



The Effects of Heart Rate Feedback and Extrinsic Reward on Students' Activity Level in Elementary Physical Education

YuChun Chen ^{a,*}

^a Physical Education, School of Kinesiology, Recreation & Sport, Western Kentucky University, KY 42101, United States.

* Corresponding Author E-mail: yuchun.chen@wku.edu

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Abstract: Due to reduced instructional time in Physical Education (PE), teachers are challenged to help students achieve at least 50% of class time in Moderate-to-Vigorous Physical Activity (MVPA). This study examined the effects of real-time heart rate (HR) feedback, extrinsic rewards, and grade level on students' activity level in elementary PE. Results showed a significant main effect for grade level. Second graders had a higher % MVPA than fifth graders. There was a significant screen \times reward interaction. Participants in the screen condition had a higher % MVPA when extrinsic rewards were involved, but those in the no-screen condition had a higher % MVPA when no extrinsic reward was given. There was a significant grade level \times reward interaction. Fifth graders had a higher % MVPA when tangible items were offered, but second graders had a higher % MVPA with oral recognition alone. The results suggested more teaching on the HR-related content and exploring different types of extrinsic rewards.

Keywords: Heart Rate Monitoring, Physical Education Technology, Extrinsic Motivation, Student Engagement, Elementary School Physical Activity, MVPA (Moderate-to-Vigorous Physical Activity).

1. Introduction

According to the Physical Activity Guidelines for Americans (U.S. Department of Health and Human Services, 2018), "Children and adolescents ages 6 through 17 years should do 60 minutes (1 hour) or more of moderate-to-vigorous physical activity (MVPA) daily" and part of the recommended duration should include aerobic, muscle-strengthening, and bone-strengthening physical activity (p. 8). School physical education (PE) with quality characteristics (e.g., class size, minimum of 50% MVPA, plenty of practice opportunities, adequate equipment and facilities) is a promising agent to help children and adolescents obtain the necessary skills, knowledge and dispositions to meet the guidelines and be physically active for a lifetime (Graham *et al.*, 2020). Due to resource allocation and administrative policy, many quality characteristics are beyond teachers' control. Minimum of 50% MVPA, however, is one that teachers can achieve by careful planning and positive reinforcement.

The integration of technology in PE is not a novice idea. For the past two decades, the use of heart rate (HR) monitors has become a common and useful

tool for teachers to measure students' activity intensity (Ignico *et al.*, 2006; Layne *et al.*, 2022; Nelson *et al.*, 2011; Partridge *et al.*, 2011). Evidently, HR monitors palpating the bare skin give arterial pulses an accurate read, providing teachers with precise minutes of MVPA based on individual student's fitness level and physiological effort (Nichols *et al.*, 2009). With technology advancements in recent years, HR status can now be displayed on a screen in the gymnasium from an overhead projector. This real-time visual feedback has been found to be a positive motivator to keep students on task and consequently increase their physical activity level. In fact, students who received HR data on display were reported to have a significantly higher time spent in MVPA than those who received no immediate visual feedback regarding their HR status (Cunningham-Rose *et al.*, 2025; Marzano, 2017; Petit, 2016; Stöckel & Grimm, 2021).

Another positive motivator to enhance children's physical activity level is extrinsic rewards such as tangible items and screen time (Epstein *et al.*, 1995; Goldfield *et al.*, 2000; Hardman *et al.*, 2011; Roemmich *et al.*, 2004). While the researchers successfully enticed their subjects to accumulate target step counts or MVPA



minutes with sports balls, frisbees, erasers, bookstore gift cards, museum passes, baseball game tickets, and access to watch movies or play video games, [Hardman and colleagues \(2011\)](#) found that extrinsic rewards did not have a lasting effect on the children's behavior towards physical activity participation. Specifically, the subjects who received peer-modeling and pedometer goals to earn rewards had the greatest step count increase during the 12-day intervention period, but it was the subjects who received peer-modeling and pedometer goals without rewards that showed a continuous increase during the 14-week taper phase ([Hardman et al., 2011](#)). This finding echoed [Xiang and colleagues' \(2005\)](#) conclusion that "extrinsic rewards could have a positive motivation effect initially, but that the motivation effect might gradually diminish over time (p. 192)."

