'Most Improved'	**School E**	E3	14,113	No valid data	9,988
7 Winner of 'Walker of the Week' Winner of Summer Competition	**School E**	E3	11,330	No valid data	5,909

* No valid data = Unreturned accelerometer or no valid three-day measurement of data

Table 4: Overview of the number of participants in (and duration of) each focus group at each time point

	Time points of each focus group			
Intervention schools	*Baseline (T0)*	*8 weeks (T1)*	*24 weeks (T2)*	*52 weeks (T3)*
School C (All Boys)	6 (35 mins)	6 (21 mins)	5 (38 mins)	5 (35 mins)
School D (All Girls)	6 (34 mins)	5 (37 mins)	6 (40 mins)	2 (31 mins)
School E (All Girls)	7 (36 mins)	7 (41 mins)	6 (24 mins)	7 (24 mins)

Figure 1: Diagrammatic representation of the temporal thematic pathways that developed during focus group interviews.

Legend: T0 (red), T1 (yellow), T2 (orange) and T3 (green).

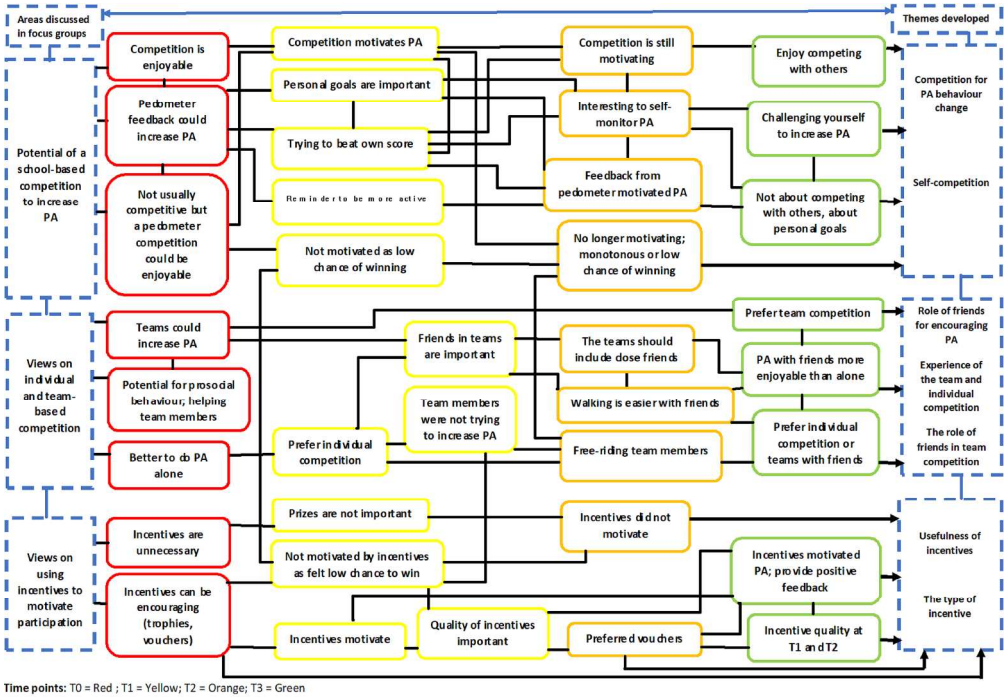

Figure 1: Diagrammatic representation of the temporal thematic pathways that developed during focus group interviews.
Legend: T0 (red), T1 (yellow), T2 (orange) and T3 (green).

592x410mm (300 x 300 DPI)

