StepStream: A School-based Pervasive Social Fitness System for Everyday Adolescent Health

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ABSTRACT
Computer-supported fitness interventions for adolescents have the potential to improve adolescents' attitudes and perceptions about physical activity through peer influence and interpersonal accountability. Past research has explored the potential of interventions based on competition and social-comparison mechanisms. We present a new approach: school-based, pervasive social fitness systems. We describe one such system: StepStream, a pedometer-based microblog we designed and deployed for four weeks with 42 US middle school students. StepStream users improved their attitudes about fitness and increased their sense of social support for fitness. The least-active students also increased their daily activity. We show that our school-based social fitness approach performed comparably in attitude and behavior change to more competitive or direct-comparison systems. These results expand the strategies available computer-supported fitness interventions. Our school-based social fitness approach to everyday adolescent health shows the potential for social computing systems to positively influence offline health behaviors in real-world settings.

Author Keywords
Social computing; pervasive health; youth; adolescents; deployments; fitness intervention

ACM Classification Keywords
J.3 [**Life and Medical Sciences**]: Health; H.5.3 [**Group and Organization Interfaces**]: Collaborative Computing.

INTRODUCTION
In recent years, the CHI community has devoted attention to obesity prevention interfaces and systems that aim to catalyze healthy behavior. Although much of this work explores systems designed for adults, an increasing number of studies and systems focus on adolescents and youth.

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One recent area of focus is pedometer-based fitness systems. These systems automate data tracking, provide pervasive access to fitness data, and work to incentivize increased physical activity. In general, youth-focused fitness systems in HCI have been designed to provide competitive or social comparison-based motivation. These experiences are typically facilitated within a small group of close friends or a coach-led competition. However, these approaches have some limitations. Competition-based systems may motivate only top performers, providing little motivational support for other participants [10,17]. Participants in school-based fitness deployments that employ rewards and direct competition often return to pre-deployment activity levels after the removal of the deployment system [9,10,12,17]. Systems that leverage strong ties for close friends may not be able to reach a large number of students and are limited to cliques where there is at least nascent interest in improved physical fitness.

We see an opportunity for a different approach: school-based pervasive social fitness systems. These systems, embedded in existing school and community practices, can leverage scalable, non-competitive social interaction to catalyze positive perceptions of physical activity and social support for fitness, while remaining grounded in the local environment. Evidence from previous school-based fitness systems and social behavior change theory gives us reason to expect a school-based social approach might prove valuable, particularly the potential of non-competitive social support to enhance collective efficacy and observational learning.

To more fully understand the potential and possible limitations of this approach, we created a school-based microblog and pedometer system for middle school students. We deployed our system—StepStream—for four weeks to 42 students attending the same US middle school in the Spring of 2013. During the deployment, students wore wireless pedometers daily, accessed the system's website from home and at school, and met weekly at the school to use the website and socialize with each other. As we will show, StepStream users improved their attitudes towards physical fitness and increased their sense of social support for fitness through the course of the deployment.

In this paper, we show how the design features of the StepStream deployment motivated a key population: low-income minority adolescents with below-average physical activity levels. We show that our school-based social fitness approach performed comparably in attitude and behavior change to more competitive or direct-comparison systems, and we expand the strategies available for fitness deployments beyond competition and direct social comparison. StepStream wasn't perfect—convincing students to log on from home proved more difficult than we anticipated, and overall step count improvement was modest. However, our school-based social fitness approach to everyday adolescent health shows the potential for social computing systems to positively influence offline health behaviors in real-world settings.

RELATED WORK

Adolescent fitness systems in HCI seek to motivate behavior change through attitude change, while leveraging self-efficacy or social comparison theory. Related systems generally fall into three categories: exertion interfaces, pervasive social systems outside the school context, and school-based competitions. In this section we describe related systems and theories of behavior change, and then identify opportunities in theory and system design.

Motivating attitude change

Most adolescent fitness studies in HCI focus on developing self-efficacy: the confidence an individual has in his or her ability to achieve a fitness goal [1]. Originally developed and validated for adults, self-efficacy is also an important component of adolescent-focused fitness interventions [5].

Social motivators may be especially salient for youth, as adolescents are particularly sensitive to peer opinion. We highlight two common social motivation theories: *social comparison* and *social support*. Social comparison theory proposes that people are motivated to adjust their behavior based on how others view them [10,17]. Thus, the theory suggests that adolescents will adjust their behaviors in a setting where they can compare to peers and superiors. This tactic can have both positive and negative results. For some, social comparison provides the boost they need to 'keep up' with the crowd. For others, social comparison may become demotivating, especially if the perceived average of others in a cohort appears unobtainable (and this is especially true for minority girls) [11]. Social support theory offers another social motivation strategy, arguing that positive social encounters and discussion are likely to lead to sustained behavior change [8]. Peers, parents, teachers and other people in childrens' lives can provide social support in many ways; prior work in HCI has focused on companionate (joining or encouraging activity), esteem (encouraging confidence) and informational support (providing tips or strategies) [8,23].

