Development, Testing and Implementation of a New Running Game to Foster
Situational Interest in Students.

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List of Abbreviations

AIDS - Acquired Immune Deficiency Syndrome
ANOVA – analysis of variance
CDC – Centers for Disease Control and Prevention
CVD – Cardiovascular Diseases
HIV - Human Immunodeficiency Virus
ICT - Information and Communication Technology
INT – Interim Situational Interest Questionnaire
LED – Light Emitting Diode
METs – Metabolic Equivalent of Tasks
HPB – Health Promotion Board
PAR-Q – Physical Activity Readiness Questionnaire
PCN – Park Connector Network
PE – Physical Education
POS – Post-activity Situational Interest Questionnaire
PRE – Pre-activity Situational Interest Questionnaire
SCT – Social Cognitive Theory
SDT – Self-Determination Theory
SI – Situational Interest
TPB – Theory of Planned Behaviour
TTM – Transtheoretical Theory
WHO – World Health Organization
Summary

Physical inactivity is of concern globally. This study is a humble attempt to provide a possible intervention mechanism for improving physical inactivity. This is done by investigating if the developed running task game with infused gamification using mobile devices is effective in arousing Situational Interest in 16-17-year-old Junior College students. Pilot study affirmed the effectiveness of the developed running game. The main study adopted the yoked experimental design and consisted of the experimental versus yoked in the first phase and evaluated sustained interest in the second phase. The findings provided significant differences in Situational Interest (Novelty, Wilks’ Lambda (Λ) = .49, F (1,39) = 40.98, \( p \leq .01 \), effect size \( \eta^2_p = .51 \); Challenge, Wilks’ Lambda (Λ) = .51, F (1,39) = 37.07, \( p \leq .01 \), effect size \( \eta^2_p = .49 \); Exploration Intention, Wilks’ Lambda (Λ) = .52, F (1,39) = 35.39, \( p \leq .01 \), effect size \( \eta^2_p = .48 \); Instant Enjoyment, Wilks’ Lambda (Λ) = .55, F (1,39) = 32.52, \( p \leq .01 \), effect size \( \eta^2_p = .46 \); Attention Demand, Wilks’ Lambda (Λ) = .66, F (1,39) = 19.71, \( p \leq .01 \), effect size \( \eta^2_p = .34 \); and Total Interest, Wilks’ Lambda (Λ) = .48, F (1,39) = 41.81, \( p \leq .01 \), effect size \( \eta^2_p = .52 \)) and between activity intensity zones (Q (2) = 4.00, \( p = .0046 \)). Rate of Perceived Exertion (RPE), average heartrate and time taken to complete the activities showed no significant differences. Sustained interest was found to be statistically significant (Q (2) = 32.40, \( p < 0.05 \)). However, there were no differences between the number of future attempts. In conclusion, the study has provided sufficient evidences for a possible mechanism in future solutions combating physical inactivity.
Chapter 1 Introduction

1.1 Background

Physical inactivity is on the rise globally and it has been associated with negative health consequences. A population that is physically inactive, has a higher chance of stroke, cardiovascular diseases and diabetes. Singapore is no exception (WHO, 2010). Recently attempts were made to tackle the problem of physical inactivity by focusing on youths as a target group to increase their physical activity (Biddiss & Irwin, 2010; Russ, Webster, Beets, & Phillips, 2015). The current study is such an attempt. The objective of the present study was to investigate how a novel running game can be designed, using insights from the domain of gamification and technology, to arouse students’ (situational) interest and to eventually make them exert more physical effort.

In this chapter, first an overview of the problem will be presented by highlighting the issue of physical inactivity and how it affects the population. Following this, the aims, hypotheses and significance of the study will be presented and discussed in the subsequent sections.

1.2 Physical Inactivity.

In 2008, an article was published by the World Health Organisation in which it was stated that there were approximately 3.2 million deaths globally, attributed to the lack of physical activity (WHO, 2017a). In the same article, it was highlighted that physical inactivity also stems from sedentary behaviour that has increased due to occupational and domestic activities. Urbanisation has resulted in several environmental factors such as highly dense traffic on roads; low air quality or the existence of pollution; and lack of parks, sidewalks and sports and recreation facilities. Despite the South East Asian Region showing the lowest percentage in prevalence of insufficient physical activity amongst the World
Health Organisation (WHO) Member States, the numbers are climbing slowly over the years. It has also been agreed to set a target of 10 percent reduction in physical inactivity by 2025 as a global effort to combat physical inactivity and reduction in non-communicable diseases (NCD).

In Singapore, based on the statistical report in 2012 (WHO, 2017c), the main causes of death in both the male and female population are due to cardiovascular diseases, diabetes and cancers. These have been proven to be adverse outcomes of physical inactivity (WHO, 2010). The National Health Survey (Ministry of Health, 2010) showed that the group of greater concern for not getting the recommended physical activity levels belong to the ages between 18 and 69. Among this group, concern lies with the school-going youths and it has been shown that influences on behaviour change are easier to be implemented in schools (Van Cauwenberghe, Maes, Spittaels, Van Lenthe, Brug, Oppert, & De Bourdeaudhuij, 2010; Kriemler, Meyer, Martin, Van Sluijs, Andersen, & Martin, 2011). Also, it had been shown that Junior College students (ages 16-18) had the worst physical activity levels compared to students in the Primary (ages 6-12) and Secondary (ages 12-16) school levels (Chia, 2010). It has been reported that about two-thirds of adults who participated in two or more sports when they were in their youths, were two to three times more likely to participate in vigorous physical activities than those who did not participate in sports in their youth (Dishman et al., 1985). Thus, this study is a modest attempt to reduce physical inactivity by testing the mechanism of a new running game which aimed to stimulate students’ interest
1.3 Proposed framework.

Running was used as the proposed activity because there were less barriers to participate. Other activities require additional equipment such as rackets, bikes and skates. The improved running game would also allow the tracking of physiological measures on physical activity like heart rate monitors, time taken, and perceived rate of exertion on the activity. These measures can be useful indicators when comparing its effectiveness with more conventional games.

Central to the design of the novel running game was the use of technology as a motivator to arouse students’ interest in the game and engage them in higher levels of physical activity. It is known that youths hold positive inclination towards the use of technology; smart phones, tablets and other Information Technology (IT) gadgets that occupy a central part of their lives (Seow, 2016). The present study attempted to capitalise on such inclination towards technology and it was expected to result in increased interest for the game. Motivation, or interest, for the game was operationalised by means of Situational Interest (SI) (Chen, Darst, & Pangrazi, 1999), which will be discussed in the next section.

1.3.1 Situational Interest. Studies related to Interest can be traced as far back as the last century. Two broad categories namely Individual Interest and Situational Interest stems from these studies (Dewey, 1913). Individual interest is stable, remains unchanged and consistent in most circumstances. Individual interest develops over time and is mostly the result of acquired experience (Dewey, 1913). For instance, interest for football can evolve from an early age, due to influences from significant others (father, friends, etc.), and can mature over the years to become self-motivating that is not easily deterred. Situational Interest on the other hand is aroused by situational stimuli (Hidi, Anderson, Renninger, Hidi, & Krapp, 1992; Reeve, 1996; Chen & Darst, 2002). For instance, a student who is introduced
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to a new game, may feel interested to find out more about this game and try to play it.

Research has shown that aroused Situational Interest can, if sustained in the long run, evolve into Individual Interest (Dewey, 1913; Schraw & Lechman, 2001; Rotgans & Schmidt, 2017). Other studies have attempted to find out how Situational Interest can be aroused; and what are the underlying psychological mechanisms. For instance, Rotgans and Schmidt investigated how the lack of knowledge affects the levels of Situational Interest (Rotgans & Schmidt, 2014) and others examining the use of Situational Interest on physical education interventions (Chen et al., 1999). Regarding the latter, five elements of Situational Interest (Chen et al., 1999) seem to play an important role: (1) Novelty; (2) Challenge; (3) Attention Demand; (4) Exploration Intention; and (5) Instant Enjoyment. These five elements are expected to be influenced by the infusion of technology, such as mobile devices, in sports activities.

1.3.2 Design using mobile devices. Novel ways that tap on technology to make conventional workouts interesting has sprouted in recent years (Deterding, Dixon, Khaled, & Nackle, 2011). For instance, the Asphalt Gym (Asphalt, 2016) in New York compliments workout sessions with the presence of strobe lights, glowing and flicker lights as pacers or as stimuli to bring a new dimension to the mundane workout sessions. Technology has advanced greatly for such creative ideas to be possible. Creative ideas to gamify mundane activities are also evident in mobile devices. An example is the Pokemon Go game which was launched in 2016 (Channel News Asia, 2016). This Augmented Reality-based game allows players to walk around the streets while attempting to catch virtual Pokemon they see on their smartphone screens. Pokemon Go has garnered over 20 million players worldwide (Dogtiev, 2018). This shows that games using mobile devices can attract the interest of users. In a global survey by Deloitte’s Global Technology, Media and Telecommunications (TMT), it
was revealed that playing games on smartphones was the most popular activity among smartphone users across South-east Asia (TODAYonline, 2015). The popularity of these games can be explained with the insights gained from the field of gamification.

**1.3.3 Gamification.** Introduced in the early 2000s, the main difference between gamification and game is that gamification is generally used to achieve goals outside the game itself. For example, gamification could be used as a platform to bring about awareness of good diet or an unconscious effort to exercise whereas the game is often autotelic (Koivisto & Hamari, 2014). Key features of gamification include visual scores, badges, leader boards, challenge in various levels, associative elements, etc. The principle of gamification includes a reward system which encompasses not just tangible rewards like trophies and prizes but also rewards in terms of status, privileges, etc. (Buckley & Doyle, 2016). Also, gamified activities tend to have specific rules and goals with quantifiable outcomes (Smith-Robbins, 2011; Salen & Zimmerman, 2004). Another concept of gamification is the association with feedback that provides reflection and learning that does not prevent failure but to develop a positive relationship with it (Buckley & Doyle, 2016; Lee & Hammer, 2011). An example is the combination of the traditional sport climbing and gamification. In the bid to increase interest in climbing, Augmented Reality Rock Climbing (Kajastila & Hämäläinen, 2014) can create an activity where climbers accumulate points as they go up the wall, with the goal to hit the specific holds while also being the first to the top. A projector is used to throw numbers up on the wall, so climbers can see the points they want to get. Visual and audio cues tell them when they have acquired the required points. At the end of the activity, there is usually the achievers’ chart that shows the rankings of players. Armed with the insights of gamification, the current study intended to design a new running
game that would arouse students’ Situational Interest in an otherwise mundane running exercise and significantly increase their physical activity.

1.4 The improved running game.

In this study, a web-based application in the Android platform, the App Inventor 2 (Massachusetts Institute of Technology, 2013) was used for the IT component of the new running game. Features of the game supported by the App Inventor 2 included: (1) the display of real-time scores to provide instant feedback; (2) the possibility of creating varying difficulty levels of the game; (3) cloud storage of data obtained during the game. Other features of the game included the leader board (where current fastest time to complete the game was articulated to the participants) and the various stimuli in the form of sound and sight.

The improved running game followed the idea of performing/doing shuttle runs between the various tablets. The objective of the new running game was to be the first to obtain 20 points. In this new running game, playing against three virtual competitors, the aim of the participant was to steal points from the virtual competitors to reach 20 points and at the same time preventing other virtual competitors from achieving the same objective. The T-shaped setup of the game included the Home Base (represented the participant’s Base) and three other Bases (each represented one virtual competitor) depicted by a tablet that is mounted 20 meters from the Home Base (Figure 14). Participants started from the Home Base after the verbal cue “Go, Go, Go!” and visual cue in the form of a countdown timer display, both from the tablets. Once the activity has started, the participants can choose to steal a point from either one of the virtual competitors. A point was added to the Home Base when the participant made a successful shuttle. Each shuttle was defined as running from the Home Base, stealing a point from the virtual competitor’s base (by touching on the tablet
screen at the Base), returning and adding a point to the Home Base by touching on the tablet screen. The virtual competitors stole from each other and from the participant. The programme was also designed such that virtual competitors could also obtain points from the Nest (virtually), which was not available to the participants. This was done to provide the element of challenge, which is an element of SI. Tablets at the respective bases displayed the number of points of the individual competitors (e.g., tablet at Home Base displayed the points of the participant) and the running time since the start of the activity. The background colour of the tablet screen turned red when a point was stolen, together with a reduction on the number displayed in the tablet. In the case when points are added, the background colour of the tablet turned to green with an addition on the number displayed. The development and testing of the new running game was intended to address several aims and hypotheses which will be elaborated below.

1.5 Aims and Hypotheses

The aim of the research was to develop and test a new running game to gain deeper insights to which extent technology is capable of arousing students’ Situational Interest in physical activity. To that end, a two-part study was conducted, namely a pilot study and a main study. The purpose of the pilot study was to provide a feasibility study to test the design of the game which included feedback from participants as well as examining if Situational Interest was evoked by the activity. Based on this feedback, improvements were made, which resulted in the final version of the running game. The revised game was then tested using a larger sample size. In the main study, on top of examining Situational Interest, a survey was also administered to determine if interest would be sustained over a longer period. In the next two sections, more information will be provided about the design considerations for the pilot study and the main study.
1.5.1 Pilot Study. The first aim of the pilot study was to examine the effectiveness of the developed task for the running game in combination with technology that could elicit Situational Interest. It was hypothesised that the infusion of technology is capable of eliciting Situational Interest. Situational interest was measured based on a Situational Interest Scale, developed and validated by Chen et al. (1999). The second aim of the pilot study was to investigate the quality of the physical activity present during the running game by measuring the intensity of the exertion. It was assumed that the participants would be engaged in a moderate to vigorous intensity level for the duration of approximately 12 to 14 minutes. Wrist-based heart rate monitors were used to track the participants’ heart rate and reference to percentage of maximum heart rate as well as calculations based on the Metabolic Equivalent of Tasks (MET) value was used to determine the intensity of the activity. Lastly, the aim of the pilot study was to gain feedback from the participants on how to improve the game.

1.5.2 Main Study. The main study consisted of two phases. In Phase 1, the improved running game which had been improved from the pilot study underwent the yoked control design to establish any possible significance. The yoked control design was “used in operant conditioning experiments in which matched research subjects are yoked (joined together) by receiving the same reinforcement but with different contingencies” (Salkind, 2010). In order to have comparable groups, a yoked-control group was selected in the main study which entailed participants having to first attempt the experimental measure (measures in the improved running game). After which, the route taken was replicated in the yoked session. This was done to ensure that the distance covered for both the experimental and yoked sessions were consistent with only the game as the only variable. Phase 2 of the study was conducted to find out if participants were willing to re-engage with this game in the future.
This constituted an important aspect of the study since it would give insights in how feasible this manipulation is for future applications.

There were two aims and hypotheses that were associated with Phase 1. Firstly, to investigate if the developed task for the running game is effective in arousing Situational Interest in the participants as compared to the yoked control. It was hypothesised that with a developed task that encompasses elements of Situational Interest and gamification, it will be perceived as a more interesting activity as compared to a typical running activity. Secondly, Phase 1 aimed to determine if the quality of the physical activity from the improved running game is higher as compared to the yoked control. It was hypothesised that that the improved running game will be able to better engage the participants and to motivate them to excel in the game, thereby having a higher physical activity level as compared to the typical running activity. In Phase 2, the aim was to investigate the sustained interest to continue with the improved running game. It was hypothesised that participants will want to attempt the game again as satisfied by the principles of Situational Interest (Chen et al., 1999).