This study aimed to examine not only the effects of real-time HR status projection and extrinsic rewards but also the interaction of the two variables on elementary school students' physical activity level in PE. Based on previous findings ([Cunningham-Rose et al., 2025](#); [Marzano, 2017](#); [Petit, 2016](#); [Stöckel & Grimm, 2021](#)), the author hypothesized that students who had access to their current HR status projected on the big screen would have a significantly higher physical activity level than those who did not have the real-time visual feedback in PE (Hypothesis #1). Moreover, supported by various scholars ([Epstein et al., 1995](#); [Goldfield et al., 2000](#); [Hardman et al., 2011](#); [Roemmich et al., 2004](#); [Xiang et al., 2005](#)), the author hypothesized that students would have a significantly higher activity level when extrinsic rewards were involved than when they were not (Hypothesis #2). When both variables were considered, the author hypothesized that the highest physical activity level would be found when students received real-time HR status and were motivated by extrinsic rewards (Hypothesis #3).

This study also investigated the effect of grade level and how it interacted with HR projection and extrinsic reward. Based on the limited and outdated literature, there was no clear consensus on children's activity levels by age. Replicated from the studies of [Saris et al. \(1986\)](#) as well as [Verschuur and Kemper \(1985\)](#), [Rowland \(1990\)](#) concluded that children's activity levels decreased as they aged. [Fairclough and Stratton \(2006\)](#), on the other hand, found a trend for the activity levels to increase as children progressed through elementary school PE. They speculated that, as children grew older, their enhanced motor ability enabled them to participate in PE activities more

successfully, which led to greater perceived competence, motivation, interest and effort, resulting in higher physical activity levels ([Deci & Ryan, 1985](#); [Malina et al., 2004](#)). Yet, [Vincent and Pangrazi \(2002\)](#) found a stable activity level in their investigation among children aged six to 12 years. This research would provide a current trend in comparison to the studies that were carried out 20-40 years ago. Specifically, how upper and lower elementary school children's activity levels differed in PE and how the grade level difference interacted with HR projection and extrinsic reward conditions.

2. Methods

2.1 Participants and Setting

The current study was conducted at a public elementary school in the Mideastern United States. In the Fall of 2024, the school enrolled approximately 790 students from pre-kindergarten to sixth grade. The population was made up of 49% female and 51% male; 40.9% White, 23.1% Hispanic/Latino, 13.5% Black/African American, 10.8% Asian/Pacific Islander, and 11.7% others; and 76% economically disadvantaged students. All classes had PE once a week for 45 minutes in a 66,000 square feet gymnasium with an electric projector screen on one side and retractable bleachers on the other. The male PE teacher was of African and American descent with over 30 years of elementary PE teaching experience. His knowledge in movement concept, fitness education, and cooperative games was well-received and recognized by the state and national PE organizations. He was an advocate for jump rope skills and had raised over \$290,000 for American Heart Association during his teaching career.

Research sample included 98 students from two second grade and two fifth grade classes. Table 1 illustrates the number of participants in each class, as well as its gender composition and PE day of the week. Tuesday classes were assigned to the screen condition (SCR), while Friday classes were assigned to the no screen (NOS) condition.

Table 1. Gender composition and PE day of each class.

	Tuesday (SCR)		Friday (NOS)		Total
	Female	Male	Female	Male	
Grade2	8	16	12	12	48
Grade 5	11	13	12	14	50
Total	19	29	24	26	98

Note. SCR = Screen Condition; NOS = No Screen Condition

The PE teacher taught the same content using the same activities based on the developmental level of the participants. The second graders went through four units on traveling skills, chasing, fleeing and dodging, underhand throwing for accuracy, and striking a playground ball with hands. The fifth graders, on the other hand, spent time in Fitnessgram testing, dribbling and striking with foot, throwing and catching with a foam ball, and striking with a golf club units. The PE teachers taught all classes except for the birdie golf unit, where two experts from the local park and recreation department were invited to bring their own equipment and teach the sport. During the birdie golf unit, the PE teacher was present to assist with behavior management.