Exertion interfaces and exergames

Adolescent fitness research in HCI has long focused on augmenting the experience of exercise: providing immediate tracking and rewards for exertion and making the process more fun. This approach, adapted from Mueller's "exertion interface" concept [21], has been shown useful in lab and classroom settings. For example, Berkovsky et al's *Play, Mate!* system leveraged a marble game mechanic: as participants moved their bodies, a marble moved through a 3D world towards a goal [3]. However, there is little evidence that short-term exposure to exertion interfaces has significant long-term attitude and behavior change benefits [15]. In response, HCI health researchers have called for more focus on theory-based attitude change as a metric for success, rather than relying on short-term activity gains [15].

MacVean and Robertson's iFitQuest system [17] is an example of an exergame explicitly designed to increase self-efficacy for adolescent fitness. iFitQuest is an iOS-based mini-game system in which a group of 12 adolescents met several times a week for 20-30 minute outdoor exergaming sessions supervised by their teacher. Students played mini-games that encouraged them to run and jump around a common playing field. iFitQuest is interesting because it encourages students across activity levels: students play next to each other, but each student's score is relative to individual performance and goals. The iFitQuest study showed encouraging improvements in participants' self-efficacy for fitness, their belief in their ability to meet fitness goals. However, the sensor data indicated a novelty effect over time, with students gravitating to lower-intensity games as the study progressed.

Pervasive social systems

Other adolescent fitness systems in HCI focus on direct social comparison. These systems have mainly been deployed outside the school setting, focusing on small groups of close friends. Chick Clique, for example, allowed up to four girls to see their own progress and that of three close friends [21,31]. Participants in the study wore pedometers and entered their step counts into the system. These steps were immediately visible to other participants. Chick Clique proved encouraging; the girls in the study felt supported and motivated by the social presence of their close friends. However, such small-group systems may be challenging to scale: group selection appears to be important, youth must already have a supportive peer network willing to engage in direct comparison, and no such system has yet tackled the complexity of shifting friendships and relationships over time.

School-based competitions

We have seen the benefits of the school as deployment site for adolescent fitness systems in our own work. In 2009 and 2010, we studied one such system: a pervasive pedometer competition called the American Horsepower Challenge, or AHPC. Developed by Humana Games For Health and sponsored by the Humana Foundation, the American Horsepower Challenge took real-world fitness data and fed it into a virtual environment [9]. Over the course of a four to five-week "heat," 20 students in each school wore shoe-mounted wireless pedometers that uploaded students' steps to a base station located in their school. Students could then access the game website, which allowed each student to check their individual progress as well as the progress of the school [32].

Both AHPC and iFitQuest are examples of a successful school-based deployment leveraging social support. In our AHPC study, students averaged an increase in their step counts by approximately 900 steps [9]. However, we found the school-based structures that made the AHPC successful were largely emergent; the most successful schools were ones where teachers created social rituals and local incentives [20,24]. Moreover, we found the overtly competitive approach likely undermined the desired results. For example, some schools chose physically fit students to represent the school and increase the likelihood of winning.

That said, the social benefits of the school as a fitness deployment site have thus far been underexplored in HCI. As our study of the AHPC shows, the schoolhouse provides a structured way for students to engage with fitness technology, providing rituals, space and time for deployments [24]. By engaging students as members of a social institution situated in a local community, school-based deployments can leverage existing social structures to promote sustained fitness practices [2,12].

Opportunity: self-efficacy beyond the individual

Previous systems have taken advantage of self-efficacy theory to motivate behavior and attitude change. However, other parts of self-efficacy have been underexplored in social computing systems for health. Over the years Bandura and others extended self-efficacy to encompass a variety of social influences on individual behavior. We highlight two: collective efficacy and observational learning effects.

A direct corollary to self-efficacy, *collective efficacy* describes an individual's "beliefs about the ability of a group to perform concerted actions that bring desired outcomes" [18]. Collective efficacy takes the social nature of individual effort into account, and focuses on the extent to which a student believes higher fitness levels are normal and achievable by her and her classmates.