Specifically, the main study addressed the three research questions of, (1) “Is Situational Interest evoked from the customised running game?”; (2) “Are there any significant differences in the physical activity intensities between the customised running game and the yoked control activity?”; (3) “Is Situational Interest for the customised game maintained after the main study period?” In this modest attempt to provide a mechanism for improving physical activity participation, it is hoped that the data collected from the research questions would provide some significance to the study.

1.6 Significance of the Study

Previous studies provide evidence that Situational Interest has been effective in text-based interest in academic writing and reading (Schraw & Lehman, 2001; Linnenbrink-
Garcia et al., 2010). However, there were limited studies using Situational Interest in physical activity and none by far using programmable technology (Zhu, 2014). A recent study that investigated the infusion of mobile technology into physical education lesson was found to have little effect in increasing Situational Interest or physical activity levels (Zhu & Dragon, 2016). The above technology infused physical education lesson made use of iPad to provide instructions for practice, included scanning of QR codes, etc. However, there were no elements of gamification involved. Although the concept of gamification and had been experimented in some gym settings, the concept had never been tested in schools and particularly with any 16 to 18-year-old age group. In addition, there is no study that subjected the infusion of technology to systematic investigation, and included Situational Interest and other measures pertaining to physical activity intensity. The present study hopes to make a modest contribution to the literature by attempting to examine the effectiveness of the mechanisms involved in the novel approach to create and develop a running game. The improved running game aims to create interest in physical activity using the principles of SI and gamification. The present study would also contribute by providing educators an option of incorporating easy-to-use programmable applications for physical activities or for analysis using the data collected.
Chapter 2 Literature Review

In this chapter, the problems revolving around the lack of motivation in physical activity among youth will first be discussed. Next, literature on studies made on motivation of physical activity will be reviewed, including the corresponding theoretical models. This will be followed by the relevance of Situational Interest in tackling the lack of motivation in fitness training among youth. The last part of the chapter reviews on how technology and gamification have been used in the implementation of Situational Interest.

2.1 Physical Inactivity in Youths

The issues of physical inactivity and the benefits of being active physically will be discussed followed by the importance of focusing the discussion on the youths. Physical inactivity has caused millions of deaths worldwide (WHO, 2010). Chronic diseases related to physical inactivity include high blood pressure, high blood glucose, obesity, high cholesterol, etc. It is a major healthcare concern not just because of related mortality, but also because there is a trend of earlier onset of chronic diseases (Blair et al., 1989; Fontaine, 2003; Olshansky, 2005; Fernandes & Zanesco, 2010; Kohl 3rd et al., 2012). The main reasons for younger population in modernised countries to suffer from chronic diseases included more desk-bound sedentary jobs; diet and lifestyle changes because of fast pace of life, (Coordain et al., 2005); more convenient transport such as personal mobility devices; and traditional forms of outdoor activities being replaced with online gaming (Shaw & Warf, 2009), etc. To better understand the situation of physical inactivity, other physiological and psychological benefits of being more active had to be reviewed because the issues of sedentary behaviours and physical activity participation are not inversely related (Wang, Chia, Quek, & Liu, 2006).

There are numerous benefits associated with physical activity (Janssen & LeBlanc, 2010; O'Donovan, 2010). Other than reducing the risks of chronic diseases, physical activities
improve cardiorespiratory and muscular fitness and overall function and health. Other physiological benefits include improved bone density, and prevention of fall for older adults (Health Promotion Board Singapore, 2011). Psychological benefits associated with physical activity included improved mental health and self-esteem (Wang, Chia, Quek, & Liu, 2006; O'Donovan, 2010). Although there are many reported benefits of physical activity and repercussions of physical inactivity, achieving the recommended physical activity levels, particularly in youths, is still a problem in developed countries.

Common barriers to physical inactivity among adolescents include lack of facilities, equipment, and trained staff for physical education (Samara et al., 2015; Kohl et al., 2013). Other considerations and concerns are related to the weather conditions, safety, homework/chores, lack of time, and lack of interest and desire (Tergerson & King, 2002; Allison et al., 1999; Tappe, Duda, & Menges-Ehinwald, 1989). Adding on to the list of common reasons for not adopting a more physically active lifestyle are the inconveniences related to exercise (e.g., the need to change and shower, lack of suitable clothes, etc.), low self-efficacy (Wang et al., 2011) and lack of self-management skills. Setting of personal goals is often found lacking in these cases (Sallis & Hovell, 1990; Sallis et al., 1992). The lack of physical activity participation are worsened by the advances in technology and conveniences that made life easier and less active. A review of qualitative studies by Cockburn and Clarke (2002) highlighted that school girls are not participating in physical activities due to a lack of choice in sports. Even though they might occasionally be curious to try on new sports/activities, the perceived lack of competency and perceived norm of feminine being opposite from the masculine sweaty image has deterred teens from pursuing physical activities (Cockburn & Clarke, 2002). Besides motivation derived from enjoyment of the activity, the review also mentioned development and maintenance of social support networks as an important aspect of physical activity participation. Thus, in this study, it is important to develop a game that
youth feel connected to, for example using mobile devices and elements for gamification, which will be discussed later in the chapter. Also, the developed game used running as the main form of activity which did not require specific skills or equipment and can be implemented in a comfortable environment that is sheltered and had a flat flooring. With the understanding of the global physical inactivity situation in youths and running as a possible form of activity for the game, it is necessary to review the relevance in the Singapore context.

In the next section, the situation of physical inactivity in Singapore is reviewed.

### 2.2 Overview of Singapore’s situation

In Singapore, based on the Health Survey by the Ministry of Health, 39.1% of the population (age 18-69) is not meeting the recommended levels of physical activity and 10.8% are obese (Ministry of Health Singapore, 2010). In line with the key desired outcomes by Singapore’s Ministry of Education of having healthy habits, enjoying physical activities and pursuing a healthy lifestyle (Ministry of Education Singapore, 2009), schools across the country have been engaging students actively with various programmes and interventions over the years.

For sedentary people, it is recommended that they engage in walking to increase their physical activities (Ministry of Health Singapore, 2010). Walking is an ideal physical activity that can reap beneficial results. It is a form of low impact activity which will cause less injury than jogging and with the sufficient intensity and duration (Liautrakul, 2011). The recommended levels of physical activity are dependent on the age group. For instance, those below the age of seven are recommended to have the activity level of 180 minutes each day of the week. For the age between 7 and 18, it is recommended that they are actively engaged with 60 minutes or more of moderate- to vigorous-intensity physical activity every day, including weight bearing activities for at least three times per week (Ministry of Health Singapore, 2010).
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Singapore, 2010). In support of the physical activity recommendation levels, a new Physical Education (PE) syllabus (Ministry of Education, 2016) was introduced in promoting physical activity into adulthood and recognises changing interest across one’s lifespan.

Although Singapore schools play their part to encourage physical activity, it is not sufficient, and students need to engage in additional activities outside of school structured Physical Education (PE) classes (Chia, 2010). Studies have shown that even though youths engage in physical activities outside of school, the accumulated amount is still insufficient to meet the recommendations by Singapore’s Health Promotion Board (HPB). The shortfall in steps corresponded to 3552–4558 step counts (29.6–35.1%) for girls and 4393–5393 step counts (29.2–33.7%) for boys (Chia, 2010) when compared to the international recommended daily step count (Tudor-Locke et al., 2004) of 12000–13000 step counts for girls and 15000–16000 step counts for boys. The above study, which was published in 2010 highlights the decreasing trend of physical activity as age increases. The group that is of concern belongs to students in the Junior Colleges (Chia, 2010). Table 1 shows the mean step counts derived from the study with the corresponding recommended step count from HPB (Ministry of Health Singapore, 2010).
A recent research found that older school-going students in Singapore are significantly less active than their younger counterparts (Wang et al., 2011). The older-school going students consists mainly of Junior College students who will be leaving the formalised education system. Current curriculum in schools requires students to participate in structured PE lessons for less than three hours a week. Other than being less active than their younger counterparts, Junior College students potentially have a high chance of dropping out from physical activity engagement after they completed their post-secondary education (Coakley and White, 1992). In summary, schools are ideal for physical activity interventions as students spend a lot of time within the campus. It is also important to engage Junior College students as studies have shown that they are the least active, compared with Primary and Secondary level students. Having established running as the possible activity for the game
and identifying Junior College students as the participants for the study, the following sections will be reviewing current literature on physical activity interventions.

2.3 Existing Literature on motivation in physical activity

Early works that went into the promotion of physical activity tended to be largely independent of any theoretical models (Buchan, Ollis, Thomas, & Baker, 2012). There was a need for interventions to be informed, supported by the relevant theoretical models and allow subsequent replication. Replication were usually done when previous studies proved to be successful and promoted the various aspects of well-being. This paradigm shift saw authors subsequently focusing towards understanding the determinants and correlates of physical activity, especially psychosocial influences (Sutton, 2008). Over time, many theoretical models sprung up and were modified or improved to better explain the participation and non-participation in physical activities. Even though some models have been used and applied in research more frequently than others, the four more prominent models (Nigg, Borrelli, Maddock, & Dishman, 2008) utilized within a physical activity context are The Social Cognitive Theory (SCT) (Bandura, 1986), The Theory of Planned Behavior (TPB) (Ajzen, 1985), The Self-Determination Theory (SDT) (Deci, 1971), and The Transtheoretical Model (TTM) (Prochaska & DiClemente, 1983).

In general, the approaches deployed in most of the literature has been categorized as either the staged-based approach and the cognitive based approach (Sutton, 2008). There exists other theories and models like the Health Belief model (Hochbaum et al., 1952), Relapse Prevention Model (Marlatt & George, 1984), etc. However, the TPB, the SCT, the SDT, and The TTM models represent those which have been tested and adopted most widely in the health behaviour and physical activity literature (Browning and Thomas, 2005). The
following paragraphs will elaborate on the four more distinct models and lastly how the Ecological model was used in physical activity interventions.

2.3.1 Social Cognitive Theory (SCT). The SCT states that behaviours, personal factors and environmental influences all operate interactively as determinants of each other (Bandura, 1986). It posits that learning by observation and modelling can acquire social skills and many non-social behaviours. The framework is used for understanding, predicting and changing of human behaviour. The three broad factors encapsulating the social cognitive theory consists of firstly, the cognitive or personal factors with specific constructs of perceived self-efficacy, personal belief of expected outcomes and coping of emotional or physiological arousal by an individual. The second broad factor looks at behavioural factors as well as motor or sport skills. Specifically, it looks at the ability to manage his or her own behaviour including setting goals, monitoring and adjusting a plan based on what works, and using self-reinforcement as well as having skills needed to engage in the behaviour itself. Lastly, the environmental factors which involves the social environment and the physical environment. Within the social environment, family members, best friends, and peers, are said to have some influence on physical activity behaviour itself. The physical environment involves opportunities and safe access to facilities or programmes that are necessary to enable a motivated person to be physically active (Bandura, 1999).

The SCT has been widely used in physical activity intervention studies (Perry et al.,1987; Fardy et al.,1996; Neumark-Sztainer, Story, Hannan, & Rex, 2003; Prochaska & Sallis, 2004; McKenzie et al., 2010) with varying methods and mixed results in the outcomes. For example, in the study to investigate the change in physical activity patterns among adolescent girls (Dewar et al., 2013), a year-long physical activity and dietary intervention was conducted with the aims to test the SCT on obesity prevention. The above study is an
extension of the Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) programme (Lubans et al., 2010). A total of 357 adolescent girls from secondary schools in Australia participated in the study. The study aimed to test the SCT using the self-efficacy, outcome expectations and proximal goals as predictors of moderate-to-vigorous physical activities after one year of intervention.

The main objective of the NEAT Girls programme was to promote lifetime physical activities, reducing sedentary behaviours, and encouraging low-cost healthy eating, and to be rolled out in a year at no additional financial cost to the school or students. The intervention was referenced with Bandura's SCT and looked at evidence-based psychological, behavioural, and environmental influences on nutrition behavioural change (Lubans et al., 2008; Cerin et al., 2009) and physical activity. The evidence-based psychological influences included self-efficacy, outcome expectations (perceived benefits), and outcome expectancies (value placed on benefits). Behavioural influences dealt with goal setting and self-monitoring. Lastly, environmental influences involved significant others like the teacher, family members and peer support. The intervention programmes consisted of enhanced school sport sessions, interactive seminars, nutrition workshops, lunch-time physical activity sessions, handbooks and pedometers for self-monitoring, parent newsletters, and text messaging for social support. The parent newsletter reported their children’s time spent in physical activity, sedentary behaviours, and self-reported fruit and vegetable consumption. Also, included in the newsletters were information that sought to increase awareness and encourage parents to support their children's physical activity and dietary behaviours. Social support using text messaging was conducted to reinforce the targeted behaviours, and these messages included reminders on undesirable behaviours like physical inactivity and bad dietary habits. Logistical support came in the form of a standard equipment pack which consisted of
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Equipment ranging from elastic tubing resistance training devices and fitness balls, to Yoga and Pilates lessons.

The results of the NEAT Girls intervention demonstrated the potential for multi-component school-based interventions for the prevention of unhealthy weight gain in adolescent girls. The students involved in the study came from low income communities. Results showed small improvements in body composition and large reductions in self-reported screen time. However, there was no increase in the time engaged in physical activities and no correlation between outcome expectations, intentions, and physical activity. Intention-behaviour relationship was absent as well. The results showed that the SCT only explained 28% of the variance in physical activity after one year. It was also suggested that other models of social cognition with ecological components (inclusion of policies, supporting organisations, etc.) could be integrated or combined in future studies (Dewar et al., 2013). The above resonated with the weaknesses in the social cognitive theory that it is too broad and lacks unifying principles and structure (Ormrod, 2014). Also, the SCT neglects the attention of motivation, conflict and emotions (Flamand, 2017). Of the SCT research conducted on physical activities, only self-efficacy was found to be of any predictive value (Buchan, Ollis, Thomas, & Baker, 2012). The next section looks at TPB which is an example of how self-efficacy is included in the framework.

2.3.2 Theory of Planned Behaviour (TPB). The TPB reinforces the Theory of Reasoned Action with the concept of perceived behavioural control (Ajzen, 1985). Theory of Reasoned Action depicts that one’s performance of a given behaviour is primarily determined by his/her intention to perform that behaviour (Ajzen, 1985). This intention is influenced by two main factors: the attitude of the person towards the behaviour and the influence of the person’s social environment or person’s decision as to whether to perform a certain behaviour.
dependent on his/her perceived social pressure (Ajzen & Fishbein, 1980). Meta-analysis and review affirms that intention is the strongest source of exercise behaviour (Hagger, Chatzisarantis, & Biddle, 2002; Downs & Hausenblas, 2005) and that attitude indeed strongly influences intention. However, both reviews indicated that the influence of significant others under subjective norm, did not predict intentions of exercise behaviour (Hagger et al., 2002; Downs & Hausenblas, 2005). It has also been found that intention-behaviour relationship was most significant within one month of intervention. Though not consistent across reviews, researchers have also found that intention-behaviour relationship in exercise is not homogeneous throughout the population. Ethnicity, maturity, gender and other subject characteristics are possible determinants (Buchan et al., 2012). When applied to exercise behaviour, the use of the TPB in studies as reviewed by Buchan et al. (2012) as well as Downs and Hausenblas (2005) suggest inconsistent or lack of scale correspondence when researchers apply the theory. Also, the theory is age group dependent due the inexperience and/or volitional control. This meant that the theory is dependent on the habits and experiences acquired at various stages of their lives (Buchan et al., 2012). Lastly, the TPB when augmented with elements of self-efficacy seems to be able to provide a comprehensive account of social-cognitive influences on physical activity motivation and participation. Another theoretical framework that looks at individual’s choices and motivations is the SDT, with the exception that the environmental factors are considered.