2.2 Data Collection

Physical activity level of the participants was measured using Heart Tech Plus (HTP, 2001) 4.0 sensors. Participants from each class were assigned with a number and they wore the same number sensor on their left upper arm every time they had PE. When a sensor was turned on and successfully detected a participant’s pulse, it automatically connected to the HTP app on an iPad using Bluetooth technology. The researcher started recording the HR data on the iPad as soon as the PE teacher turned on the music for their standard warm-up routine. Throughout the lesson, participants in the SCR condition could see their (1) current, average and maximum HRs, (2) minutes, seconds and percentages of MVPA, and (3) time spent in each HR zone. The HR status was projected on the projector screen and presented in three different pages, which were rotated through every minute by the researcher. The HR zones were color-coded and highlighted around the block of each sensor on the app

and projector screen: zone 1 blue (less than 50% of maximum heart rate; MHR), zone 2 green (50-60% of MHR), zone 3 yellow (60-75% of MHR), zone 4 orange (75-90% of MHR), and zone 5 red (90-100% of MHR). Every second a participant’s HR reached and stayed in zone 3-5 counted towards their time spent in MVPA. The color coordinated with their current HR zone reflected on all three pages. Participants in the NOS condition did not have access to their HR status except for the color of zone 1, 2, 5 flashing as a blue, green or red dot on the HR sensor. The researcher stopped recording when the PE teacher finished his lesson closure.

Over the fall semester, HR data were recorded in nine sessions. The first session was used to regulate each participant’s MHR. One hundred and sixty beats per minute (BPM) was set up for all participants per recommendation of HTP’s research team. The system updated each participant’s MHR and recalculated the BPM range in each HR zone, creating an individualized fitness profile.

All participants surpassed the 160 BPM benchmark spending 52-99% of class time in MVPA during the first session. At the end of session 2-5 after the researcher stopped the app, names of the participants who spent at least 50% of class time in MVPA were announced in front of everybody. At the beginning of session 6-9 before the PE teacher started the warm-up, the researcher showed everyone a box of tangible items (i.e., pencil sharpeners, rubber bracelets, stress balls, keychains, pinback buttons, temporary tattoos, vinyl stickers) and announced that anyone who reached 50% of class time in MVPA at the end could pick out two items from the box. Table 2 illustrates the experimental design by the screen and reward conditions.

Table 2. Experimental design.

	Session 1	Session 2-5	Session 6-9
SCR Condition			
Grade 2	Regulate MHR	SCR without extrinsic rewards	SCR with extrinsic rewards
Grade 5			
NOS Condition			
Grade 2	Regulate MHR	NOS without extrinsic rewards	NOS with extrinsic rewards
Grade 5			

Note. SCR = Screen Condition; NOS = No Screen Condition; MHR = Maximum Heart Rate

2.3 Data Analysis

Data were entered and analyzed using SPSS 30. Descriptive statistics were computed to calculate frequencies of the sample by screen condition, grade level, and gender. A three-way mixed-design ANOVA was used to identify any significant main effects or interaction effects on the two between-subjects factors (i.e., screen condition and grade level) and one within-subjects factor (i.e., reward condition) on the participants' activity level during session 2-9. Since the session length varied from 30 minutes 30 seconds to 42 minutes 10 seconds, %MVPA was used for analysis even though MVPA minutes, average HR, MHR, calory burnt, and total steps were also available from the HTP portal. Alpha was set at .05 for all analyses.

3. Findings

3.1 Between-Subjects Effects

A significant main effect for grade level was found ($F(1, 89) = 5.853, p < .05, \eta^2 = .062, 1-\beta = .668$). As a group, the participants in the second grade ($m = 79.25$) had a significantly higher %MVPA than those in the fifth grade ($m = 74.00$). The main effect for screen condition was not significant ($F(1, 89) = .059, p = .81, \eta^2 = .001, 1-\beta = .057$), nor was the screen condition \times grade level interaction ($F(1, 89) = 2.591, p = .11, \eta^2 = .028, 1-\beta = .357$).