Self-efficacy theory also offers a potentially less demotivating alternative to social comparison: *observational learning effects*. Through observational learning (defined as "learning to perform new behaviors through peer modeling") individuals can change their own behaviors in reaction to changes in social norms, rather than just comparing themselves to high-performing individuals [18]. Critically, observational learning effects have been shown to be especially effective in adolescent-focused behavior change applications [30] and adolescents' self-efficacy is more tied to an emerging sense of agency associated with their transition to adulthood [33].

The difference between designing for self-efficacy and designing for collective efficacy & observational learning is a subtle but important one. Prior systems designed for social comparison typically allow students to directly compare their activity with other individuals. Observational learning effects, however, would tend to emphasize a comparison to the group. Combined with collective efficacy, there is an opportunity to reflect group success back to the individual as a motivational tool without competition. Additionally, few persuasive health systems design for peer social *support* (which involves the user as both giver and recipient), opting instead for the more egocentric model of social comparison. Instead, pervasive social computing systems based on peer encouragement and social support, powered by observational learning, offer the potential to reflect a group sense of expertise and success back on the individual.

SYSTEM DESIGN

Based on our analysis of previous systems (including our own experience studying the AHPC) and the social behavior change theory literature, we designed our own system: StepStream, an after-school program and social network site for middle school students to share and encourage everyday lifestyle activity. StepStream allows participating students to check their daily and historical step counts, read congratulatory messages about the their fitness accomplishments and the accomplishments of their peers, write their own messages, and play a collaborative game.

Formative work

To understand how adolescents from our target community think about technological approaches for encouraging everyday physical fitness, we conducted several formative participatory design studies over the course of three years. In these studies, we worked with 112 students age 11-14 in small groups to generate storyboards and skits for pervasive social health games. We also conducted a multi-week pilot trial of StepStream, and redesigned the system based on participant use and feedback [19].

School-based

Rather than just deploy pedometers and our web blog, we leveraged the school-based nature of StepStream to blend online and offline interactions. We set up weekly after-school check-in meetings in the school computer lab so participating students could meet and hang out, supervised by study staff and a teacher from the school. We limited participation to students in one school, so everyone viewing an individual participant's message or activity was someone in their close or peripheral social sphere.

Weekly after-school meetings were a key part of the system design, and directly inspired by our formative work. The strongest theme to emerge from our formative work was students' desire for 'social presence'—the sense that their friends and classmates would be available to play and chat. Students in our formative studies told us repeatedly how much they valued live interaction and the sense that their friends and classmates were present in a social health system [19]. Through regular meetings during the deployment, we sought to encourage students to blend the StepStream website into their offline social interactions, giving students time and space for indirect comparison and observational learning with fitness as the backdrop.

Pedometer-based

StepStream tracked step counts as a proxy for students' everyday lifestyle activity. Pedometers have often been used in social fitness deployments for youth, and we wanted the physical computing portion of our system to be robust, familiar to users and easily comparable to previous work. Students wore FitBit Zip pedometers that store 30 days of activity and have a battery life of 3 months. Daily step counts were uploaded to the website through a base station positioned in a common area of the school.

Social interface

In StepStream, we consciously incorporated social communication in the website design. This, we hoped, would provide more opportunities for social support. As soon as students logged in, they were taken to the social stream, where they could see other students' messages, records of games other students had played, and congratulatory posts for students who exceeded their own baselines on a given day. This design inverts the common approach in social fitness applications for youth. Other systems either focus on the individual's progress primarily (e.g. the FitBit dashboard) or on the raw step counts of friends [31]. StepStream focuses on what friends are saying and doing within the system.

Indirect social comparison & observational learning

Unlike most previous systems, StepStream was not overtly competitive; it offered no rewards for outperforming other students and there was no common leaderboard for direct comparison. The American Horsepower Challenge, for example, showed students how their school was doing compared to other schools, and focused on direct raw step count competition. Chick Clique showed users their friends' raw step counts in a persistent list.

We carefully limited students' visibility into each others' progress. StepStream generated congratulatory messages for each student who walked above their baseline average. However, raw step counts were only visible to the person who walked them; students could not see each others' raw physical activity. Instead, they saw and shared activity points. Each student received 400 activity points for an average day's steps. When a student walked more than their daily average (that is, garnered more than 400 points in a single day) the system generated a congratulatory message in the social stream for all to see. Others could not see exactly how much the student had walked, but could see the student's personalized achievement. This allowed StepStream users to focus on personalized achievement and general awareness rather than competing directly. Instead of direct social comparison, StepStream enabled an indirect means of observational learning—and made way for students to observe general trends and learn from them. In doing so, we hoped to avoid some of the more demotivating aspects of social comparison.