2.3.3 Self-Determination Theory (SDT). First published in 1971, the SDT (Deci, 1971) assumes that individuals are inquisitive, active, self-driven, interested and eager to succeed by nature. The theory further suggests that individual have three basic psychological needs, autonomy, competence and relatedness (Buchan et al., 2012). In a nutshell, Self-Determination Theory looks at the quality of one’s motivation in each situation and the
The Self-Determination Theory proposes that the motivation and behaviour towards an activity varies from degrees of volitional control or regulated with experiences of pressure that is perceived as not within the control of oneself. An example of such a study (Edmunds, Ntoumanis, & Duda, 2008) looked at female exercise class participants (mostly consisting of university students) enrolled in a 10-week exercise programme that was exposed to the teaching style based on SDT or direct instructional teaching style. In the single-blind intervention design, the leadership style of the instructor was adjusted as per the SDT based teaching style or the direct instructional teaching style (as control) (Edmunds et al., 2008). With the SDT intervention group, the exercise instructor was deliberate on promoting autonomy support by taking the perspective of the exercise class participants into account, acknowledging their feelings and providing them with necessary information and opportunities for choice. In the control group, the prescribed exercises were based on those chosen by the participants in the intervention group. This was akin to other studies where the use of pressure, demands and extrinsic rewards were kept to the minimum (Black & Deci, 2000; Reeve, Deci, & Ryan, 2004). In all the above studies, the structure was established. The structure came in the form of clear expectations, creating sufficient levels of challenge as well as providing timely and informative feedback (Reeve, 2002; Reeve et al., 2004).

In the above study by Edmunds, Ntoumanis, & Duda (2008), the exercise instructor dedicated psychological resources to the participants, showing that she was interested in them, and that she was concerned about their well-being. Qualitative measurements included basic demographics of the participants, perceived support for autonomy, structure of programme and personalised interaction provided by the exercise instructor. Other measurements also included psychological need satisfaction, sources of motivation, behavioural intention and both positive and negative effects. This comprehensive experimental test shows an
intervention in a real-life setting that is based on the SDT. The results from the study suggest that the degree of support to allow autonomy decision, structure and personalised interaction provided by exercise leaders can positively influence behavioural, cognitive and affective responses to exercise.

The limitations of this study consist of 10-weeks duration for the study which may not be long enough to consider the long-term effects of this approach. Also, the lack of generalisation such as consideration of both genders and a wider age group were other limitations. Over the decades, the SDT has laid foundations for further advancements in related areas. They include the effects of social environments on intrinsic motivation; the development of autonomous extrinsic motivation and self-regulation through internalisation and integration; individual differences in general motivational orientations; the functioning of fundamental universal psychological needs that are essential for growth, integrity, and wellness; and the effects of different goal contents on well-being and performance (Deci & Ryan, 2011). Empirical data have provided evidence for value of SDT in understanding and promoting exercise behaviour (Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003). Reviewed study by Teixeira and his collaborating researchers ascertain that all forms of autonomous regulation predict exercise participation across a range of samples and settings (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). The shortcomings of the theory presented in the review include limited studies that show the strength of the theory in longitudinal studies. Also presented are recommendations to expand the work in experimental studies in the exercise domain to better examine the causal mechanisms and process aspects of motivation for physical activities. Other than social-cognitive models such as SCT, TPB and SDT, researchers have considered stage-based theoretical framework like the TTM to address the various limitations.
2.3.4 The Transtheoretical Model (TTM). Transtheoretical Model or stages of change describes the stages that individuals move through when attempting to change behaviour. The stages progress from precontemplation (not intending to make a change), contemplation (considering making changes), preparation (making small changes), action (engaging in new behaviour), to maintenance (sustaining the change over time) (Prochaska & DiClemente, 1983). Social cognitive models presented limitations to behavioural change interventions and this has prompted researchers to use the stage-based approach such as TTM to overcome these constraints (Buchan et al., 2012). The change process in TTM is represented by the behavioural or experiential changes used by an individual to modify their experiences. The theory was originally formulated for interventions of addictive behaviours but has not been very effective in health behaviours. This is because there are fundamental differences between the addictive behaviours like smoking and health behaviours like regular exercise habits. Systematic reviews showed that methodology was inconsistent across studies that seek to promote changes in physical activity attitudes and this could be the result of a poor appreciation of the various stages of change in TTM. Also, the review by Adam and White (2003) reported an insignificant effectiveness of stage-based intervention for long term intervention in promoting physical activities. Interventions focusing on just the individual, neglecting the effects of environment and other social factors may be over-simplifying the multifaceted complex phenomenon of physical activity. To understand the ever-changing complex behaviour revolving around physical activity behaviours, other more encompassing models may be required.

2.3.5 Ecological Model (EM). In this regard, newer approaches like the ecological model were contrived. The EM depicts that the combination of psychosocial and policy variables will best explain physical activity (Sallis, Baumen, & Pratt, 1998). Planning and
implementing of health promotion interventions when using the ecological model seeks to include intrapersonal, interpersonal, organisational, community and policy factors. With the ecological approach, activity is believed to increase when individuals, significant others and other organisations are involved. Similar to the TTM, one will see significant increase in physical activity level when they have developed the confidence in their ability to be active, understands and expect benefits from being active, have the intention to be active and to have the behavioural skills needed to get and stay active (Prochaska & DiClemente, 1983; Sallis, Bauman, & Pratt, 1998). Support in the form of encouragement, role modelling and even transportation support from significant others such as family, friends provide the social environment needed to increase activity levels. This is comparable to the construct of the SCT. Organisational changes to provide access to fun and available policies that support physical activities, topped with skilled staff in the engagement is another construct under the ecological approach. The last construct of community looks at the influences from the community and environment in which they live or spend their time. In this construct, increased physical activity occurs when the environment (community) provides safe access to enjoy physical activities. Moreover, the community can support by reducing the barriers to physical activities and provide access to existing facilities. For example, in Singapore, more playgrounds have been converted to be more children-friendly with inclusion of fitness areas for the general population and the sprouting of more indoor play areas to provide opportunities for physical activities. The disadvantages of the ecological approach as reported by Buchan et al. (2012) is the belief that physical activity behaviours are linear when it is apparent that physical activities involved complex behaviours, resulting from situations, and interaction of factors at various levels. Table 2 provides a summary of the five theoretical frameworks reviewed above. A summary of the gaps and limitations of the SCT, TPB, SDT, TTM and EM as applied in physical activity interventions will be presented following section.
2.3.6 Gaps in theoretical model. The five frameworks reviewed above still present many inconsistencies. For example, SDT does not present the exact process by which motivational orientations are converted into intentions and behaviour and although the TPB has provided an effective basis for the explanation of variance in intentions and health-related behaviour, it has not been able to identify the origins of the antecedents of the behaviour. Also, there are contradicting reviews on the theoretical models even when combined for example between SDT and the TPB (Chatzisarantis, Hagger, & Smith, 2007). The EM, even though it takes into consideration the environment factors, does not take into the cognitive elements and neglects the motivational factors. The behaviour-change processes often require other external cues or prompt to facilitate the influence of the environmental factors (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003). Despite being widely used in previous physical activity studies, the SCT only had predictive value in the domain of self-efficacy and showed positive significance only in self-reports (Ormrod, 2014; Flamand, 2017). The TTM has shown to be effective in short term interventions, however, behaviours associated with physical activity are complex and may not necessary follow in stages as depicted in TTM (Brug, Conner, Harré, Kremers, McKellar, & Whitelaw, 2005). In this thesis, the use of another motivation variable, Situational Interest, seeks to provide an alternative to the many existing theoretical models thereby allowing researchers to relook into more relevant interventions to promote physical activities.
Table 2

*Summary of most pertinent theoretical models commonly used in physical activity interventions.*

<table>
<thead>
<tr>
<th>Social Cognitive Theory</th>
<th>Theory of Planned Behaviour</th>
<th>Self-Determination Theory</th>
<th>Transtheoretical Model</th>
<th>Ecological model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perceived Self-efficacy</td>
<td>1. Intention to act</td>
<td>1. Quality of one’s motivation</td>
<td>1. Changes in stages</td>
<td>1. Intrapersonal</td>
</tr>
<tr>
<td>2. Manage skills/ goals</td>
<td>2. Determined by person’s attitude</td>
<td>2. How behaviour changes in environment</td>
<td>i. Precontemplation</td>
<td>2. Interpersonal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Policy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Key Features*

1. Intrapersonal
2. Interpersonal
3. Organisational
4. Community
5. Policy
6. Perceived self-efficacy
7. Social environment
8. Organisational influence
2.4 Situational Interest (SI)

2.4.1 Interest studies. With the understanding that physical activity behaviours are multifaceted; and that it is a complex entity affected by determinants at various levels, a possible approach that encompasses the key elements in the behaviour change theoretical models, as reviewed above, could be the use of SI. Work on interest can be traced back to the 1800s where German philosopher and pioneer of modern psychology, Johann Friedrich Herbart, perceives that interest allows for correct and complete recognition of an object, leads to meaningful learning, promotes long-term storage of knowledge, and provides motivation for further learning. (Schiefele, 1991, p. 300). Pioneer of functional psychology, John Dewey (1913), concluded that “the appeal to sheer effort amounts to nothing” without interest. When interest has developed, learning may take place. The broad concept of Interest can be further categorised into Individual Interest and Situational Interest. Individual Interest is developed over time during a person's constant and consistent interaction with certain activities in a specific environment. It is viewed as evolving along with a person's knowledge repertoire and value system (Krapp et al., 1992). Therefore, the key to Interest study is to develop a sustainable Individual Interest that may stem from Situational Interest.

2.4.2 Earlier studies in Situational Interest. Situational interest is a person-activity interactive or relational construct. It "flows from a person's relationship with a particular activity" (Reeve, 1996, p. 170) and occurs instantaneously when there is a match between a person and an activity. Situational Interest refers to information that is of temporary value, environmentally activated, and context-specific (Hidi, Renninger, & Krapp, 1992). Evidence of situational interest can be traced back to the works of Schank in 1979. He believed that interest was evoked in numerous ways. One way was via the reference of major life themes such as sex, religion, politics and death. Other ways include the occurrences of unusual and
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unexpected events. Although the specific terms of Individual and Situational Interest were not explicitly used, the described top-down interest seems to appear as being more personal in nature and the bottom-up interest related to that of situational (Schraw & Lechman, 2001).

In the review of literature by Schraw and Lechman (2001), many works in situational interest seems to stem from text-learning. Changing the way participants engage in a task, providing specific cognitive goals, or giving individual reasons to persist in a task may increase Situational Interest via selective attention or a greater desire to find the task interesting (Schraw & Lechman, 2001).

In addition, studies in text-learning have shown that prior knowledge and Situational Interest provided evidence that knowledge is related to interest and learning when readers possess an adequate degree of prior knowledge or when the text provides that knowledge. It has been noted that exceptionally high or low levels of knowledge lead to low interest, whereas moderate amounts of knowledge may lead to higher interest because it creates a desire on the part of the readers to learn more about the topic (Schraw & Lechman, 2001).

Defined as the appealing effect of characteristics in an activity or a learning task on individuals (Hidi & Anderson, 1992), situational interest may provide the necessary social or environmental construct for one to be engaged in exercise or physical activity. The relationship between learning and interest, with emphasis on situational interest has also been defined because of knowledge-derivation (Rotgans & Schmidt, 2014). As an alternative hypothesis, the trigger maintenance hypothesis (Hidi & Baird, 1986) was highlighted. It is assumed that interest is not always a stable attribute of the learner, only changing with the growth of knowledge but it can also be aroused or triggered in various events.

The knowledge-deprivation hypothesis as described by Rotgans and Schmidt (2014) stems from a perceived knowledge gap between an individual and what seemingly needs to be known. In their investigation on students’ learning in history and geography, it has been
demonstrated that the lack of knowledge is critical for the emergence of situational interest and this lack of perceived knowledge must be acknowledged by the learner. Most importantly, it has been found that repeated arousal of Situational Interest leads to significant increases in Individual Interest (Rotgans & Schmidt, 2017).

2.4.3 Constructs in Situational Interest. The effects of situational interest studied were mainly in reading, writing, mathematics, and science education (Chen & Darst, 2002). The general theoretical model delineating situational interest and its situational and psychological sources comprises of seven factors that intrinsically motivate a person to engage in an activity and lead the person to an instant feeling of being interested (Deci, 1992). The multidimensional theoretical model consists of Novelty, Challenge, Exploration Intention, Desire Arousal, Time Alteration, Attention Demand and Sense of Delight. These seven factors under the activity, mental disposition, and interactive experience will now be explained with more details.

Novelty and Challenge are the functional components under the activity category. Novelty has been conceptualised as a gap between information known and unknown, or information deficiency and has a function to elicit human beings’ exploratory behaviour (Berlyn, 1996; Spielberger & Starr, 1994). Challenge has been defined as the level of difficulty relative to one’s ability. It is identified as a factor that might attract one to engage in an activity (Harter, 1978). Exploration Intention, Desire Arousal and Time Alteration fall under the mental disposition category. These functional components are likely to arouse a person’s instant perception of situational interest in the activity and may increase the person’s intrinsic motivation to engage in it (Deci, 1992). Exploration Intention includes the curiosity element where one will be keen to discover the means to improve and to engage in deeper understanding of an activity. Desire Arousal has been described as how inspiring it is for one
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to engage in an activity; whether the activity is appealing and engaging and how one finds it enticing. Time Alteration is defined as perceived time duration for the activity. It is the factor that how one may feel that time has stopped or appeared to be going faster or having lost track of time, while engaging in a Situational Interest-based activity. Lastly, in the interactive experience category, the functional components include Attention Demand and Sense of Delight. They serve as the basis on which the person develops and evaluates the degree of enjoyment offered by the activity.

2.4.4 Key dimensions of Situational Interest in physical activity. Most research on Interest had been conducted in academic domains in the form of text processing and learning, however the study by Chen, Darst and Pangrazi (1999) examined how the above theoretical articulation could be used to examine the multidimensionality of situational interest in relation to physical education and activity. In their study, a four-stage iterative design was used. Each previous stage served as a base on which the next stage was conducted. Stage 1 looked at the suitability of selected statements in distinguishing interest levels between jogging and gymnastics stunts using Cohen’s effect size. The purpose of the Stage 2 was to examine whether situational interest was a multidimensional construct, using exploratory and factor analysis. The five dimensions of situational interest: Novelty, Challenge, Exploration Intention, Instant Enjoyment, and Attention Demand provided significant results after the analysis. In Stage 3, the preliminary model using the six dimensions (including Total Interest) elicited in Stage 2 was analysed using confirmatory factor analysis. In the fourth stage, the construct of situational interest derived from the previous stages was re-examined in a basketball chest-pass and a pass-shoot task using an exploratory factor analysis. Table 3 shows the summary of the method and analysis used in the various stages. The significant results from the four stages provided the basis for the six dimensions of Situational Interest to
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be used in other studies (Chen and Darst, 2001; Subramaniam, 2010; Zhu & Dragon, 2016).