3.2 Within-Subjects Effects

The main effect for reward condition was not significant ($F(1, 89) = .876, p = .35, \eta^2 = .010, 1-\beta = .153$). However, there was a significant interaction effect between screen and reward ($F(1, 89) = 8.931, p < .005, \eta^2 = .091, 1-\beta = .840$). Participants in the SCR condition had a higher %MVPA with extrinsic rewards ($m = 78.24, SD = 11.24$) than without ($m = 75.92, SD = 11.49$). An opposite trend was found in the NOS condition, where the higher %MVPA was located without extrinsic rewards ($m = 78.82, SD = 11.03$) than with ($m = 73.94, SD = 15.46$). Figure 1 illustrates the screen \times reward interaction plot. Moreover, a significant interaction was found between grade level and reward condition ($F(1, 89) = 5.511, p < .05, \eta^2 = .058, 1-\beta = .641$). Fifth graders had a higher %MVPA with extrinsic rewards ($m = 74.84, SD = 15.57$) than without ($m = 73.22, SD = 12.34$), but second graders had a higher %MVPA with oral recognition alone ($m = 81.28, SD = 8.67$) than with tangible rewards ($m = 77.21, SD = 11.59$). The grade level \times reward interaction plot is illustrated in Figure 2. Lastly, there was no significant reward \times screen \times grade level interaction ($F(1, 89) = 3.088, p = .08, \eta^2 = .033, 1-\beta = .412$).

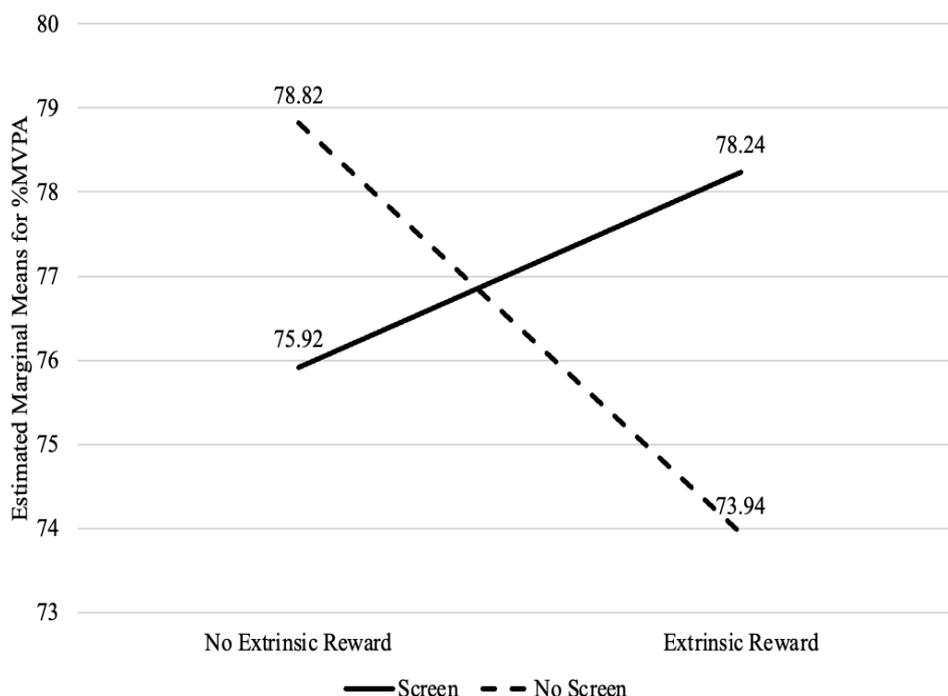


Figure 1. Interaction plot for screen and reward conditions.