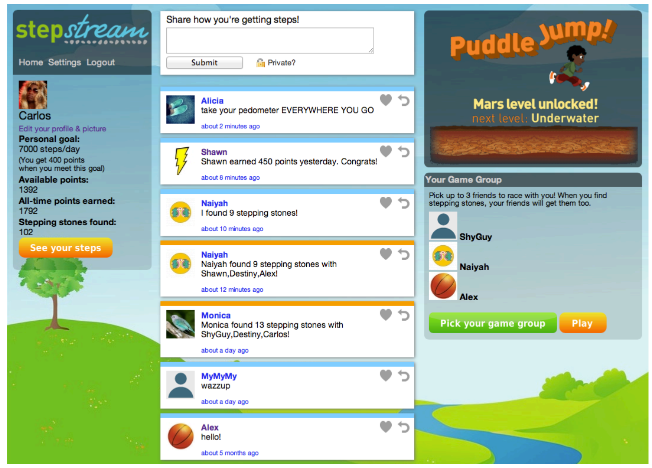

Figure 1: StepStream website screenshot: personal info on the left, the social stream in the center, and gameplay on the right.

Collaborative gameplay for collective efficacy

Students could use their activity points to play *PuddleJump*, a racing game we designed for StepStream based on our formative studies [19]. We hoped this game would create a common experience and be a reason for students to log in from home, creating a collective sense of achievement within & between in-person sessions. Each gameplay cost an average day's points. In the game, students raced through multiple levels, and must jump to avoid puddles in the road. As they played, students collected "stepping stones." Once the students had collectively found enough stepping stones, a new level in the game was unlocked (which we hoped would generate a sense of collective efficacy). The game was single-player, but students could choose to play the 'with' up to three friends (asynchronously). When the student finished the game, their friends also got any stepping stones the student found during gameplay, and the website generated a gameplay message mentioning the player and friends in the stream.

METHOD

The StepStream study is part of a multi-year project aimed at engaging schools and students in an urban community around health and social computing. As part of this larger project, we have worked with students likely to face adult obesity. We have employed a variety of methods to understand students' preferences and reactions with respect to social systems for fitness, ending with a month-long deployment of the StepStream system. Along the way we have collected and analyzed design concepts, system usage logs, focus groups and interviews.

Participants

We drew participants from a public middle school in a large urban school district in the Southeast United States. This school was selected in coordination with the local educational authority. The project team met with district representatives to discuss the planned activities and purpose of the study, and these officials helped identify a school likely to benefit from an adolescent obesity-focused intervention.

Demographics

Forty two (42) students participated in the study. Students were demographically representative of the school as a whole: 45% male (school: 53%), 55% female (school: 47%), 76% African American (school: 69%), 10% Hispanic (school: 9%), 14% Asian (school: 7%). The median age for participating students was 13, and most students were in the 6^{th} and 7^{th} grade. Although we didn't collect income information from the students themselves, 72% of students at the school qualify for free or reduced meals from the Title I program, a US federal meal assistance program targeted at children in low-income households.

Based on self-report, students in the study are not significantly more overweight than national averages (about 1 in 3 American adolescents is overweight or obese). Thirteen students (31%) qualified as overweight (>1 standard deviation above average) [7]. However, the students in our study face higher than average risks of becoming overweight or obese. They live in a majority-minority low-income medium-density urban community with low walkability. Significant race-correlated health disparities exist in their local community; for example, in 2010 68% of Black or African American adults in the county were overweight or obese, compared with 52% of White adults. [13] Additionally, both lower-income and minority households report feeling significantly less safe walking around their neighborhoods, a statistic often correlated with higher rates of obesity [26,27,29].

Students' Internet & social media use mirrored national averages. Students reported going online an average of 2.65 hours per day, and all but two students regularly accessed the Internet from home. For comparison, the 2011 Pew Online Teen Demographic survey reported that 92% of 12-13 year olds go online [22].

Deployment

We conducted a four-week deployment of the StepStream system in Spring 2013. We met with students as part of an after-school program once a week, for a total of five meetings. Before the first meeting, we set up a base station (a PC located in the school security office with a dedicated WiMax connection) and created accounts for each pedometer. Each time students walked past the base station, the pedometers uploaded their steps.

After-school meetings

In partnership with the deployment school, we created an official after-school program held immediately after school for one hour a week during the course of the deployment. One teacher was present at each meeting as a representative of the school, but did not engage in the research activity and generally sat in the back of the room grading papers. This weekly after-school structure served as a familiar template for the students, teachers and administration, and gave us the ability to check in with students throughout the deployment.