The 24-item Situational Interest Scale (Appendix A) derived from this validation study was used to determine if SI was elicited from the new Running game.

Table 3

**SI validation in physical activity: Stages of Data Collection and Analysis**

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Item Development</td>
<td>Multidimensionality Examination</td>
<td>Multidimensionality Verification</td>
</tr>
<tr>
<td>Stimulus activity</td>
<td>Videoed jogging and gymnastics stunts</td>
<td>Videoed jogging and gymnastics stunts</td>
<td>Videoed jogging and gymnastics stunts</td>
</tr>
<tr>
<td>Instrument</td>
<td>Item evaluation instrument</td>
<td>Situational Interest Scale</td>
<td>Revised Situational Interest Scale</td>
</tr>
<tr>
<td>Data Analyses</td>
<td>Examining distinguishing capability of items using Cohen’s d (effect size)</td>
<td>Exploratory factor analysis, Cronbach’s α</td>
<td>Confirmatory factor analysis, Cronbach’s α</td>
</tr>
</tbody>
</table>


Using the validated construct of Situational Interest in physical activity, Chen and Darst (2001) conducted a study to examine the effects of task design on Situational Interest. The four basketball tasks with varying cognitive and physical demands were, (1) stationary chest pass; (2) defensive footwork; (3) pass-shoot combination and (4) five-minute video on identification of skills. Repeated measures MANOVA was conducted to compare the responses of the 24-item Situational Interest Scale collected immediately after each task. Some findings include, Situational Interest is a function of learning task design in physical
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activities. This finding provided evidence that Situational Interest can be used not just in reading task design (Hidi et al., 1992) but also in physical activity studies. Next, Situational Interest was found to be influenced by the extent of cognitive demand a learning task provided. This was reinforced in other studies that showed enhanced interest in physical activity was to increase the cognitive demand (Subramaniam, 2010). Another finding from the study by Chen and Darst (2001) revealed that perceived Situational Interest is independent of prior knowledge and experience. Lastly, age, gender, individual interest had little mediation effect on Situational Interest. In the study by Chen and Darst (2001), the data collected were limited to short term responses and other motivational factors not being considered.

Electronic technologies including mobile devices have been used as motivation tool to promote Situational Interest and physical activity (Sun, 2012). In a recent study, Zhu and Dragon (2016) investigated the effects of mobile technology integration on student Situational Interest and physical activity fluctuation in physical education lessons. Despite a previous study providing evidence of deeper knowledge being demonstrated in throwing and catching activity due to the utilisation of digital video technology (Casey & Jones, 2011), Zhu and Dragon (2016) was not able to reveal significant results with the use of mobile devices. In their study, integration of technology came in the form of instructions via iPad (mobile device by Apple Incorporated), the use of Quick Response (QR) codes and the use of applications for calculations of heart rates during activity (Zhu & Dragon, 2016). Five physical education lessons which included various fitness stations covering the topics of, (1) Relative physical activity intensity; (2) Heart rate and physical activity intensity; (3) Energy expenditure related to walk/ jog and talk with heart rate monitoring; (4) Energy expenditure related to walk/ jog/ run with heart rate monitoring and (5) Energy Balance were used. The participants in the experimental groups were equipped with additional knowledge on the use
of the above-mentioned infused technology and had lessons started from scanning of the QR codes, following instructions and utilising applications on the iPad to obtain heart rate throughout the respective sessions. In the comparison group, the physical activities were identical except that the participants had verbal instructions from teachers and used only accelerometers. Analysis of variance with repeated measures indicated that students in the experimental group took less steps and spent less time in the moderate to vigorous physical activity (MVPA) zone. Situational Interest levels for the experimental group was also significantly lower than the comparison group. The results were contradictory to the findings by other studies due to several limitations. Instead of using the full scale of 24 items, only the four questions under the Total Interest dimension were selected and used in this study thus the influences of other dimensions were not considered. It was reported that technical glitches may have affected the results in one of the sessions. In their conclusion, it was reported that mobile technology infused physical activities may not be effective over short time duration with no direct physical activity prompt.

In summary, situational interest provides an alternative theoretical approach over traditional behavioural models to encourage learning and possibly in promoting learning behaviours by creating precipitating events. Using the guiding principles of Novelty, Challenge, Exploration Intention, Instant Enjoyment, and Attention Demand as proposed by Chen and colleagues (1999), investigation by means of situational interest considering physiological learning or improvements in physical activities may provide an alternative solution to the crunching problem of physical inactivity worldwide.

2.5 Technology and Gamification to implement Situational Interest.

The next section will look at how technology has become an integral part of peoples’ lives, and how it can be used to elicit the potential of Situational Interest in this current time
and age to tackle the problem of physical inactivity. Also, there will be a discussion on the concept of Gamification which involves the use of technology and how this can aid to implement Situational Interest to enhance the development of an interesting physical activity.

Approximately one-third of the global population are users of mobile devices (EMarketer, 2014) due to advancement in technology. The adoption of the mobile phone by young people is a global phenomenon in recent years and it has been transformed from a technological tool to a social tool, fully integrated into the lives of young people (AkanlisikumAkanferi, Kwami Aziale, & Asampana, 2014). 93% of youths in Singapore were found to own a mobile device based on the latest Young Asians survey conducted by global market research firm Synovate (Chua, 2010). Internet-based use including the use of social media and accessing online materials for their school work or interests has made mobile devices an everyday necessity for youths. Other than communication, the survey revealed that the top uses by youth include taking photos, listening to music and playing games. As such, infusing the use of mobile devices with Situational interest as a guiding principle could provide a possible mechanism for improving physical activity levels. On top of Situational Interest, another concept, Gamification, could reinforce the use of mobile devices.

Gamification is defined as “the use of game design elements in non-game contexts” (Deterding et al., 2011). Gamification was first introduced in the early 2000s, however, the notion of such a concept and attention grew only in 2010 with the emphasis by various industry players and awareness from conferences (Groh, 2012). Systems revolving around gamification commonly employ motivational features like immediate success feedback, continuous progress feedback, or goal-setting through interface elements like point scores, badges, levels, or challenges and competitions; relatedness support, social feedback, recognition, and comparison through leader boards, teams, or communication functions; and
autonomy support through customisable avatars and environments, user choice in goals and activities, or narratives providing emotional and value-based rationales for an activity (Seaborn and Fels, 2015). Using reference to the self-determination theory (Deci, 1971), the game-based design should also encompass the concepts of relatedness, competency and autonomy (Groh, 2012). The principle of relatedness corresponds to gamified systems where it is connected to individual’s goals and linked to a meaningful community of interest. It should also create a meaningful story and considerations should be made in relation to its meanings in the social context. Competency in gamification seeks to provide interesting challenges. Other factors include clear, visual, varying, and well-structured goals as well as timely valuable feedback. Autonomy in gamification means the fact that play should be voluntary and though important this idea should not devalue the activity.

In the review by Johnson et al. (2016), it was highlighted that gamification is an important and relevant health behavioural change concept in today’s world due to several reasons. Firstly, games or gamified systems can intrinsically motivate the initiation and continued performance of health and well-being behaviours unlike other extrinsic motivators like social pressure or overt rewards. Next, as more are engaged in gaming activities, the concept of game design elements become approachable and appealing to wider populations.

Establishing that gamification, mobile devices and situational interest are key constructs of the study. It is important to evaluate how best to incorporate them in this study. To infuse gamification and situational interest using mobile devices, it would be necessary to use existing functions or applications as the platform. However, recent studies have shown that most existing applications do not encompass the whole concept of gamification, let alone the inclusion of Situational Interest (Lister, West, Cannon, Sax, & Brodegard, 2014; Edwards et al., 2016). Therefore, to incorporate all three concepts, application developing platforms were reviewed for the development of an application that could be used in this study.
A search over the internet for application development tools showed many available softwares, including Webflow, Infinite Monkeys, App Inventor 2, Thunkable, Appy Pie, etc. For this research, the use of application development tool has been selected based on its ease of use as compared to microcontrollers. Microcontrollers are more versatile in nature. However, because of the challenges in hardware design (that is, additional knowledge in electronics), thus it was not considered. Based on the constraints and specifications, the App Inventor 2 was selected as the application development tool that would infuse the concepts of Situational Interest and Gamification in a new running game with the use of mobile devices.

2.6 The New Running Game

In the attempt to improve physical activity levels in youth, this study hoped to provide a possible mechanism via a new running game. It has been established that five dimensions of SI, namely Novelty, Challenge, Attention Demand, Exploration Intention, Total Interest and Instant Enjoyment could be infused in the game (Chen, Darst, & Pangrazi, 1999). This establishment was possible as the main activity of the running game is similar to the validation study by Chen, Darst and Pangrazi (1999). The validation study (Chen, Darst, & Pangrazi, 1999) yielded Cronbach’s Alpha (Cronbach, 1951) values of between .78 to .95. Supporting the concept of SI is the idea of gamification which included game elements of the following: (1) self-representation with avatars; (2) three dimensional environments; (3) narrative context (or story); (4) feedback; (5) reputations, ranks, and levels; (6) marketplaces and economies; (7) competition under rules that are explicit and enforced; (8) teams; (9) parallel communication systems that can be easily configured; and (10) time pressure (Reeves & Read, 2009; Deterding, Dixon, Khaled, & Nacke, 2011). Gamification components included (1) leader boards; (2) levels; (3) digital rewards (points, badges); (4) real-world prizes; (5) competitions and (6) social or peer pressure. With the theoretical framework in
mind, the new running game would be developed, and tested. A running game was proposed as it requires the least amount of technical skills. Barriers due to lack of skill like motor control and other specific skills would greatly reduce one’s willingness to participate (Allender et al., 2006; Dishman et al., 1985).

Similarly, to eliminate other factors like social and environmental factors like participating in a group, the proposed running game had to be customised to allow only one participant each time. Warm up activities in physical education lessons, ice breaking games in orientation settings and even traditional games played during unstructured periods can provide some reference for this study. The paragraph below describes some games that have been used in the above-mentioned settings.

2.6.1 Dog and Bone. Two teams line themselves up facing the “Bone” placed in the middle of the playing area (Figure 1). Players in each team are numbered. The game master calls out a random number. The corresponding numbered player from both teams must grab the “Bone” and run back to their team, to attain one point. The opposing player must chase the player who first grabs the “Bone”. If the opposing player manages to catch the opponent with the “Bone”, the point goes to the opposing team.

![Figure 1: Set up of the Dog and Bone game.](image-url)
2.6.2 Game of Kho Kho. The game of Kho Kho (Sen, 2007) is a version of the tag game. The game originated from India. Each team consists of 12 players, but only nine players take the field. A match consists of two innings with each inning consisting of chasing and running. The example below shows an example of one inning, with Team A taking on the role as Chasers and Team B as Defenders. Eight of the nine members in Team A sits/kneels in the middle of the court, in a row, with adjacent members facing opposite directions (Figure 2). The 9th member from Team A starts from one of the poles (located at the end of the playing area), ready to tag the members from Team B. The Defenders (Team B) play in the field, three at a time and the team that takes the shortest time to tag/tap all the opponents in the field, wins. The Defenders can go between players from Team A who are in their sitting/kneeling positions, but the Chaser (from Team A) is not allowed to turn back while running or go between his/her teammates. The chaser can, however, go to pole and touch it and can go back or go to other side. The chaser who has been attempting to tag the Defenders can pass on his/her duty to any of his/her members by tapping on their back and taking over the member’s sitting/kneeling position. The “new” chaser gets up and attempts to tag the opposite team members. When the first three members from Team B are tagged out, the next three members come in. The roles of Team A and Team B will be exchanged when all nine members of Team B are tagged out.
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Figure 2: Set up of the Kho Kho game.

2.6.3 Rob the Nest Game. Like the game of Dog and Bone, each member in the team is numbered (one to three in this example). When the game master calls out a number, the corresponding numbered member of each team picks up an object and places in his/her team base. The object can be from the central pool or from the opponent’s base. Members are not allowed to obstruct or defend opponents stealing from their base.

Figure 3: Set up of Rob the Nest Game with four teams of three players each
The criteria that were used to determine the final game chosen included: (1) the possibility of modification to a single player game infused with the principles of gamification; (2) a game that is not commonly played to provide elements of novelty; (3) rules of the game that are easy to comprehend. Rob the nest game (Figure 3) was used as the reference as it provided the element of uncertainty, challenge and it was a game that allowed many possible variations. Kho Kho had too many variables to the game and Dog and Bone game may not be as engaging for an individual, specific to this study.

2.7 Rationale of study

The pandemic of physical inactivity is of global concern and despite the many interventions; the trend of prevalence has continued to grow. Popular theoretical models provide adequate frameworks for researchers to work on. However, there still exist gaps and there could be clearer interpretations on how each theoretical model could be used or used in combination. Situational Interest provides an alternative to the models, providing key elements like Novelty, Challenge, Attention Demand, Exploration Intention and Instant Enjoyment that are also present in other models.

Based on the theoretical framework of Situational Interest and understanding the relevance of gamification as a form of sustaining interest, this study endeavours to develop and validate a running game that will provide educators and programme coordinators a novel approach to improve the quality of physical activities. A pilot study was necessary, to examine if the stimulus was appropriate for the age group in question, as well as to review possible improvements to the developed application. In the main study, a yoked control would provide a realistic comparison to determine the effectiveness of the running game and the physical intensity of the activity itself.
Chapter 3 Pilot Study

The aim of the pilot study was to develop and ascertain the validity of the game developed for inducing Situational Interest to be used in the main study. It was also an opportunity to identify possible logistical problems related to the execution of the main study. Preliminary data collected was also useful in assessing proposed data analysis. Valuable feedback from participants provided information to further improve the design. The application for the conduct of the pilot study was approved by the Nanyang Technological University Institutional Review Board (Appendix B1). The NTU IRB reference number for this study is IRB-2016-08-036. In this chapter, the development of the task and the design of the running task is first discussed. This is followed by the details of the pilot study, including the results. Lastly, the key takeaways from the pilot study is summarised at the end of the chapter.

3.1 Development of Task

3.1.1 Customised “Rob the Nest Game”. The task in the main study was to test a new running activity implemented as a game. To facilitate that, a customised “Rob the Nest Game” was developed and pilot tested. It was designed and programmed with the App Inventor 2 web-based application developing platform.

The customised game in the pilot study (Figure 4) was designed for one participant to compete against two virtual competitors. The tablets were mounted vertically in a portrait manner at the same height of 125cm above the ground. Identical tablet mounts were used to hold the tablets to ensure minimum obstructions to the touch screen. The objective of the game was to be the first to obtain the designated number of points (virtual eggs). Each shuttle is defined as the run from the Home Base to another Base/Nest and back to the Home Base again. One point was obtained when the participants successfully brought a virtual egg back
to the home base. All four tablets were activated simultaneously with a three-minute countdown timer. While the timer is counting down, participants start their warm-up. Each participant was called back to the base tablet at least 30 seconds before the end of the countdown. The activity started when the countdown timer on the tablets reaches 0. Once the activity has started, the participants could choose to run to the Nest to pick up a virtual egg by touching the tablet’s screen at the Nest. Alternatively, the participants could steal a virtual egg from virtual competitor 1 or virtual competitor 2 by touching the screen at Base 1 or Base 2 respectively. The programme was also made such that virtual competitors could obtain points from either the Nest or by stealing from one another and from the participant. A stolen virtual egg results in the loss of one point. A virtual egg was successfully placed in the Home Base by touching the Home Base Tablet. There was a total of 100 virtual eggs available in the Nest at the start of the activity. The tablets displayed the number of points or available virtual eggs at the respective bases. The activity was terminated upon the decision of the participant, when either one of the virtual competitors had obtained 20 points or when participant had obtained 10 points.
3.1.2 Application Developer Platform. The App Inventor 2, created by Professor Hal Abelson and the team of inventors (Massachusetts Institute of Technology, 2013) was used to create the application that was used to elicit the concept of SI in a running game. The free cloud-based platform is only available online at http://ai2.appinventor.mit.edu/. To use the application developer platform, one needs to first create and login with a valid Google account. After that is done, users will be able to create all the necessary programming and it can be readily saved into the platform’s database.