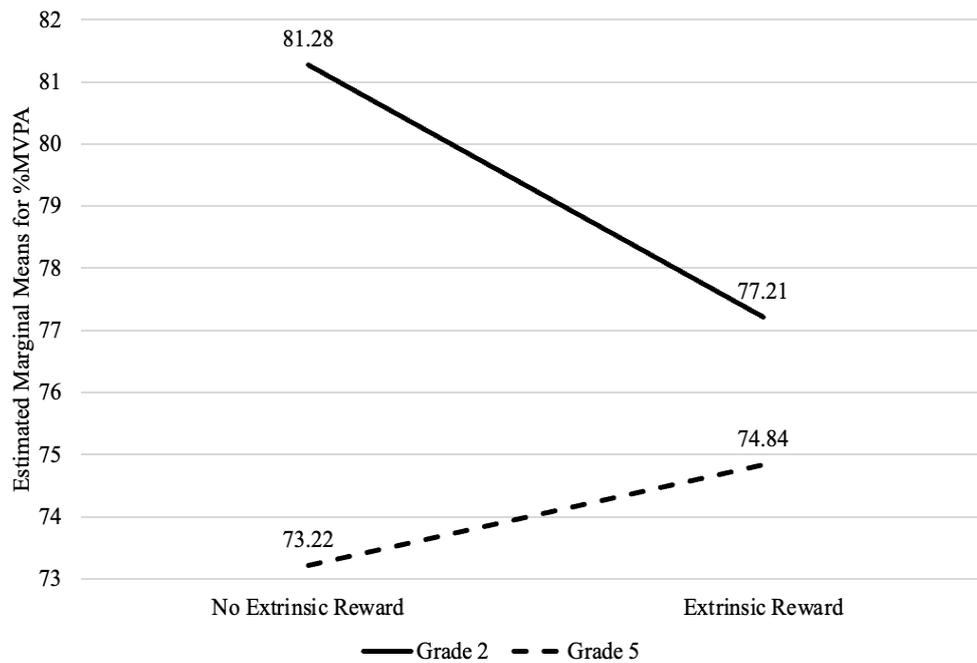
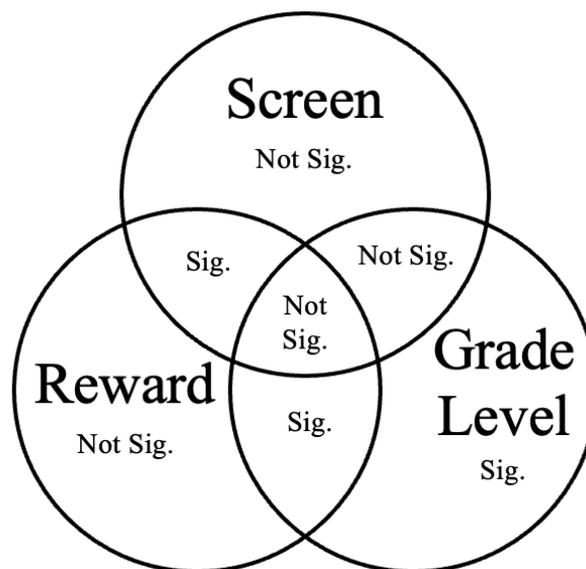


Figure 2. Interaction plot for grade level and reward condition.



Note. Sig. = Significant difference from mixed-design ANOVA

Figure 3. Summary of the results.

4. Discussion

This study examined the effects of two motivators (i.e., real-time HR feedback and extrinsic reward) that have been found promising to increase elementary school students’ activity level in PE. Data collected from second and fifth grade classes gave this research an additional perspective on grade level difference and how the three factors interacted with one another. The logical relationships and summary of the

results are illustrated in Figure 3. The results suggested that real-time HR feedback or extrinsic reward alone was not a strong motivator to stimulate a greater activity level. Rejecting hypothesis #1, the participants without the visual feedback on their current HR were just as active ($m = 76.36$) as their peers with HR data in sight ($m = 76.81$). This finding undermined the consensus on the advanced technology and its potential to increase activity levels in PE (Cunningham-Rose *et*