In the first meeting (held in a classroom in the school), we conducted pre-intervention surveys and distributed pedometers. We showed students how to wear the pedometers and then took them to see the base station (located in the security office at the school entrance) and instructed them to walk past it at least once per day. During the first week, we collected students' pedometer data from the base station but did not give them access to the system website, so we could establish baseline activity levels and give students a chance to get used to the pedometers. On the day before the second meeting, we created a baseline average daily step count for each student. We took the mean of their daily step counts for days where they recorded more than 1,000 steps. This allowed us to set a personalized baseline for each student.

In the second meeting, we met the students in the school computer lab and gave students access to the website. Students logged in and we showed them the various features of the site. This introduction lasted about 15 minutes, after which students were free to use the system, chat and hang out for the remainder of the hour. The researchers reset and replaced any malfunctioning or lost pedometers, and walked around answering questions. We also held the third and fourth meetings in the computer lab, giving students time to interact with the system and report broken or lost pedometers. In these meetings, students generally gathered in four to five clusters and then logged into the site. The computer lab had five rows of 10 computers each, so students were able to sit near friends and chat. The researchers spent the bulk of these meetings replacing pedometers and resetting passwords for students.

In the final meeting, students took a post-intervention survey and we conducted a focus group to talk about their experiences during the deployment. Several weeks later, we met with students again and conducted three smaller focus groups with 8-10 students each.

Data collection & analysis

We evaluated StepStream in several ways: through pre/post surveys, focus groups, log data analysis of participants' interactions on StepStream, and step data analysis.

Pre/post surveys

We distributed surveys before and after the deployment. These surveys were designed to expose significant changes in participants' attitudes to physical activity, sports and fitness, as well as social support for fitness. The surveys we used have been validated for use with children and based on the survey instruments used in many physical activity interventions, including the AHPC (e.g. [4,9,14]). Our surveys are taken directly from prior work in physical activity promotion. Our self-efficacy questions are taken from the SPARK school-based physical activity project

[28]. We also gave students a modified version of the "Social Support and Exercise Survey", a standard measure of peer social support for exercise. To complement pedometer data, we surveyed students using the IPAQ measure for physical fitness, which asks students to report time spent exercising over the last 7 days [28]. These measures have been used extensively within the physical activity literature, and were first used in HCI by our previous study of the AHPC. We drew our questions directly from the AHPC survey to facilitate cross-study comparison. We compared pre and post surveys using the Wilcoxon Signed Ranks test for within-subjects designs.

Focus groups

After the deployment concluded, we conducted four focus groups: one with all participants, and three with smaller groups of 8-10 students each. In the focus groups, we sought to understand whether or how StepStream changed the way students think and talk about health and fitness, and to better understand how they fit the deployment into their daily lives. We focused on gathering students' individual experiences of StepStream, and we probed them to tell us about their use of the system outside of the weekly meetings. We concluded by asking students what they would change about StepStream.

Log data & step data

We also collected log data from the system including logins; articulated friend relationships and their changes over time; posting; even lurking. We qualitatively analyzed students' messages using an iterative coding method where two researchers independently coded each message, then agreed on a common set of codes, and then independently coded a second time with the common code set. We also performed descriptive quantitative analysis of logins and message frequency.

To analyze students' step data, we concentrated on a sub-sample of 21 students who ended the study with sufficient baseline and post-baseline data for analysis (that is, they had four or more step days in the baseline week and 12 or more step days over the rest of the challenge, following best practices from the youth pedometer literature [25]). Students in our sub-sample mirrored the participant pool in all ways we could measure, including average BMI (6 [29%] overweight), ethnicity (16 [76%] African American, 2[10%] Hispanic, 3[14%] Asian), gender (9 male [43%], 12 female [57%]) and average age (12.5). Critically, our sub-sample did not appear to be more active: average steps per day for the sub-sample (6408) were almost identical to the overall average (6481). The in-the-wild nature of school-based fitness deployments means students may often lose or forget to wear their pedometers on certain days, and focusing on a sub-sample with more robust step count data is a common procedure in youth-focused pedometer-based deployments [16,25]. For example, in the AHPC only 66% of students qualified for step data analysis [9].

We analyzed students' average steps per day, looking for overall improvement and correlations with other variables, such as baseline steps per day. Following best practices from the physical activity literature, we imputed missing data using the baseline average (that is, assuming no change post-baseline) and performed repeated-measures ANOVA tests for significance [25].