3.1.2.1 Key design considerations. The developed application was named Pilot Customised Rob The Nest (PRTN). Development and design of the logic and programming was based on the task described in the above. The design process involved four key
considerations. Firstly, the application had to be able to mimic the “movement” of the virtual competitors and reflect the “movement” on the four tablets. Secondly, the sequence and timing of the participant’s movement needed to be tracked so that it could be used for the calculation of activity intensity. Thirdly, the initial and final display on the tablets needed to be considered to provide the necessary cues to start and end the game. Lastly, the inclusion of sound and other visuals during the game were made to provide immediate feedback.

3.1.2 Logic. With the key design considerations in mind, the initial logic for each component were conceptualised and worked on. The tracking of sequence and timing was easily managed with the storage of data when the participant touched the screen of the tablet. Sound and visuals were also simple to be included. Initiation of the activity was done with the concurrent activation of all four tablets which kickstarted the programmed countdown timer of 180 seconds. When the countdown timer reached 0, the participant commenced their run for the activity. The end of the game was marked by the tablet display corresponding to the specific picture (Figure 5) to symbolise the winner (virtual competitor or participant). If the participant had decided to not continue with the activity, the last touched tablet was recorded with the corresponding running time display on the same tablet.
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**Figure 5:** (a) Display at Home base when the participants win; (b) Display at virtual competitor’s base when it wins

3.1.3.3 Design logic difficulty. The biggest hurdle was to address the various situations that may occur with the participant and virtual competitors. The initial idea was to use the cloud storage system and based on the random sequence of possible event, to adjust the values on the tablet. For example, one possible event could be for the participant to steal from the Nest while both virtual competitors stole from the participant. In this scenario, one point needed to be deducted from the Nest tablet after being touched by the participant and simultaneously two points needed to be removed from the participant’s tablet. The initial attempt was to provide each unique scenario on the cloud system and when the tablets read from it at fixed timings, the changes will be made at the respective tablets. Unfortunately, the outcome was not as intended. The next proposed method was to randomise the event and to store the change value for each tablet on the cloud (e.g., for event E1, display value on tablet at Base 1 would have a change value of +1 while display value on tablet at Base 2 would have a change value of -1 while the rest of the tablets remained the same). At fixed intervals, each tablet would access the change value from the cloud and update the latest value to be
displayed. This method was unsuccessful as well. Figure 6 shows the two logics that did not quite work out.

The problem with both methods was the inconsistent retrieval rates which caused values to be erratic. To circumvent the problem, a randomisation of the list of possible events was done, after which each tablet was loaded with the fixed sequence. This meant that the tablets no longer need to retrieve data from the cloud system, making it more stable and reliable. The images of building blocks for creating the application are available in Appendix C.
E1 is stored in the cloud system

Based on the event the number for addition or subtraction for each tablet is stored in the cloud system

Tablets 1-4 go to the cloud at fixed intervals to retrieve respective value

Tablets 1-4 adds or deducts the relevant number to the number on screen.

Tablets 1-4 process the event and adds or deducts the relevant number to the number on screen.

Event selected at random e.g. E1

Event selected at random e.g. E1

(a)

(b)

Figure 6: (a) Event based storage and recall; (b) Value based storage and recall
3.1.3 **Installation.** To test or use the created application, there was the option of creating a QR Code, which can be read by the tablet’s QR Code reader or to create the application file and save it into the tablet directly. The screen shots in Figure 7 show some of the displays programmed.

*Figure 7:* Display on tablets (a) initial screen, location to be selected, (b) Screen selected for Left Virtual Opponent, (c) Long press on screen activates the time stamp and countdown of 180 seconds begins, (d) Points at the base with running time in the corner
3.2 Participants

10 students between the ages of 16-18 were selected from a Junior College to participate in the pilot study. The participants consisted of five males and five females with varied physical fitness levels and different prior experiences in running. Parental approval and participant consent forms were obtained before the start of data collection. All participants were informed of the right to unconditionally withdraw from the study if they wished to do so.

3.3 Instruments

3.3.1 Tablets. Four similar tablets, running on the same Android platform were used in the pilot study. The tablets used were the Acer Iconia One 8 B1-850 (Acer Inc., 2016). Each tablet had a screen size that measured eight inches across diagonally. The audio levels of all tablets were set to be identical (at maximum volume) to ensure consistency in the audio feedback provided to the participants. Brightness and touch sensitivity on each tablet were also set to maximum and high respectively. Using ergonomics as a reference (Salvendy, 2012), the tablets were mounted within the 15 degrees range below eye levels of the participants (height = 1.68 ± .09 meters), with the centre of the tablet at 1.50 meters above ground level.

3.3.2 Situational Interest Scale. Participants’ interest in carrying out an activity, as well as perception of an activity was measured by the 24-item Situational Interest Scale (Chen et al., 1992). Validation studies on the use of Situational Interest Scale in physical activities had been conducted by Chen, Darst and Pangrazi (1999) and has since been used in a variety of other studies including the study by Huang and Gao (2014). The Situational Interest Scale consisted of six subscales, each with four questions namely (1) Novelty (item 5:...
“This is a new-fashioned activity for me to do.”; item 10: “This activity is fresh.”; item 16: “This activity is new to me.”; item 17: “This is an exceptional activity.”; (2) Challenge (item 9: “It is a complex activity.”; item 11: “This activity is a demanding task.”; item 22: “This activity is complicated.”; item 24: “It is hard for me to do this activity.”); (3) Exploration Intention (item 1: “I like to inquire into details of how to do it.”; item 3: “I want to analyse it to have a grasp on it.”; item 13: “I like to find out more about how to do it.”; item 21: “It is hard for me to do this activity.”); (4) Instant Enjoyment (item 8: “This activity is exciting.”; item 14: “The activity inspires me to participate.”; item 15: “It is an enjoyable activity to me.”; item 19: “This activity is appealing to me.”); (5) Attention Demand (item 4: “I was concentrated.”; item 6: “I was very attentive all the time.”; item 7: “I was focused.”; item 23: “My attention was high.”); and lastly (6) Total Interest (item 2: “The activity is fun to me.”; item 12: “This activity is interesting.”; item 18: “This is an interesting activity for me to do.”; item 20: “It is fun for me to try this activity.”). The six factors are Exploration Intention, Attention Demand, Instant Enjoyment, Challenge, Novelty and Total Interest. All questions were randomised in sequence. A five-point Likert-type scale (5 = strongly agree, 1 = strongly disagree) was used for the participants to rate and 24 randomly placed questions. The Situational Interest Scale is listed in Appendix A.

3.3.3 Pre-activity Information. Situational Interest is evoked when there is an awareness of the lack of sufficient knowledge in the related topic (Rotgans & Schmidt, 2014). Using this as one of the guiding principles, the pre-activity information (Appendix D) was administered to provide the necessary information to the participants to stimulate the Situational Interest for the running game. On the other hand, information should be concise and interesting (Lengel & Kuczala, 2010) and not more than 15 minutes to maintain the attention of the participants. Verbal articulation of the pre-activity information was given on
an individual level (“Running as one of the cheapest if not the cheapest form of exercise that one can partake in.”); “Do you know what are the recommended physical activity levels for your age group? It is 60 minutes or more of moderate- to vigorous-intensity physical activity every day, including vigorous-intensity physical activities that may include weight bearing activities for at least three times per week.”; “Cardiovascular training is the base for fitness and participation in sports.”; “With a good cardiovascular base, recovery is faster, able to last longer in games and play, and the obvious health benefit in the long run.”; “2.4 kilometres run test is only one of the ways cardiovascular health is measured which is to provide an estimation of one’s maximal oxygen uptake capacity. The higher the oxygen uptake or VO2 levels, the better one utilises oxygen that is taken in.”; “Other measures, of cardiovascular health include the Cooper test (Cooper, 1969) which correlates the VO2 levels based on the distance covered in 12 minutes, the Multi-stage 20-meters shuttle run test (Leger & Lambert, 1982) commonly known as the Beep Test also provides an alternative to measure one’s cardiovascular fitness.”; “One of the objectives of this game is to incorporate some elements of game and at the same time infuse elements of physical activity/fitness test.”; “A key attribute of people who are engaged in sports and exercise is the ability to make decisions quickly. Through this game, your decision making will be put to the test.”; “With technology advancing and growing awareness of analytics, this study hopes to provide some supporting evidence that it may be worthwhile for future sports venues to be equipped with sensors and visuals alike.”; “Growing popularity of analytics where numbers give sense and quantification to learning and activity levels.”). The Situation Interest Scale was administered the second time within the study protocol after the articulation of the Pre-activity Information to investigate its effectiveness.
3.3.4 Heart rate monitor. The Polar A360 Fitness Tracker (POLAR, 2016) with wrist-based heart rate was used to collect information related to the heart rate during the pilot study to determine the intensity of the activity. The accuracy of the POLAR A360 is based on photo plethysmography (Spierer et al., 2015). Hence the wearer would need to wear them tightly on the wrist to reduce light leaking, and affect the sensor. Once the fitness tracker was snugly worn on the wrist, the participants would swipe on the touch screen of the tracker and the “Training” mode was selected. The “Running” selection within the “Training” mode was activated with the similar swipe and touch actions. The participant’s heart rate would then be displayed in a matter of seconds. At the end of the session, the heart rate including other information like distance travelled, calories, etc. were captured and stored in the device by selecting the option after stopping the activity. This is done by pressing and holding onto the screen for three seconds. As a backup, the POLAR A36+0 was connected to an iPad where the relevant heart rate information was displayed and recorded. Synchronising the tracker post data collection allowed the selection of necessary information to be used via the POLAR Flow platform (Figure 8). Selection of heart rate monitor was based on reliability of trackers, availability, as well as comfort for the participants. The wrist-based heart rate monitor had been validated to be as accurate as ECG (Electro Cardio Graph) monitors used in hospitals (Tuulari, 2015). An iPad was used to link to the heart rate monitor wirelessly. This iPad was used to view the heart rate in real-time and was also able to store the relevant information collected during the session.
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Figure 8: A screenshot of the heart rate information gathered for the duration of the activity
3.4 Procedure

Participants first provided information on their perception and/or interest in running by using the Situational Interest Scale. This was followed by the pre-activity information that was articulated to the participants verbally to arouse SI. The Situational Interest Scale was administered for the second time immediately after the pre-activity information to ascertain if there are any changes to interest in the running game with SI infused into the activity. Participants took part in the customised “Rob the Nest” game. The Situational Interest Scale questionnaire was used for the third time after the game. Lastly, a brief semi-structured interview was conducted to gather participant’s feedback of the activity.

3.5 Results

The first objective of the pilot study was to develop and validate the task for the running game to determine its effectiveness in eliciting SI in the participants. Secondly, the pilot study aimed to determine if the developed task was able to engage participants actively in the moderate to vigorous intensity region. As the pilot test was exploratory in nature with small sample size, no statistical test was carried out.

3.5.1 Situational Interest. The results (Table 4 and Figure 9) showed that SI had increased across the three different stages that the questionnaire was conducted. All the elements in the Situational Interest Scale had a score corresponding to a positive indication of above 83% that they exist in the running game, except for the Challenge component (66%).
Table 4

Means and Standard Deviations (SD) of Situational Interest Scale Questionnaire

<table>
<thead>
<tr>
<th>Elements</th>
<th>Pre(^1) (SD)</th>
<th>Int(^2) (SD)</th>
<th>Pos(^3) (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration Intention</td>
<td>3.55 (0.60)</td>
<td>3.88 (0.56)</td>
<td>4.18 (0.64)</td>
</tr>
<tr>
<td>Instant Enjoyment</td>
<td>2.88 (0.94)</td>
<td>3.95 (0.55)</td>
<td>4.38 (0.63)</td>
</tr>
<tr>
<td>Novelty</td>
<td>1.83 (0.87)</td>
<td>4.13 (0.59)</td>
<td>4.48 (0.64)</td>
</tr>
<tr>
<td>Attention Demand</td>
<td>2.95 (0.90)</td>
<td>3.80 (0.68)</td>
<td>4.25 (0.71)</td>
</tr>
<tr>
<td>Challenge</td>
<td>2.80 (1.02)</td>
<td>3.00 (0.86)</td>
<td>3.30 (1.11)</td>
</tr>
<tr>
<td>Total Interest</td>
<td>2.95 (0.93)</td>
<td>3.98 (0.70)</td>
<td>4.40 (0.55)</td>
</tr>
</tbody>
</table>

Note. \(^1\)Pre-activity. \(^2\)Interim, after pre-activity information. \(^3\)Post-activity.

Figure 9: Responses from the Situation Interest Scale. "Pre" represents the responses before the Pre-activity information was articulated; "Int" presents the Interim responses after the Pre-activity information was articulated; "Pos" represents the Post response.
3.5.2. Heart rate, time taken, and distance covered. Heart rate of each participant was tracked using the wrist-based heart rate monitor. The time taken to complete each shuttle was recorded via the timestamp captured each time the participants contact the touch screen of the tablets. This allowed the total distance to be computed and total time taken to be tabulated. Table 5 shows the summary of the data collected and computed from the running game.

Table 5

Summary of average heart rate, time taken to complete, and distance covered for the pilot study

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Total Time Taken (s)</th>
<th>Average Heart rate (BPM)</th>
<th>Total Distance Covered (m)</th>
<th>METs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>540</td>
<td>166</td>
<td>1171.4</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>610</td>
<td>156</td>
<td>1212.6</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>523</td>
<td>161</td>
<td>1172.0</td>
<td>6.7</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>607</td>
<td>160</td>
<td>1216.2</td>
<td>6.0</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>481</td>
<td>168</td>
<td>1169.6</td>
<td>7.3</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>505</td>
<td>163</td>
<td>1170.2</td>
<td>7.0</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>528</td>
<td>174</td>
<td>1173.8</td>
<td>6.7</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>247</td>
<td>157</td>
<td>647.2</td>
<td>7.9</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>251</td>
<td>155</td>
<td>683.6</td>
<td>8.2</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>246</td>
<td>177</td>
<td>781.2</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Note. ^1Beats per Minute. *Metabolic Equivalents
Based on the calculations, the estimated heart rate zone for 16 to 18 year olds to be in the active in the moderate to vigorous levels are between 101 and 173 beats per minute (CDC, 2015; HPB, 2011). The data collected shows that all participants were active in the recommended levels (CDC, 2015). The Metabolic Equivalents calculation (Humphrey, 2006) also shows that all participants were active in the moderate to vigorous intensity level (WHO, 2017b). This affirms the fact that the running game has an intensity that is high enough to be deeming beneficial in the physical aspect.