al., 2025; Marzano, 2017; Petit, 2016; Stöckel & Grimm, 2021). Also rejecting hypothesis #2, the participants had a slightly higher %MVPA with oral recognition alone ($m = 77.20$) than with tangible items as extrinsic rewards ($m = 76.04$). This finding sided with Hardman *et al.* (2011) and Xiang *et al.* (2005) theory that extrinsic rewards may not have a lasting effect on increasing and sustaining desired activity level over time. Due to unexpected circumstances, only nine sessions per class were recorded over the 15-week semester, which was more in line with Hardman and colleagues' (2011) 14-week taper phase than their 12-day intervention period.

Although there was a significant interaction effect between the screen and reward conditions, the participants who had access to their HR status in sight and potential to earn tangible items did not generate the highest %MVPA (Figure 1). The highest %MVPA was identified when the participants received no real-time HR data and no extrinsic reward, rejecting hypothesis #3. This finding suggested a "double or nothing" mentality: the screen was used as a helpful reference for the SCR group to stay on track of earning tangible rewards, but the NOS group appeared better off with neither of the motivators. This phenomenon helped explain why the first two hypotheses were rejected because it was when both motivators were in play that they could produce a significant difference. There was, however, a limitation on the experimental design (Table 2) because the participants stayed in their respective SCR and NOS conditions and received the reward conditions in the same order. Had the participants experienced both screen conditions and/or received the reward condition in reverse order, the results could be totally different.

The result from grade level analysis indicated the younger participants were more active than their order counterpart, siding with the theory that children's activity levels decreased as they aged (Rowland, 1990; Saris *et al.*, 1986; Verschuur & Kemper, 1985). This conclusion was drawn with caution due to the nature of PE units taught in each grade level. All four units in the second-grade classes (i.e., traveling skills, chasing, fleeing and dodging, underhand throwing for accuracy, and striking a playground ball with hands) were carefully planned and skillfully executed by the PE teacher with minimal waiting time. The PE teacher followed the same principle in his fifth-grade units (i.e., Fitnessgram testing, dribbling and striking with foot, throwing and catching with a foam ball, and striking with a golf club units), but there were inevitably some waiting time during the first unit as the participants took

turns to be tested in pairs. Besides, there were an ample amount of waiting time in the last unit because the participants were divided in groups of five and took turns to take three swings at a time, and then they all went retrieve the birdies before the next round.

Combined with the significant interaction with the reward condition, it appeared that the older participants were motivated by extrinsic rewards, but the younger ones were significantly more active without such motivation (Figure 2). It was possible that the younger participants did not see the tangible items as an attractive motivation to be any more active than they already were. Apparently, the joy from running around the gym, playing tag, tossing bean bags into a hula hoop, and playing four square was motivated enough to produce an average of 81.28% of class time in MVPA in the second-grade classes. This finding somewhat contradicted the "double or nothing" approach mentioned earlier. Future research from a greater sample size with a within-subjects crossover design or a between-subjects experimental design is warranted to further explain the contradiction.

5. Conclusions

As physical educators continue to find optimal motivators to enhance activity levels in PE, the results of this research were encouraging. First, there is much left to teach our future generations the meaning of different HR status and the importance of reaching and maintaining in certain HR zones. The participants in the present study might not fully understand the HR data projected on the big screen and use it to manipulate their HR in order to achieve certain goals. Second, the tangible items offered might not be attractive rewards for the participants in the present study, but they might be enough to motivate children elsewhere. Fellow PE teachers and researchers are also encouraged to explore different types of extrinsic rewards and find one that fits well with different grade levels. Cultural markers today may be collectible toys, technology-related items and time to spend on their hand-held devices. Lastly, there are more ways to enhance activity levels in PE than the two motivators tested in this study. It should start with PE teachers' planning and implementation of age-appropriate activities. Combined with administrative and parental support, PE teachers are in a better position to find what motivates their students and what don't.

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Ethics Approval Statement

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Informed Consent

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Does this article pass screening for similarity?

Yes

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