FINDINGS

StepStream users reported increased enjoyment of physical activity and increased peer support for fitness. Students used StepStream within and between our after-school meetings, and exercised regularly throughout the deployment. Students enjoyed the game, but played it less often than we had hoped. We also saw indications that participants with lower initial activity levels made the most improvement in step counts over the course of the deployment. In this section, we report the results of our surveys, focus groups, and log data analysis.

Improved attitudes & social support

Since health behavior change theories all focus on attitude change as a prerequisite to sustained behavior change, we were particularly interested to see how StepStream may have influenced students' perceptions of their own abilities, comparison to other students, and fitness in general.

Overall, the results from the surveys were encouraging. Compared to a pre-deployment survey, StepStream users reported increased enjoyment of physical activity ($Z=-1.89$, $p<.05$, $r=.67$). Social support indicators were also encouraging: overall, students were more likely to think of their friends as partners in their everyday fitness. Students reported greater encouragement for physical activity from friends ($Z=-1.92$, $p<.05$, $r=-.46$). We asked about peer social support in the focus groups and free-response section of the survey as well, and students shared a variety of ways this social support manifested. One typical such response came from a student who told us "My mom bought a pedometer and we walked together." Another shared "Sometimes when you walk with your friends it's like more fun than doing it yourself."

Students also reported feeling a greater sense of fitness expertise as a result of StepStream. Compared to the pre-study survey, students in the post-study survey reported that friends were more likely to ask them for ideas on how to get exercise ($Z=-1.96$, $p<.05$, $r=-.49$). Participants were also more likely to talk about how much they like to exercise ($Z=-1.92$, $p<.05$, $r=.53$). One student even reported being mildly chastised for her enthusiasm: [eventually] "my teachers and family and friends were like stop [talking about pedometer fitness]." Another student told us that he valued the ability to connect with others similarly interested in fitness. "It's a great way to connect with other people who like to exercise and communicate."

We saw no statistically significant changes in more deep-seated or long-term attitudes, such as participants' perceptions of their own abilities in sports they currently play, their abilities in other organized physical activities such as PE class, or their self-reported time engaging in sports. It is also possible that some of the increase in students' interest and enthusiasm could be attributable to participating in a pedometer trial itself.

However, the changes we did see were encouraging. Adolescents' attitudes to social support for fitness are difficult to change, and statistically significant improvements in these attitudes do not always occur, even in otherwise successful systems [16]. In the AHPC, for example, students' reported levels of fitness enjoyment did not increase, and while students reported increased social support from teachers, social support from friends and parents stayed the same [9,23].

Increased step counts for least active

StepStream appeared to help those most in need of elevated fitness levels: those whose initial baselines were below the group average. We found a moderate negative correlation between improvement over baseline and starting baseline (Pearson's R of -0.6). The overall trend for all subjects was modest. Students averaged 6137 steps/day in the baseline period and 6465 steps/day while using StepStream, but the difference was not statistically significant. However students whose initial baselines were below the group average (the lower 50%) improved their daily step counts by an average of 1,088 steps/day while using StepStream (repeated measures ANOVA, $p=.02$). Similar improvements have been seen in adolescent pedometer programs in the health promotion literature; in these studies, an increase of more than 1,000 steps/day is considered significant, when combined with improvements in psychosocial indicators. It is also common for these studies to show significant improvement for lower activity youth with only modest improvements overall [16]. In our previous work, students in the AHPC improved their daily step counts by 828 steps compared to baseline, and the lower 50% improved their daily step counts by 1364 steps/day [9].

Website use and the social stream

The social stream in StepStream was an even mix of social discussion, physical activity posts and gameplay reports. A total of 502 posts were generated during the deployment. Students could create free-form public messages in the website using a prompt box at the top of the page, and the system also generated posts when students played a game, marked each other as friends, and when students had an above average step count. Students wrote 187 (37%) messages, played 186 (37%) games, and StepStream generated 129 (26%) system notices.

Students used the website the most during the after-school meetings. 65% of logins occurred during the meetings, and 35% of logins occurred between meetings. System use followed a consistent pattern during the course of the deployment. For example, 39 users logged in to StepStream on the day of the first meeting, and 30 on each of the subsequent meeting days. Meeting days also saw the highest non-meeting logins: 7 each, compared to an average of 3 non-meeting logins per day overall.

Web site activity continued regularly through each meeting. Students sent an average of 7 messages per minute during these meetings, peaking at 9 messages per minute about 40 minutes in. We gave no additional instructions during the meetings, and students could easily have logged in once and then abandoned the system for the rest of the hour. We therefore interpret students' messaging activity as an indication of interest beyond doing what they were told.