3.6 Feedback and Possible Improvements

Immediately after the participants have completed the game, they attempted the Situational Interest Scale for the last time. A semi-structured interview was carried out about five minutes after the game for the participants to recover briefly from the exertion. The interview consisted of two main areas, namely the conduct of the study which included the setup, venue, briefing, etc. and the programming of the game. The responses from the interviews are summarised below.

Conduct of the game:

- The duration of the pre-activity information was ideal, and the content was relevant.
- To have the exploratory element, participants should not have prior knowledge of the game or to observe other participants during the game.
- The height at which the tablets were mounted was ideal for all the participants.
- It will be more realistic to put images of people above the tablets belonging to the virtual competitors. Many felt with the presence of the photos, they feel more motivated to work towards a win.
The presence of a score chart could motivate the participants to work harder to have their names on the chart. However, the flip side of that is if the timing is made known in the score chart, it will provide an indication on how long the game might be. To harness the advantages of the score chart, a possible alternative is to include the name and class only.

The size of the tablets is ideal. If they are too big, the participants could view the various tablets from a further distance and make decisions earlier. Smaller screen size on the other hand makes touching a little more difficult.

There was generally positive feedback on the design of the game however, the participants felt that it would be better with the following improvements to the game:

- The setup of the tablets created discrepancies in the distance between the Nest to the Home base and the distance between the virtual competitor’s base to the Home base. Many choose the route to the Nest more than the others due to the distance. A setup of equidistance would be more ideal.

- The tablets were designed to prevent “double-tapping”, however the setting could be set to be more sensitive as there were many instances where participants had to move back again to re-touch the tablets.

- The activity was intense while it lasted. However, some participants felt that it could be longer as they felt the game concluded too quickly. A duration of approximately 12 minutes was ideal. On the other hand, there were others that felt it was too tiring to focus on the activity for more than 10 minutes.

- In this pilot study, all participants managed to win the game. However, when revealed that someone has achieved a higher score, most of the participants wanted to try the game again to get a better score.
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- It was an interesting game which many wanted to play again to see how they could pace themselves better and do even better.

- It was agreed by all participants that the common winning point of 20 should have been set.

- The initial number at the Nest could be reduced to between 15 to 25 as well to increase the difficulty and create additional situations for the participants.

- The sound signal was essential as it provided feedback on whether the tablet registered the touch.

- Most participants could not understand the change in the background colour of the display. Some felt it was just random changes to the display. Others felt that this visual stimulus could be better articulated. The reason for this visual stimulus was to create the exploratory element. Participants would be constantly exploring if their guess on the colour change corresponded to the change in the displayed number. Thus, it was not explained the reason for the colour change in the display background.

- There was one participant who felt that it would be more interesting if two participants compete against each other in this game. For this study, this may create additional uncertainties and variables that the current study may not be able to explain. However, this suggestion could be considered for future researches.

- Some provided suggestion for other programme logic that involves reacting to certain decisions made by the participant. However, due to the lack of knowledge and competency of the researcher, this may only be possible in future studies.
3.7 Lessons learnt from the pilot study.

Despite positive responses indicating that the customised running game was a suitable activity, there were still many areas that could be improved.

3.7.1 Preparation. The preparation prior to the pilot study was very critical as there was only one researcher setting up, briefing the participants, troubleshooting technical glitches and collecting data. Careful planning and understanding the manpower constraints can ensure that essential information was captured, and study was carried out properly. Due to an oversight, there was one set of data that could not be used as the heart rate tracking was not activated. Also, getting too many participants and collecting data back-to-back is very exhausting and risk the chance of missing certain critical information. One of the tablets was not usable just before the first participant started. There was time wasted getting the backup set and setting it up.

3.7.2 Developed application. The user interface of the App Inventor 2 was very intuitive, making it easy for beginners to work on it. However, more time and experience were needed to work out a logical flow in programming to ensure a seamless transition between the various functions of the game. The pilot study allowed the opportunity to explore possible ways to improve the application. With more time to prepare and improve for the final main study, more attention could be put into ensuring the other applications in the tablets do not interfere with the programme and every tablet is updated with the latest operating system.

3.7.3 Pre-activity information. The aim of pre-activity information was to arouse interest in the participants. Although the pilot study showed significant results, some
participants might have missed out information as it was communicated verbally. For the final study, written information was used instead, to prevent any other effects due to the tone or way the information was articulated to the participants.

3.7.4 Heart rate monitors. More attention needs to be given to the participants in order for the trackers to operate properly. A few participants did not select the mode to capture the heart rate or did not select the save option after that. Also, the session in the iPad that was used for was void as there was an expiry date set, unknown to the researcher. Fortunately, the full day tracking mode was available for retrieval.

3.7.5 Participants. It is very important that the participants are not able to view the game in action prior to their turn, this is because it will affect the decision-making process and may lose its novel effect.

3.8 Improved version.

The feedback provided by the participants as well as the situations experienced during the pilot study were considered. The following improvement were included into the revised game.

3.8.1 Procedure. The procedure for running each participant’s session is consequential for quality data collection. Participants will first complete the PAR-Q (Appendix E) form, followed by putting on the heart rate monitor. It is important that the heart rate monitor is set in the correct mode to capture all proceedings of the session. After that, the front loading of information as well as details of the activity is briefed to each participant. A consistent three minutes warm up ensured that participants were adequately
prepared for the activity. Thirty seconds before the start of the activity, the heart rate monitor is double checked to make sure data had been recorded. Ten seconds before the start of the activity, the heart rate is noted down. Although the finishing time is recorded online, it is also recorded manually upon completion of the game. Immediately after the game, participants indicated their level of perceived exertion levels using the Borg’s Rate of Perceived Exertion (RPE; Borg, 1982; Appendix F) scale. This is followed by filling up of the 24-item SI scale and lastly, the survey on whether the participants would want to attempt the running game again.

3.8.2 Setup. A T-shaped setup was used for the main study. The change from the fan shaped setup was due to inconsistent run distances during the pilot study. With the T-shaped setup the improved game becomes more challenging as participants will have to make decisions looking at all the tablets. In the T-shaped setup, there is a wider angle of vision where participants needed to process the various information. As shown in Figure 10, varying paths in the fan-shaped setup were generally due to last minutes decisions, tied to various stimuli from the tablet displays. The yellow sector depicts the angle of vision of the participants. In a T-shaped setup there a wider angle of vision that participants needed to cover to process the various information for decision making. All tablets were mounted at the same height using the mobile badminton poles and tablet mounts (Figure 11)
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Figure 10: Examples of actual paths taken by participants during the pilot study.

Figure 11: Mounting of the tablet on the badminton pole.
3.8.3 Application. Every tablet (including the standby piece) was updated with the latest operating software. Also, unnecessary applications were disabled to prevent any background operation, notifications or updates. The “long-press” function to activate the four tablets simultaneously was modified to include a “lock” mechanism. Hence when participants accidentally activated the “long-press” function, the app would not be restarted. The game was modified to have three instead of two virtual opponents and a nest. The “cloud-based” nest was only available to the virtual competitors. Participants had to get 20 points (like the virtual opponents) to win the game.
Chapter 4 Main study

4.1 Introduction

The pilot study provided information that led to the improved version of the customised game. In the improved game, it was ensured that the scheduling and process of the participants to undertake the various activities was more spread out or done over more days. The venue for the activities was also changed to a T-shaped setup as compared to a fan shaped set up. This change was made from the pilot study as participants were making different shuttle running distances which would affect the comparisons between the participants. For the instruments involved, a review of the developed application was made to reinforce unnecessary disruptions that may arise during the activities. Improvements to the four tablets and one spare tablet include disallowing all updates of other applications and not allowing unnecessary applications to be running in the background. Other improvements made to the instruments include, (1) pre-activity information was printed in hardcopy instead of being read out to the participants; (2) ensure all heart rate monitors were worn correctly with the correct settings (Figure 12); (3) images of virtual competitors were included to create a more realistic competition; (4) equal winning point of 20 for virtual competitors and participants.
Figure 12: (a) The initial screen with labelled heart rate number (number 5). (b) swiping the screen up and down and touching the screen to select training. (c) running mode was selected by similar swipe and touch. (d) display of heart rate and duration of activity.
The main study consisted of two phases, with the first conducted in two sessions, the experimental (treatment) condition and the yoked control. The yoked control session was conducted one week after the experimental condition session. The second phase of the main study looked at whether participants would be willing to participate in future sessions of the improved game, as an indication of sustained interest. Approval from the Nanyang Technological University Institutional Review Board with reference number IRB-2017-08-031(Appendix G2) was obtained before the commencement of the main study. Based on the feedback and evaluation of the pilot study, the main study had been devised. The main study was conducted with the intent to address three research questions, namely (1) “Is SI evoked from the customised running game?”, (2) “Are there any significant differences in the physical activity intensities between the customised running game and the yoked control activity?”, (3) “Is there sustained interest for the customised running game?”. The corresponding aims of the study were firstly to investigate if the developed task for the running game was effective in arousing SI in the participants as compared to the yoked control using the Situational Interest Scale. Next, the heart rates, perceived exertion levels and time to compete the activities were used to determine if the quality of the physical activity from the improved running game was better than the yoked version. Lastly, we examined the level of sustained interest for the improved game after the main study period using the “Willingness to participate” survey (Appendix H).

4.2 Method

4.2.1 Participants. Forty students (20 male and 20 female) between the ages of 16-18 were recruited by convenience from a Junior College to participate in the study. Participants in the main study were not part of the pilot study. Based on G-power calculations, with effect
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size = .26, alpha at .05, and power = .8, the sample size needed was 32. Considerations for possible participant drop-out had been factored in. Parental approval and participant consent forms were obtained before the start of data collection. All participants were informed of the right to withdraw unconditionally from the study if they wished to do so.

4.2.2 Instruments. The instruments that were used in the main study were similar to those in the pilot study. They included the improved “Rob the Nest” game; the application developer platform, App Inventor 2; four tablets running on Android platform; the Situational Interest Scale; the pre-activity information; the “Willingness to participate” survey and lastly the wrist-based heart rate monitors.

4.2.2.1 Situational Interest Scale. The validated (Chen, Darst, & Pangrazi, 1999) Situational Interest scale was administered at the end of the improved running game and at the end of the yoked control session. The instrument consisted of 24-items measuring six subscales (e.g., Novelty, item 5: “This is a new-fashioned activity for me to do.”; Challenge, item 11: “This activity is a demanding task.”; Exploration Intention, item 13: “I like to find out more about how to do it.”; Instant Enjoyment, item 8: “This activity is exciting.”; Attention Demand, item 23: “My attention was high.”; and lastly Total Interest, item 18: “This is an interesting activity for me to do.”). All items were scored on a 5-point Likert scale (1: “Strongly Disagree”; 2: “Disagree”; 3: “Neither Disagree nor Agree”; 4: “Agree”; 5: “Strongly Agree”). The reliability of the six subscales was determined by generating Cronbach’s Alpha (Cronbach, 1951). The alpha-values for the six subscales were as follows: 
\[ \alpha_{Novelty} = .88; \alpha = .76; \alpha_{Challenge} = .84; \alpha_{Exploration Intention} = .76; \alpha_{Instant Enjoyment} = .87; \alpha_{Attention Demand} = .80; \alpha_{Total Interest} = .84. \] The mean alpha for the entire Situational Interest Scales was \( \alpha = .83 \), which is indicative of acceptable reliability.
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4.2.2.2. Heart Rate Monitoring. The first was in the form of heart rate monitoring that was elaborated in Section 3.3.4. Previous studies (Keytel et al., 2005; Firstbeat Technologies Ltd., 2007) have showed strong correlations between heart rate monitoring and activity-based energy expenditure which had been widely used as a tool for measuring physical activity. The A360 wrist-based heart rate monitor developed by Polar Electro Oy (Polar, 2016) used in this study has been validated to be reliable in the detection of heart rate using the technology of photo plethysmography. In the study by Okita, Ayabe, Higashino, & Kumahara (2017), the Polar A360 was validated by comparing results from the chest-strap based heart rate monitor (Polar M 400, Polar) and the indirect calorimetry (AE-300S, Minato Medical Science) as the criterion measure for heart rate and energy expenditure, respectively. There was significant correlation between the Polar A360 and the criterion measures ($p < .05$) with relative measurement error of 7.6% and 8.9% respectively. Esa (2015) also showed that the heart rate results obtained in a treadmill test is significantly correlated to the Electro Cardio Graph (ECG) results ($p < .05$).

4.2.2.3. Rate of Perceived Exertion (RPE) Scale. As a second measure, the RPE Scale (Borg, 1982) was adapted to estimate the intensity of the activities. The Borg’s RPE Scale has been widely used in measuring perceived exertion in activities and has been validated in various studies (Chen, Fan, & Moe, 2002; Eston 2012; Scherr, Wolfarth, Christie, Pressler, Wagenpfeil, & Halle, 2013). Self-reporting of the Borg’s 6 to 20 scale (Appendix F) provided information on the intensity of the activity perceived by the participant (6 representing “No exertion at all”; 7 to 8 being “Very, very light”; 9 to 10 being “Very light”; 11 to 12 being “Fairly light”; 13 to 14 being “Somewhat Hard”; 15 to 6 being “Hard”; 17 to 18 being “Very
hard”; 19 to 20 being “Very, very hard”). The self-report was administered using pen and paper immediately after the participants have completed the activity.

4.2.2.4 Timing. The last measure was the time taken by each participant to complete the respective activities. This was done via the running time indicated on the tablets. Time was tracked as part of the application developed because this will allow a timestamp when the tablets were touched. The time measured was also cross-checked with the wrist-based heart rate monitors. Pen and paper recording of the heart rates at the start and end of the activities provide corresponding time taken that can be cross checked with the App-based timer. The logic of the programming works in the following manner: when the relevant clock (that has a pre-set function to fire at regularly set intervals to perform manipulations, etc.) is activated, the timer increases the “milliseconds” value display (first digit only) on the tablet by one unit. The interval of each addition was set to be a millisecond. The display value continued to increase until it reached 1000 milliseconds. If the “milliseconds” value display went above nine, the “seconds” value display increased by one unit. The “seconds” value display increment was determined by the number on the “milliseconds” value display. In a similar fashion, the “minute” value display increased by one unit when the “seconds” value display went above 59. Figure 13 shows the building blocks created using App Inventor 2 for the timer function.
Figure 13: Building Blocks for the timer function.
4.2.2.5. **Behaviour Indicators.** The “Willingness to participate” survey (Appendix H) was used to indicate participants’ willingness to re-engage with future games. The survey included closed dichotomous questions (e.g., “In your opinion, was the customised running game interesting?”); item list question (e.g., “How many more sessions of the customised game would you like to try?”) and open questions (e.g., Reasons for attempting again.”).

4.2.3. **Procedure.** Participants started with the experimental (treatment) condition. The participants were first screened for their well-being using the Physical Activity Readiness Questionnaire (PAR-Q) (Appendix E) on the activity day. Information of the PAR-Q and the participants’ responses were recorded using pen and paper. This was followed by the pre-text information to stimulate participants’ interest. Participants were then equipped with the wrist-based heart rate monitors and proceeded with the warm up for 3 minutes. Participants then attempted the improved “Rob the Nest” game.