Supplementary Material I: Topic Guide

Topic Guide			
Pre-intervention	**End of phase one (External regulation; Introjected regulation)**	**End of phase two (Introjected regulation; Identified regulation)**	**12 months post-baseline follow up (Integrated motivation)**
Explore the barriers and facilitators to PA What stops you from being physically active? (Relational support) Role of parents/friends in your PA? (Autonomy support; Relational support) Any ideas to increase PA? (Autonomy support) Opportunities for PA within school/community? (Autonomy support; Relational support)	**Explore the experiences of StepSmart** How easy is it to find ways in which to be more active? (Autonomy support) Did completing the StepSmart Challenge with friends make it easier? Or more pressure? (Autonomy support; Relational support) Do you enjoy telling people about your success in terms of PA (e.g. showing others your steps)? (Perceived competence; Relatedness)	**Explore the how participants felt about the different competition elements** How did the team competition compare to the individual competition? (Relational support) Some of the class were more/less active than you. How did you feel when you compared your steps to the class? (Perceived competence) Did team members encourage you to be active or not? (Autonomy support) How did you feel if you didn't contribute to the team/school's step count? (Perceived competence)	**Explore if there has been a change in PA (formation of habit)** One year on: how active are you now (compared to before you took part)? Did you make changes to your PA? Why/why not? *(changes to routine ... active travel, walking with friends etc.)* If you did make any changes, which are you still doing? What strategies helped? (Autonomy support)
Explore the acceptability of the intervention components Have you ever heard of…or used a pedometer? What is it you (dis)like about them? Feelings on writing down your own daily steps goals in a workbook.	**Explore the attitude towards PA** Do you enjoy PA? What are your main reasons for being active? (i.e. role of the prizes and other elements?)	**Explore how the StepSmart Challenge instigated any changes in participants PA** How do you feel about PA since the StepSmart Challenge? What have you enjoyed?	**Explore how participants felt about the StepSmart Challenge** Why did you choose to participate? Good/not so good aspects of the competition? Did the competition motivate – no/at beginning/all throughout?

(Perceived competence; Autonomy support) What features of a website would you find appealing? How do you feel about entering a school-based competition? Any advantages/disadvantages to team vs individual competitions What prizes would motivate young people to take part?	Do you enjoy finding new ways of becoming more active? (Autonomy support) Do you think your motivation towards PA has changed?	Has the StepSmart Challenge increased your PA? If not, what would motivate you to be more active? Since the StepSmart Challenge, what new opportunities have you found to be active? (Autonomy support) Anything outside your control stopping you from being active? (e.g. park proximity, family, other) (Autonomy support; Relational support)	
	To explore the consequences of PA Do you find yourself having more energy? Do you feel more confident in being able to achieve things? (Perceived competence) How do you feel after you've completed some PA? Do you think you are more active now than when you started? Why?	**Explore how participants felt about the use of the pedometer** How often did you use the pedometer? What did you like/dislike about it? (e.g. Feedback) (Perceived competence; Autonomy support) How many of you are still using the pedometer? Why?	**Explore how participants felt about the team/individual competition** Class vs school, was one enjoyed more? (Autonomy support; Relational support) Influence of friends on being active? (Autonomy support; Relational support) Opportunity to make new friends? (Relational support) Feelings about not contributing to the team/school step count? (Perceived competence) More motivated if friends wanted to do well in the competition? (Relational support)

		Explore how participants felt about the rewards/prizes What did you think of the prizes? Tell me how well they worked to motivate you? How did you feel if you didn't win a prize? (Perceived competence) If no prizes, but still a competition, would you still be as active? Why?	**Explore how participants felt about the rewards/prizes** Type of prizes preferred, including ttrophy or a certificate? Not competing against others, but beating your own goal? (Autonomy support; Perceived competence)
		Explore how the website and Facebook group were used Things you liked/didn't like about the website? What did you think of Facebook group? (Autonomy support; Relational support) Which way would you prefer to get your information from? (Autonomy support)	**Mood/motivation did these change at different stages of the intervention?** Feelings if didn't make as many steps as others? Did that affect your mood? (Perceived competence; Relational support) If you did/didn't do well - did that motivate/demotivate you? (Perceived competence; Relational support) If felt like don't have a good chance to win would that make you stop trying? (Perceived competence; Relational support)

Red text illustrates how items in the topic guide are linked the concepts of self-determination theory