As expected, some students posted messages about health. These messages took the form of advice and encouragement for fitness (e.g. "BRING YOUR PEDOMETER WITH YOU EVERYWHERE YOU GO!"), or public commitments (e.g. "I'm going to walk around to stay FULLY ACTIVE!!!!!"). 1 in 10 messages was health-related.

However, a majority of the messages in StepStream were primarily phatic in nature, that is they conveyed little 'content' but were instead intended for social grooming, identity presentation or emotion display. Many messages were variants on 'welcome' such as "HI ^ ^", "HI THERE! :)", "wazz up my people" or "hey everybody". Although they peaked in the first session, these 'welcome' messages continued throughout the study. 1 out of every 3 messages was a 'welcome' message. In addition to the 'welcome' messages, we saw everything from 'nonsense' messages (e.g. "JKYZSCY7TSFGTVSCY…") to messages that were just another user's username. We also saw evidence of inter-personal statements in the stream. For example, some students even tried to start rumors of a relationship between two other students.

Students used StepStream naturalistically, chatting and playing with each other throughout and between in-person meetings. We expand on these issues in the discussion section.

StepStream beyond the classroom

We also looked at the pedometers as physical manifestations of the StepStream system. Students took their pedometers (and thus a piece of StepStream) with them everywhere they went. In our observations and focus group discussions, students reported being emotionally attached to their pedometers. Upon entering the computer lab for the weekly meetings, we were often met with a short line of students with devastated faces, apologizing for having lost their pedometers. Overall, about half of the students in the deployment lost their pedometer at one point. This was partly due to the nature of pedometer deployments; any youth-focused pedometer deployment will result in substantial pedometer loss.

Students wore their pedometers in some surprising places. For example, 11 students reported wearing their pedometer in the shower, and several accidentally put the pedometer through the wash. 14 students even wore the pedometer to bed. One student told us "I went to bed and when I woke up I had like 112 steps. And I was like 'I sleepwalk!'" Another student kept her pedometer close at hand during the night "It was like the middle of the night and I needed to go to the bathroom, so I put it on to get steps. So I went to sleep and then I woke up and it was on."

Gameplay

Gameplay was the one area in which StepStream performed below our expectations. While students played *PuddleJump* throughout the challenge (that is, there was no steep drop-off or measurable decline in usage across the deployment), gameplay mainly took place during the in-person meetings. Overall, 70% of games were played during the meetings.

Students played the game an average of 5 times each over the course of the deployment. Students also used the social aspect of the game: they had the option of choosing up to three friends to play with, and after the first day, all gameplay sessions were 'with' at least one other user. However, we designed the game to be played two to three times per week; we hoped to extend the social presence of the in-person meetings into asynchronous, daily use. While students enjoyed playing the game, they seemed to prefer not to play it when others were not around (that is, between meetings). This result was disappointing because we were counting on the game to generate a sense of collective efficacy outside of the weekly meetings and to act as a light incentive to wear the pedometer daily (since students could only play the game if they had walked enough steps). Fortunately, (as we describe in the next section) the meetings themselves became important events for establishing collective norms.

This result may be due in part to students' persistent desire for live interaction. We knew from formative work that participating students would value live interaction and that the social presence of their peers would play a key role in the system's success [19]. This preference for live interaction is reflected in our focus group discussions and surveys as students told us they wanted their friends to be in the game with them live, and in person if possible. Students may also simply have tired of the game; we are not professional game designers or game researchers, so the game itself was merely designed to be "good enough" to act as a diversion and give students another reason to log in between meetings. We based the game's design on similar games created by students in our participatory design studies (and on popular commercial games such as Jetpack Joyride and Temple Run), but one simple game may never have been enough to generate significant interest on its own. In focus groups and surveys, many students told us they wanted to see a greater variety of games in future versions of the system. In our own future work, we plan to take this suggestion to heart.

DISCUSSION

Overall, our study results provide evidence that the combination of the StepStream website, pedometers and regular after-school meetings created a system that allowed students to socialize around fitness. Our study also raises interesting questions about school-based social fitness systems for youth, particularly around the social support mechanisms at work, the in-person component of the deployment, and the promise of "hanging out" as a strategy for sustained long-term use.

Social support, & observational learning in StepStream

Users of StepStream reported higher levels of peer social support for fitness after using StepStream. We suspect a combination of features within StepStream itself may have impacted students' sense of peer social support. There were at least two features of the website designed to generate this sense of peer support: automated congratulations and gameplay success messages. Students who logged into StepStream were likely to see a mix of messages from other students, congratulatory messages for other students, and successful gameplay sessions. We suspect that this combination of real messages and physical activity reports created the feeling that students were hanging out *around* fitness, if not actually talking *about* fitness. Students' messages made the site feel alive, and the gameplay and step achievement posts weaved in health-focused content.