4.2.3.1 **Improved game.** The basic task of the improved game required the participants to make runs between the competitors’ bases and the home base. The movement mimics that of the shuttle run or the Multi-Stage Fitness Test. Participants needed to touch the tablets at the various locations to depict movement to the base. By touching on the tablet, the time stamp was created on the cloud-based document. The setup and task were similar to those in the pilot study, with participants making shuttle runs, to obtain as many points as they can by making their runs to steal from other bases and adding to theirs in the process.

The improved game (Figure 14) was attempted by one participant each time, competing with three other virtual competitors. The objective of the game was to be the first to obtain the stipulated game points. Each shuttle was defined as the run from the home base to another competitors’ base and back to the home base again. One point was obtained when
the participants successfully brings a point back to the home base. The activity started when the countdown timer on the tablets reaches 0. Once the activity has started, the participants can choose to steal a point from either one of the virtual competitors. The point was stolen when the participant touches the screen at the respective locations. The virtual competitors stole from each other and from the participant. The programme was also made such that virtual competitors could also obtain points from the Nest (virtually), which was not available to the participants. A stolen point resulted in the loss of one point from where it was stolen. A point was successfully added by touching the Home Base Tablet. Display panels display the number of points by the participants and virtual competitors and the running time since the start of the activity. The activity came to an end when either of the following three conditions were met. Firstly, upon the decision of the participant the game could be terminated at any juncture (recorded on paper as incomplete). Secondly, when either one of the 3 virtual competitors has obtained 20 points (recorded on paper as “LEFT”, “RIGHT” or “FRONT” to denote which virtual competitor has won). Lastly, the game came to an end when the participant has obtained 20 points (recorded on paper as “WIN”). To create a more realistic image of the opponents, images of real people were placed above the tablets as shown in Figure 14.
Figure 14: Proposed setup of the improved “Rob the Nest” running game
Immediately after the “Rob the Nest” Game, the Situational Interest Scale was administered. Following that, participants completed the “Willingness to participate” survey. The exact route taken by each participant was recorded and used in the delivery of the second session in the yoked control setting. The sequence and route taken by each participant were captured when the participants touched the tablets during the improved game. Heart monitors were stopped and removed after the survey was completed.

4.2.3.2 Yoked Control. In the second session under the yoked control setting, each participant started in a similar process as the first session (treatment condition) of filling in wellness condition. Instead of the pre-activity information, basic instructions on the yoked control activity were given. The instructions were, “In this second session, you will be covering the same route taken in the first session. There will be no game element. The task is to complete the same number of shuttles as the first session. The tablets that are set up only act to track the number of shuttles taken. Please remember to tab on the tablets as you reach them, like how you tabbed them in the first session.” Following the basic instructions, each participant performed the 3-minute warm up (as per the first session) and attempted the activity in the yoked control setting.

The personalised route was communicated to the participants before the activity and cues were provided during the activity. Participants had to complete the activity in the shortest time possible. In the yoked control set up, the concept of the virtual opponents was removed. The existence of the tablets only acted to track the time taken for each shuttle and the overall timing. Stimulus in the form of light and sound were also removed. Figure 15 shows the set up for the yoked control.
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Figure 15: Proposed setup of the Yoked Control
Under the yoked control setting, the Situational Interest scale was administered once participants completed the shuttle runs based on the prescribed route. The route was based on the sequence made in the first session. In addition to the Situational Interest scale, the “Willingness to participate” survey was administered for participants to indicate their intentions to try the running game again. The flow of the procedure is summarised below in Figure 16.

**Figure 16: Flow of Main Study**
4.2.4. **Data Analysis.** A three-step approach was used to analyse the data: (1) analysis of self-report data on the Situational Interest that was evoked based on the Situational Interest Scale; (2) analysis of self-report data and physiological data based on the RPE, heart rate readings and time to complete, and (3) analysis of self-report data in the form of the Willingness to participate questionnaire was used to determine sustained interest. The analysis aimed to address the three research questions, (1) “Is Situational Interest evoked from the customised running game?”; (2) “Are there any significant differences in the physical activity intensities between the customised running game and the yoked control activity?”; (3) “Is Situational Interest for the customised game maintained after the main study period?”.

In the first step of the analysis, it was determined whether there was a statistically significant difference between the experimental (treatment) study and the yoked control in terms of participant’s self-report levels of Situational Interest. To that end, it was compared whether there were mean-level differences between the six subscales of the Situational Interest Scale. Six one-way, repeated-measures analysis of variance (ANOVA) were used to determine if there were any significant differences for the various subscales between the experimental study and the yoked control. The independent variable was treatment vs. control and the dependent variables were the six subscale variables (i.e., Novelty, Challenge, Exploration Intention, Instant Enjoyment, Attention Demand, and Total Interest. In addition to the Wilks’ lambda and $p$ value, the effect size was calculated by means of eta-squared.

In the second step of analysis, two methods were used. Firstly, a three one-way repeated measures ANOVA were used to compare the means of the respective dependent variables in the two conditions. The independent variables were treatment vs. control and the dependent variables were heart rate during activity, RPE of the activity and time taken to complete activity. Next, to compare the percentage of participants engaging in the vigorous zone between the treatment and control, Cochran’s Q test (Cochran, 1950) was conducted. The vigorous zone is
calculated to be above 163.1 beats-per-minute based on the Karvonen formula (Karvonen, Kentala, & Mustala, 1957).

The last step of the analysis was to determine if interest for the improved game would be sustained. To that end, a Cochran’s Q test (Cochran, 1950) was administered on the dichotomous data to determine if there was as statistically significant difference between the willingness to re-engage with the game in the future. The assumptions for the use of Cochran’s Q test are (1) responses are binary and from the same number of matched samples; (2) the participants are independent of one another and were selected at random from a larger population; (3) the sample size is sufficiently large. The results are presented next using the proposed data analysis.
Chapter 5 Results

All 40 recruited participants provided data for both the treatment and control sessions. The analysis of the data was concluded in three parts to address three main aims. The first aim of the study was to investigate the SI level evoked by the improved running game. Secondly, the study aimed to investigate whether the improved running game resulted in more exertion in terms of physical activity levels. Lastly, it was investigated whether there were sustained interest to re-engage with the activity.

5.1 Situational interest in improved game

The first part of the analysis examined whether there were significant mean differences between the treatment versus control for all six subscales of the Situational Interest Scale. The results of the one-way repeated-measures ANOVA revealed a significant main-effect for all six subscales, in favour to the improved running game. Novelty, Wilks’ Lambda ($\Lambda$) = .49, $F(1,39) = 40.98$, $p \leq .01$, effect size ($\eta_p^2$) = .51; Challenge, Wilks’ Lambda ($\Lambda$) = .51, $F(1,39) = 37.07$, $p \leq .01$, effect size ($\eta_p^2$) = .49; Exploration Intention, Wilks’ Lambda ($\Lambda$) = .52, $F(1,39) = 35.39$, $p \leq .01$, effect size ($\eta_p^2$) = .49; Instant Enjoyment, Wilks’ Lambda ($\Lambda$) = .55, $F(1,39) = 32.52$, $p \leq .01$, effect size ($\eta_p^2$) = .48; Attention Demand, Wilks’ Lambda ($\Lambda$) = .66, $F(1,39) = 19.71$, $p \leq .01$, effect size ($\eta_p^2$) = .34; and Total Interest, Wilks’ Lambda ($\Lambda$) = .48, $F(1,39) = 41.81$, $p \leq .01$, effect size ($\eta_p^2$) = .52. See Table 6 and Figure 17 for an overview.
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Figure 17: Mean differences of the all subscales between the treatment and control were significant at .05 level (2-tailed)

5.2 Activity Intensity

The second part of the analysis entailed investigating whether there was any significant difference in physiological stress imposed between the improved running game and the yoked control session. In the first method, the dependent variables included average heart rate, RPE and time to complete. Data from RPE (Mean RPE_{treatment} = 15.83 ± 2.07; Mean RPE_{control} = 15.23 ± 1.75), time taken (in seconds) to complete (Mean T_{treatment} = 362.19 ± 117.28; Mean T_{control} = 358.75 ± 115.55) as well as the heart rates (Mean Beats Per Minute_{treatment} = 168.20 ± 8.76; Mean Beats Per Minute_{control} = 168.13 ± 11.01) of the two physical activities were used as the comparison. The results of three one-way repeated measures ANOVAs suggest that there was no statistically significant difference between the improved running game and the control: The main effect for the average heart rate, Wilks’ Lambda (Λ) = 1.00, F (1,39) = .001, p = .97, effect
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size ($\eta_p^2 < .01$; rate of perceived exertion (RPE), Wilks’ Lambda ($\Lambda$) = .94, $F (1,39) = 2.58, p = .12$, effect size ($\eta_p^2 = .06$; and time taken to complete the activity, Wilks’ Lambda ($\Lambda$) = .98, $F (1,39) = .82, p = .37$, effect size ($\eta_p^2 = .02$). The second method compared the data between the percentages of participants engaged in the vigorous zone between the treatment and yoked control session. Cochran’s Q Test revealed significant differences between the treatment and yoked control session with results of 80% and 60% respectively ($Q (2) = 4.00, p = .0046$).

5.3 Sustained Interest

The last part of the analysis investigated the extent to which the improved running game evoked sustained interest. More specifically, the willingness of participants to re-engage in future games. An analysis of within-group data using Cochran’s Q test (Cochran, 1950) was used to analyse the responses by the participants. Analyses were made to determine the effect of the sustained interest of the participants from the “Willingness to participate” survey. The data from the question “How many more sessions of the customised game would you like to try?” was used. The data corresponding to the reasons for indicating future attempts were reviewed. Participants had the option choosing the statement or statements that best describe their intention to participate in future sessions. These statements include, “I want to win the game.”; “I want to better my performance in the game.” and “This is good training.”. There was also the open-ended option of specify their own reason.

5.3.1. Number of future attempts. The dichotomous data corresponding to the responses for not wanting to attempt the improved game was compared to the data of wanting to attempt the improved game again. Separate analysis was done for the post treatment session and the post control session. The percentage of participants that responded to no attempts was 5% and that of between one to four attempts was 95% in the post treatment session ($Q (2) = 32.40, p < 0.05$). As hypothesised, there were significantly more participants that wanted to participate in future games. Similar results were observed in the post control session. In the post control
session, the percentages of no future attempts and between one to four attempts were 12.5% and 87.5% respectively ($Q (2) = 22.500, p < .05$). This shows that the difference was significant in favour of participants responding positively to attempting the improved game again.

5.3.2. Post treatment versus Post control. The McNemar’s Test (McNemar, 1947) was applied. Figure 18 shows a graphical representation of the percentages of the responses within each category. The results of the McNemar’s test were $p (0) = .25; p (1) = .51; p (2) = 1.00; p (3) = .55; p (4) = .50$ showing that there were no significant differences between each corresponding category (number of times that participants would attempt the game again) between the post treatment and the post control session.

![Figure 18: Graphical representation of the percentages of the responses within each category](image-url)
5.3.3. Reasons for attempting future sessions. Table 6 shows the reasons for future attempts at the improved game. The main reasons for expressing intent to take part in future sessions were, “I want to better my performance.” and “This is good training.”. This could mean that the participants in the study were generally motivated to strive for improvement and perceived the activity as challenging enough as a physical activity. Other reasons provided by the participants after the treatment included, “I would like to find out the tricks behind the game.”; “This is challenging.”; “I want to beat high score.” and “This encourages me to run (gamification).”. The results showed that there were no significant differences when comparing the post treatment session to the post yoked control session (for each of the reasons selected by the participants).

Table 6

<table>
<thead>
<tr>
<th>Reasons for future attempts at the improved game.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>WG</td>
</tr>
<tr>
<td>BF</td>
</tr>
<tr>
<td>GT</td>
</tr>
<tr>
<td>OS</td>
</tr>
</tbody>
</table>

Note: WG = “I want to win the game.”; BF = “I want to better my performance.”; GT = “This is good training.”; OS = other comments.
Chapter 6 Summary and Conclusions

Physical inactivity is a global pandemic plaguing mostly the developed countries. There is an uprisen trend of the younger population contracting chronic diseases associated with physical inactivity (Biddiss & Irwin, 2010; Russ et al., 2015). It is therefore a concern that needed to be addressed. Schools provided an ideal platform to reach out to youths as students spend a large amount of time on campus. In Singapore, studies revealed that Junior College students were the least active as compared to their younger counterparts in the Primary and Secondary levels (Chia, 2010). In the bid to understand the physical activity behaviours of Junior College students, the current study endeavoured to investigate possible mechanisms for motivation. Motivation was operationalised as Situational Interest in this study. Guided by the principles of Gamification, a new game was developed and tested. In this new game, running was used as the main form of activity.

The new game included the use of Information and Communication Technology (ICT) which was current with the popularisation of mobile devices and most importantly relatable with youths (Du, 2015). The study comprised of the pilot study as well as the main study, with the main study evaluated in two phases. Participants between 16 to 18 years old, from a Junior College were selected to participate in the one session pilot study and/or the two sessions in the main study. Data were collected on participants’ SI responses, perceived exertion during the activity and intention to participate in future games. Other data included time to conclude as well as heart rate responses. The study was conducted with the hope to make a modest contribution to the literature by attempting to examine the effectiveness of the mechanisms involved. In this novel approach, a new running game was developed with the aim of creating interest in physical activity. Findings from the study could also provide educators an option of incorporating easy-to-use programmable applications in sports venues for the development of interest or simply for data analytics.
6.1 Summary of Findings

The improved running game has demonstrated that it is able to foster Situational Interest and indirectly encourage participation at a higher intensity. With the concept of gamification and use of mobile devices, the data collected from the improved running game provided evidence to support the sustained participation of the improved running game in future sessions. The objectives of the exploratory pilot study were (1) to develop a customised game based on the five dimensions of Situational Interest using mobile technology; (2) to establish if the customised game was able to evoke Situational Interest and; (3) to collect valuable feedback for improvements to the customised game. Results from the pilot study provided information to improve the customised game for the main study. The pilot study demonstrated SI was evoked from the activity and participants had exerted physically at the moderate-to-vigorous intensity levels. Although there was feedback for improvement, the game concept was largely acceptable by the participants. The results from the pilot study showed a high rating for the sub-scales of the SI. Improvements made after the pilot study included an improved setup that was able to provide a more consistent distance (equal distances of 20m). With this improvement, there were no instances of participants who made abrupt changes to their route. Also, the fastest time achieved was articulated to the participants before the activity in the main study.

The main study was conducted with the objectives to (1) establish if the improved game was able to evoke Situational Interest; (2) compare the physical activity intensity of a game-based activity versus a prescriptive based activity; (3) establish if interest (based on intention) for the improved game may be sustained over a longer duration. The outcomes revealed that Situational Interest was evoked in the improved running game. Moreover, SI was rated higher between the improved running game and the prescribed running activity (yoked control). The result is consistent with studies that examined the effects of task design for learning in physical education in which there were differences in SI response to the various tasks.
Development, Testing and Implementation of a New Running Game to Foster Situational Interest in Students.

A further examination of the data suggested that the highest ranked factor in the Situational Interest scale for the improved game was novelty. Subramanian and Silverman (2007) also suggested that novelty is a key element that should be added in the selection and design of physical activities to sustain enjoyment. Novelty has been shown in the study (Weierich, Wright, Negreira, Dickerson, & Barrett, 2010) to influence affective areas that include cognitive process of decision making. This linked to the results of the improved game having a higher novelty rating compared to the control as participants had to make quick decisions on the paths to take when the stimuli were presented to them. Contrast to the findings in SI, the findings in the physical activity intensity attributes were not as hypothesised.