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

Developed from:
Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

No. Item	Guide questions/description
Domain 1: Research team and reflexivity	
Personal Characteristics	
1. Inter viewer/facilitator	Which author/s conducted the interview or focus group? **PB, RO'N, RC (page 8)**
2. Credentials	What were the researcher's credentials? E.g. PhD, MD **PhD (PB), PhD (RO'N), MPH (RC) (page 8)**
3. Occupation	What was their occupation at the time of the study? **PB: Research Fellow, UKCRC Centre of Excellence for Public Health/Centre for Public Health** **RO: Research Fellow, UKCRC Centre of Excellence for Public Health/Centre for Public Health** **RC: PhD Student (page 8)**
4. Gender	Was the researcher male or female? **Male (PB), Female (RO'N), Male (RC) (page 8)**
5. Experience and training	What experience or training did the researcher have? **PB: Qualified social worker, training in thematic analysis, Computer Assisted Qualitative Data Analysis (CAQDAS) packages** **RO'N: Experience in the design, conduct and analysis of a photo elicitation and focus group based qualitative research. Training in focus group facilitation and the NVivo** **RC: MPH with a focus on health services research comprising training on qualitative research methods. Formal training in NVivo during PhD (page 8)**
Relationship with participants	None **(page 8)**
6. Relationship established	Was a relationship established prior to study commencement? **No (page 8)**
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research

	Participants who took part in the focus groups were a sub-sample of those who were involved in the StepSmart intervention study. Participants were told that the purpose of the discussions were to explore their experiences of the StepSmart Project (page 6-7).
8. Interviewer characteristics	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic **None**
Domain 2: study design	
Theoretical framework	
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis **The intervention was underpinned by Self-determination theory (page 5). Thematic Analysis Framework Method was used for qualitative data analysis (page 8)**
Participant selection	
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball **Purposive sampling used for participant focus groups (page 6-7)**
11. Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email **Face-to-face by the teacher (page 7)**
12. Sample size	How many participants were in the study? 19 participants **School C (n = 6); School D (n = 6); School E (n = 7) (Table 4)**
13. Non-participation	How many people refused to participate or dropped out? Reasons? **Focus group participants present at each time point varied due to participant absences (mean 6 participants; range 2–7 participants). No participants refused to participate or dropped out. (page 9 and Table 4)**
Setting	
14. Setting of data collection	Where was the data collected? e.g. home, clinic, workplace **Focus groups were conducted on school premises (page 7)**
15. Presence of non-	Was anyone else present besides the participants and

participants	researchers? **No, only the participants and researchers were present (page 7)**
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date **Year 9 classes from 3 schools over 2015-2016** **School C: All male aged between 12 to 14 years** **School D: All female aged between 12 to 14 years** **School E: All female aged between 12 to 14 years** **(page 9 and Table 3)**
Data collection	
17. Interview guide	Were questions, prompts, guides provided by the authors? **Yes (page 7)** Was it pilot tested? **No (page 7)**
18. Repeat interviews	Were repeat interviews carried out? If yes, how many? **Four were carried out in total. Data were collected one-month pre-intervention (T0); at the end of the team competition (8 weeks) (T1); end of the individual competition (post-intervention) (24 weeks) (T2); and at 12-month follow-up (T3). (page 7)**
19. Audio/visual recording	Did the research use audio or visual recording to collect the data? **Audio recordings were made during each focus group (page 7)**
20. Field notes	Were field notes made during and/or after the interview or focus group? **No**
21. Duration	What was the duration of the interviews or focus group? **Average length of focus groups = 33 minutes (range = 21-41 minutes) (page 9, Table 4)**
22. Data saturation	Was data saturation discussed? **Yes (page 8)**
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction? **Transcripts were not returned to participants for comment, and they did not provided feedback on findings (page 8). However, given the nature of the QLR design core concepts that were apparent at T0 were revisited at subsequent time points to test the validity of the theory.**

Domain 3: analysis and findings	
Data analysis	
24. Number of data coders	How many data coders coded the data? **Three (RC, PB and ME) (page 8)**
25. Description of the coding tree	Did authors provide a description of the coding tree? **Yes (page 8)**
26. Derivation of themes	Were themes identified in advance or derived from the data? **Themes were derived from the data (page 8)**
27. Software	What software, if applicable, was used to manage the data? **NVivo (Version 10, QSR, Southport, UK) (page 8)**
28. Participant checking	Did participants provide feedback on the findings? **Transcripts were not returned to participants for comment, and they did not provided feedback on findings (page 8). However, given the nature of the QLR design core concepts that were apparent at T0 were revisited at subsequent time points to test the validity of the theory.**
Reporting	
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number **Yes (pages 9-15)**
30. Data and findings consistent	Was there consistency between the data presented and the findings? **Yes (pages 9-15)**
31. Clarity of major themes	Were major themes clearly presented in the findings? **Yes (pages 9-15)**
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes? **Sub-themes are discussed (pages 9-15)**