This in-person social support complemented social support occurring outside the schools. In our surveys and focus groups, students told us they made time to exercise together and talked about the system with each other on occasion. However, offline discussion alone was unlikely to be responsible for the level of change in social support we observed with StepStream. For comparison, in the AHPC—which relied almost exclusively on offline means of social support—students reported little improvement in peer social support [9]. Taken together, the social support implications of StepStream are heartening; students can be reluctant to talk about health topics, and a system that can engage them without forcing artificial discussions may prove more sustainable in the long term.

Meetings as digital events

To the extent that StepStream improved students' sense of social support and attitudes towards fitness, it seems to have done so *because* of the school-based meetings and students' time together. While students engaged with the system daily by wearing a pedometer, about two thirds of website logins occurred during the three weekly one-hour after-school meetings we held in the school's computer lab. We designed these meetings to primarily be check-in sessions, where students could log in and check their steps, share a tip about how to get steps or an encouraging note, and seek help with pedometer replacements or repair. But in the course of the deployment, we came to realize the meetings had a more significant role: as digital events and catalysts for blending online and offline social interaction, with fitness as a backdrop.

The meetings occurred right after school, and students arrived energized and ready to socialize. Although we were not able to observe every conversation, the general topic of these conversations was often anything but health. Mainly, the meetings seemed to serve as a space to "hang out" with friends and classmates, with fitness in the background. That students would use a social system for this grooming, chatting and play makes sense—hanging out is what adolescents do online [6].

However, StepStream was an important and constant backdrop in these meetings. Most students left StepStream open for the whole hour, checking in with the social stream. They posted messages and played games throughout the meetings. Students would break to chat with each other, then look back at StepStream and post or play another game. Students were more than simply attending a meeting, or sitting alone together glued to their screens. If anything, during the meetings students were *together together*: hanging out in small groups throughout the computer lab while monitoring and responding to the social stream.

"Hanging out" as a self-sustaining strategy

If adolescents adopt a social health system into their normal "hanging out" behaviors, such systems have the potential to shape those interactions and foster new norms. This is a delicate process: StepStream took a light touch, advocating personal improvement and discouraging competition. It's possible that a more proscriptive or overtly curricular approach might be rejected, but when done appropriately, these sorts of 'digital events' hold great promise for youth-focused social health deployments.

In carving out a blended online/offline space with fitness as the backdrop, StepStream appeared to foster a 'new norm' around fitness, and targeted opportunities for observational learning. Students observed each other playing the game, hanging out in the fitness system, and being congratulated for getting steps and internalized this. While hanging out together, students undoubtedly engaged in social comparison, but without leaderboards or step counts, their opportunities for competition were (purposely) reduced.

Additionally, StepStream appeared to avoid the initial novelty effect often associated with the introduction of a new technology, in which participant interest in the system wears off and activity slows. Within the study period, we saw little evidence of such a novelty effect (such as a drop in logins, messages or meeting attendance). Sustaining middle school students' interest over even a month-long program can be challenging. However, structuring our deployment as an after-school program allowed students to periodically re-connect, and allowing students to hang out without 'doing work' within the meetings may be a key reason for students' continued engagement through the end of the deployment.

Theory meets reality

StepStream shows the promise of a social computing approach to make important attitude and perception changes in the short term. We designed our system to encourage peer social support and observational learning effects without relying on direct social comparison or competition, and this produced encouraging increases in key attitude, social support and physical activity measures. By letting adolescents 'hang out' around fitness without proscribed 'top-down' motivational techniques, we provided opportunities for observational learning effects.

However, a month-long study is not long enough to show true health behavior change or to encounter longer-term novelty effects. Students' self-efficacy for fitness remained largely unchanged, and providing a non-competitive sense of collective efficacy (through the game) provided more challenging than we'd anticipated. Additionally, our one-school study design means we can't directly compare competitive and collaborative design features within our deployment.

Still, our study shows that a blended online/offline social approach to adolescent fitness offers an encouraging model for others, and a valuable lesson for longer-term studies. To truly test this approach, we hope to run a multi-site deployment over a longer time span. This will let us manipulate individual design features and test the long-term potential of our approach.

CONCLUSION

In this paper, we introduce school-based social fitness systems for everyday adolescent health. Our approach—embedded in existing school and community practices that privileges collective awareness over competition—leverages observational learning effects and collective efficacy, and blends online and offline activity and interaction through website and intervention design.

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