There were no significant differences in the intensities when comparing the RPE, time taken to complete the activity and average heart rate between the improved game and the yoked control. It was hypothesised that RPE rating and heart rate would be higher and time taken would be shorter in the improved game as compared to the yoked control. The Perceived Rate of Exertion, RPE has been used widely (Tucker, Marle, Lambert, & Noakes, 2006; Coutts, Rampinini, Marcara, Castagna, & Impellizzeri, 2009; Eston, 2012) to measure physical activity intensity levels, which is a subjective response from the participants. No significant difference was observed in the mean responses. This self-perceived scale has been shown to differ in gender and in regular exercisers (Skatrud-Mickelson, Benson, Hannon, & Askew, 2011). Next, in the yoked control even though there were no external stimuli other than the instruction for the participants to complete the prescribed shuttles in the fastest time, many of the participants shared that it was a more focused task. The knowledge of how long the activity might be (based on the treatment session) encouraged some participants to exert at a higher intensity to finish the perceptibly less interesting activity quickly that is evident in the SDT (Deci, 1971). The motivation to complete an uninteresting task may also have accounted for no significant differences to the time take to complete as well as the mean heart rate between the two activities.
Coupled with the TPB (Ajzen, 1985), when participants have decided on performing a task with higher intensity, heart rate will be increased, and this inevitably increased the rating on the RPE scale. Despite having no significant differences for the mean heart rate between the two activities, there were significant differences when comparing the heart rate zones.

Further examination of the heart rate within the moderate (50% to 70% of heart rate reserve; CDC, 2015) and vigorous zones (70% to 90%; CDC, 2015) respectively revealed that there were significant differences when comparing the heart rates in the intensity zones (p < .05). This showed that significantly more participants were engaged in the vigorous zone in the treatment session as compared to the yoked control session. The results could have been caused by the stimuli from the improved game which encouraged the participants to increase their pace. Also, as the improved game was the first time for the participants on the activity (novelty effect); they might not have been able to control their pace well. After investigating the effect of SI and intensity of the physical activity levels, the sustainability of the activity with the possibility of developing Individual Interest in physical activity will be discussed.

Data from the “Willingness to participate” survey were analysed by comparing the dichotomous response from the survey. It was hypothesised that there will be significantly more participants, who will sign up for future sessions as there were other levels to attempt. Results from the data revealed that there was a significant difference between the percentage of participants (Treatment .95 ± 0.22; Control .88 ± .33) who expressed that they were keen to attempt between one to four sessions in future and the percentage of those who are not keen to attend anymore sessions (Treatment .05 ± .22; Control .13 ± .33). Further analysis of the results comparing the post treatment responses and the post control responses demonstrated that there were no differences in the responses between the two activities. The results demonstrated that students were motivated to participate in future sessions. However, these results need to be interpreted with caution as the current study only measures the intention to participate and not
the actual physical activity participation. Previous studies on motivation, including the SDT (Deci & Ryan, 1985; Ryan & Deci, 2000) reported that intrinsic motivation contributed to sustained interest (Cerasoli, Nicklin, & Ford, 2014). Intrinsic motivation is displayed when individuals find the task enjoyable (Instant Enjoyment in the case of Situational Interest) and relatable to themselves (Patall, Cooper, & Robinson, 2008). The relatability of the improved game might be due to the health and fitness benefits; the challenge posed to attempt the other levels of the game and the prestige of having the highest recorded time to be recognised by others. The above contributed to incentives that form part of the extrinsic motivation (Cerasoli, Nicklin, & Ford, 2014). In this study significant findings of SI, together with increased physical activity intensity as well as sustained interest were found in the improved running game. The findings provided evidence that the improved running game can be implemented as a possible mechanism in enhancing physical activity. However, no study is without limitations.

6.2 Limitations

The improved game could be made more interactive. Sensors and lights like those in Yishun River Green playground (“SOHO Systems,” n.d.) where children are actively engaged by the stimuli would be more interesting than the current set up of only screen displays. The current set up for the running game was rather basic and lacked this kind of higher levels of sophistication. However, that was not the objective of this study. The objective was to explore the basic psychological mechanisms, and if the integration of ICT and application of gaming principles can increase students’ interest and level of physical engagement. Another shortcoming is that these principles can only be applied to games when they are novel. As soon as the novelty wears off, another new game may need to be introduced. Otherwise, students need to be motivated by other psychological mechanisms (competition, need for perfection, etc.). Next, the game concept could be enhanced to be made into high-intensity interval form of running instead of the current moderate-intensity continuous running (Bartlett, Close, MacLaren,
Gregson, Drust, & Morton, 2011). Another shortcoming is that the findings cannot be
generalised. Data were collected from one Junior College and the findings need to be replicated
with students from other schools and even with other age groups. In addition, the mechanism
was tested in the context of a running game. It is not certain how it applies to other games that
involve other motor movements like throwing, jumping, etc.

6.3 Directions for Future Research

Future research should explore the concept of the Hemmingway effect (Hemmingway, 1935; Oyama, Manalo, & Nakatani, 2018) where positive motivation is observed when failing
to a certain extent in tasks. For example, setting up minor setbacks like winning the game but
not getting the full credits will give participants the motivation to attempt the game again. This
is provided the process of attainment is perceived as possible by the participants and other
external factors support this “near miss” experience (Reid, 1986). Another possibility would be
to incorporate existing popular online/ mobile games into physical movements. For example, in
the global phenomenon game of Pokémon, other than just walking and swiping on the screen,
perhaps more elements of physical activity with higher intensities could be factored in.

Finally, in this study, the participants were healthy and despite not being avid runners,
were not averse to running. An area that could be looked at would be to investigate if games
could be developed to interest the specific group of youths who are sedentary.
Development, Testing and Implementation of a New Running Game to Foster Situational Interest in Students.

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Development, Testing and Implementation of a New Running Game to Foster Situational Interest in Students.


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Development, Testing and Implementation of a New Running Game to Foster Situational Interest in Students.


Appendix A: Situational Interest Scale

<table>
<thead>
<tr>
<th>Based on your perspective of running…</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Disagree or Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I like to inquire into details of how to do it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2 The activity is fun to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3 I want to analyse it to have a grasp on it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4 I was concentrated.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5 This is a new-fashioned activity for me to do.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6 I was very attentive all the time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7 I was focused.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8 This activity is exciting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9 It is a complex activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10 This activity is fresh.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11 This activity is a demanding task.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12 This activity is interesting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13 I like to find out more about how to do it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14 The activity inspires me to participate.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15 It is an enjoyable activity to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16 This activity is new to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17 This is an exceptional activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18 This is an interesting activity for me to do.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19 This activity is appealing to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20 It is fun for me to try this activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21 I want to discover all the tricks in this activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22 This activity is complicated.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23 My attention was high.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24 It is hard for me to do this activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix B1: IRB Approval for Pilot Study

IRB Approval for Pilot Study

Research Support Office

IRB-2016-08-036

10 October 2016

Assistant Professor Kee Ying Hwa National Institute of Education

NTU INSTITUTIONAL REVIEW BOARD APPROVAL
Project Title: Pilot test and development of a "Rob-the-nest" running game

I refer to your application for ethics approval with respect to the above project.

The Board has considered your application and noted from your application that your research involves collecting behavioral data from participants using questionnaires.

You have also confirmed that informed consent will be obtained from the participants and you have guaranteed the confidentiality of your participants' biodata obtained from them.

The documents reviewed are:
   a) NTU IRB application form dated 31 August 2016
   b) Participant information sheet and consent form: version 1 dated 31 August 2016
   c) Data collection form: version 1 dated 31 August 2016

The Board is therefore satisfied with the bioethical consideration for the project and approves the ethics application under Expedited review. The approval period is from 10 October 2016 to 09 October 2017. The NTU IRB reference number for this study is IRB-2016-08-036 Please use this reference number for all future correspondence.

The following protocol and compliances are to be observed upon NTU IRB approval

1. All research involving procedures greater than minimal risk on minors (individuals who are less than the legal age of 21 years old) requires IRB approved written Parental Consent and assent from the participant to be obtained before any research protocols can be administered. Minimal risk refers to an anticipated level of harm and discomfort that is no greater than that ordinarily encountered in daily life, or during the performance of routine educational, physical, or psychological examination.

2. Only the approved Participants Information Sheet and Consent Form should be used. It must be signed by each subject prior to initiation of any protocol procedures. In addition, each subject should be given a copy of the signed consent form.
Appendix B2: IRB Approval for Pilot Study

2. Consent forms are important documents therefore they should be stored in the strictest arrangement. Loss of consent form would result in disciplinary action.

4. No deviation from, or changes of, the protocol should be initiated without prior written NTU IRB approval of an appropriate amendment.

5. The Principal Investigator should report promptly to NTU IRB regarding:
   a. Deviation from, or changes to the protocol.
   b. Changes increasing the risk to the subjects and/or affecting significantly the conduct of the trial.
   c. All serious adverse events (SAEs) which are both serious and unexpected.
   d. New information that may affect adversely the safety of the subjects of the conduct of the trial.
   e. Completion of the study.

6. Continuing Review Request/ Notice of Study completion form should be submitted to NTU IRB for the following:
   a. Annual review: Status of the study should be reported to the NTU IRB at least annually using the Continuing Review Request/ Notice of Study completion form.
   b. Study completion or termination: Continuing Review Request/ Notice of Study completion form is to be submitted within 4 to 6 weeks of study completion or termination.

7. All Principal Investigators should comply with existing legislation that would have an impact on the domain of their research.

Professor Lionel Lee
Chair, NTU Institutional Review Board encl.

cc Members, NTU Institutional Review Board

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Appendix C1: Images of building blocks
Appendix C2: Images of building blocks
Appendix C3: Images of building blocks
Appendix C4: Images of building blocks
Appendix C5: Images of building blocks
Appendix D: Pre-Activity Information

1. 2.4 kilometers running test is only one of the ways in which cardiovascular health is measured which is to provide an estimation of one’s maximal oxygen uptake capacity. The better the oxygen uptake or VO₂ levels, the better one utilises the oxygen that is taken in.

2. A good cardiovascular base, recovery for exercise is faster, you will be able to last longer while playing games and many health benefits in the long run.

3. One of the objectives of the game is to collect possible norms for a running activity / test.

4. In this activity, your ability to make quick decisions will be put to the test.

5. With technology advancing and the growing awareness of analytics, this study hopes to provide proof of concept that it is very feasible for future sports venues to be equipped with sensors and visuals alike.

6. Analysing behaviours in exercise and performances using setups like the ones in the activity can provide users with better information. Better exercise programmes can also be prescribed.

7. There are various levels of difficulty for the customised game. The level you will be trying today is at level 1.
Appendix E: Physical Activity Readiness Questionnaire (PAR-Q)

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor? 
   - Yes ☐  No ☐

2. Do you feel pain in your chest when you do physical activity? 
   - Yes ☐  No ☐

3. In the past month, have you had chest pain when you were not doing physical activity? 
   - Yes ☐  No ☐

4. Do you lose your balance because of dizziness or do you ever lose consciousness? 
   - Yes ☐  No ☐

5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity? 
   - Yes ☐  No ☐

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition? 
   - Yes ☐  No ☐

7. Do you know of any other reason why you should not do physical activity? 
   - Yes ☐  No ☐
### Appendix F: Rating of Perceived Exertion (Borg RPE Scale)

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No Exertion</td>
</tr>
<tr>
<td>7</td>
<td>Very, very light</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Very light</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Fairly light</td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Hard</td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Very hard</td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>20</td>
<td>Maximum exertion</td>
</tr>
</tbody>
</table>
Appendix G1: IRB Approval for Main Study

IRB-2017-08-031

23 October 2017

Assistant
Professor Kee
Ying Hwa
National Institute
of Education

NTU INSTITUTIONAL REVIEW BOARD APPROVAL
Project Title: Testing and Implementation of Situational Interest in a Running Game

I refer to your application for ethics approval with respect to the above project.

The Board has considered your application and noted from your application that your research involves collecting behavioural data from participants through questionnaires, physical activity and video recording.

You have also confirmed that informed consent will be obtained from the participants and you have guaranteed the confidentiality of your participants' biodata obtained from them.

The documents reviewed are:
   a) NTU IRB application form dated 15 September 2017
   b) Participant information sheet and consent form: version 1 dated 15 September 2017
   c) Data collection form: version 1 dated 15 September 2017

The Board is therefore satisfied with the bioethical consideration for the project and approves the ethics application under Expedited review. The approval period is from 23 October 2017 to 22 October 2018. The NTU IRB reference number for this study is IRB-2017-08-031. Please use this reference number for all future correspondence.

The following protocol and compliances are to be observed upon NTU IRB approval

1. All research involving procedures greater than minimal risk on minors (individuals who are less than the legal age of 21 years old) requires IRB approved written Parental Consent and assent from the participant to be obtained before any research protocols can be administered. Minimal risk refers to an anticipated level of harm and discomfort that is no greater than that ordinarily encountered in daily life, or during the performance of routine educational, physical, or psychological examination.

2. Only the approved Participants Information Sheet and Consent Form should be used. It must be signed by each subject prior to initiation of any protocol procedures. In addition, each subject should be given a copy of the signed consent form.
Appendix G2: IRB Approval for Main Study

3. Consent forms are important documents therefore they should be stored in the strictest arrangement. Loss of consent form would result in disciplinary action.

4. No deviation from, or changes of, the protocol should be initiated without prior written NTU IRB approval of an appropriate amendment.

5. The Principal Investigator should report promptly to NTU IRB regarding:
   a. Deviation from, or changes to the protocol.
   b. Changes increasing the risk to the subjects and/or affecting significantly the conduct of the trial.
   c. All serious adverse events (SAEs) which are both serious and unexpected.
   d. New information that may affect adversely the safety of the subjects of the conduct of the trial.
   e. Completion of the study.

6. Continuing Review Request/ Notice of Study completion form should be submitted to NTU IRB for the following:
   a. Annual review: Status of the study should be reported to the NTU IRB at least annually using the Continuing Review Request/ Notice of Study completion form.
   b. Study completion or termination: Continuing Review Request/ Notice of Study completion form is to be submitted within 4 to 6 weeks of study completion or termination.

7. All Principal Investigators should comply with existing legislation that would have an impact on the domain of their research.

Professor Lionel Lee
Chair, NTU Institutional Review Board
encl.
Appendix H: Willingness to participate in future sessions

Please read the questions carefully and answer each one honestly:

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
<th>Skip</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In your opinion, was the customised running game interesting?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Will you be keen to attempt the customised running game again?</td>
<td></td>
<td></td>
<td>If “NO”, skip to Question 5</td>
</tr>
<tr>
<td>3. Reasons for attempting again (tick where relevant)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>a. I want to win the game</td>
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<tr>
<td>b. I want to better my performance in the game</td>
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<tr>
<td>c. this is good training</td>
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<tr>
<td>d. others (please specify):</td>
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<tr>
<td>4. How many more sessions of the customised game would you like to try?</td>
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<tr>
<td>a. 1</td>
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<td>b. 2</td>
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<tr>
<td>c. 3</td>
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<td>d. 4</td>
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<td>5. Reasons for NOT attempting the customised game again (tick where relevant)</td>
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<tr>
<td>a. no time</td>
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<td>b. don’t like running</td>
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<td>c. not interesting</td>
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<td>d. others (please specify):</td>
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