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Original Article

Effects of a sport education instructional model and heart rate monitor system on the physical activity and jump rope performance of fourth grade students

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Abstract
Models-based instruction (MBI) has shown to improve student learning in Physical Education (PE). Combined with the use of technology feedback, one MBI the Sport Education (SE) Model, has the potential to not only enhance student outcomes but bring together learning communities to enhance the overall environment. The purpose of this study was to examine the effectiveness of student learning/performance through MBI and technology. Specifically, on the influence of using heart rate monitors in combination with the SE Model to impact MVPA and jump rope performance. The study consisted of 130 (61 Female, 69 Male) 4th grade students from three PE classes. Students' classes were randomly assigned to one of three intervention groups. All students completed a pre-and-post 30-second jump performance test, and a subsample of students was asked to wear accelerometers to capture MVPA among the three groups. Also, two of the groups wore heart rate monitors as a potential motivational device, one with and without the instructional intervention piece. Descriptive statistics and mean scores were calculated. ANOVA tests were conducted to determine the effects of the intervention on the jump rope performance test amongst all groups as well as to test potential differences in percentage of MVPA over the educational unit between the three intervention groups. Results from this research show that 4th grade students were more likely to both, (1) increase in their 30-second jump rope performance tests, and (2) time spent in MVPA when trained within the SE model and given opportunities to track target heart rate than compared to a traditional Jump Rope unit or a traditional delivery with heart rate monitors. The SE model produced favorable results in jump rope performance and overall MVPA in 4th grade students. Continued analysis of technology use and instructional approach is recommended for elementary students.
Keywords: **elementary students, skill performance, instructional models, heart rate, jump rope**

Introduction

Models-based instruction (MBI) is recommended when teaching physical education (PE) based on evidence showing these techniques can increase student learning, motivation, and achievement (Metzler 2021). In fact, Casey (2014) believes that researchers need to be doing more to determine how we can encourage teachers, and pre-service teachers (Valério et al. 2021) to adopt an MBI approach and how it may facilitate improved student motivation in PE. The intent of each instructional approach is to promote learning and address the development of each child (Gurvitch and Metzler 2013). While the extent of teacher use of each model is unknown or moderately utilized at best (Casey 2014), there has been significant research conducted on how to deliver MBI in PE. For years, a common approach to teaching PE was direct instruction. PE teachers implemented direct instruction and teacher-centered practices based on their own experiences or it was modelled to them by other teachers (Gurvitch et al. 2008). The model is typically defined by teacher dominated instructional delivery and assignment of tasks for the students to complete. Students would work to achieve the objectives within a set amount of time and then move on to the next activity, again presented and dominated by the instructor. While there are benefits of the approach, learning is dependent on the desired approach of the student and thus more student-centered MBIs have been introduced through the years to complement direct instruction.

One MBI that was introduced to teachers several years ago and has garnered much research attention is the Sport Education (SE) model (Siedentop 1994; Siedentop et al. 2019). The goal of SE was to create an authentic sport experience which would help students develop as competent, literate, and enthusiastic sportsperson (Siedentop 1994). The instructional philosophy behind the SE model centers around small, heterogeneous learning groups, or teams. Within these teams, students would have the opportunity to learn from each other as well as share in the responsibilities. The SE model focuses on six key features: seasons, team affiliation, formal and practice competition, record keeping, festivity and a culminating event. The inclusion of all six is important, yet each feature may be emphasized differently dependent on the goals of the season. Given that sport is still an intricate part of our society and chosen as one of the main physical activity outlets for youth and adults, the SE MBI and aligned content can be motivational for students learning in PE.

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When using MBIs, one integral consideration is the fidelity of instructional model delivery. This is important as the intricacies of how the model presented has been specifically identified and aligned with reaching specific student outcomes. Thus, for MBIs like the SE, the key features or assumptions of the model need to be presented effectively to reach outcomes and avoid a custodial-delivery (i.e., incomplete version) of the model (Curtner-Smith 2009). These decisions to offer reduced versions of the model can reduce fidelity and chances of reaching intended outcomes. However, given the realities of teaching and context, Casey (2014) argues that flexibility in model delivery is a prerequisite for teacher adoption and student success. For example, while most elementary SE seasons have a minimum of 12 lessons (Siedentop et al. 2019), a season of shorter duration may eliminate certain components but may be more developmentally appropriate for younger students. For example, Layne and Hastie (2016), in their examination of using SE with 2nd grade students, included competition for a throwing unit without a culminating event. The intent of the study was to evaluate SE with primary grades and its overall success. A culminating event was not included due to the nature of competition and the ability of 2nd graders to calculate scores. Due to the framework of different sports and activities, some SE seasons could be modified to align with the goal of the season and/or the developmental level of the students. In addition, schools may be restricted by the amount of time students spend in PE. If students only attend PE one time a week, teachers may be limited by time and changes to the season structure and SE delivery may need to occur to help student growth.

One additional element that can support MBI approaches but has received limited attention is the use of technology (Casey et al. 2017; Hill and Valdez-Garcia 2020). With the ever-evolving world of technology, teachers are faced with the challenge of maintaining an understanding of technology use and competencies with an already limited amount of available time (Palao et al. 2015). However, the incorporation of technology within PE has the potential to not only enhance student outcomes but bring together learning communities to enhance the overall environment, especially when used in conjunction with models like SE (Hastie et al., 2010). The impetus for this study is combining features of the SE model with technological advancements with the goal of meeting the objective of the SE model (Siedentop, 1998). That is helping students become more competent while also increasing enthusiasm using technological feedback to help students achieve more.

Examination on the motivational performance benefits of technology use within MBI, especially with elementary students is lacking. In their review of SE research Hastie et al. (2011) and Wallhead and O'Sullivan (2005) indicated that investigation has been limited with students from elementary grades. Specifically, only 11 of 66 studies (Approx. 17%) had examined PE settings from the 5th grade or below with only three focusing on physical activity. Recent research indicates that one additional study on physical activity (Ward et al. 2017) and one on skill performance (Hastie et al. 2017) have been conducted with these ages. In addition, one study has examined both PA and skill performance (Ward et al. 2019). More research on instructional approaches combined with technological use is needed to determine the impact on student physical activity levels and skill performance.

Ward et al. (2017) examined a season of SE to determine if students reached the recommended levels of in-class moderate-to-vigorous physical activity (MVPA). Results revealed that students spent an average of 54.5% of lesson time engaged in MVPA. An interesting finding from this study was that students MVPA was lowest when engaged in competition compared to instructional time and free practice. Free practice consisted of students preparing an exercise routine that would be completed by two groups during the competition phase. The lower numbers during competition could be contributed to the format of the model in that students served as officials, scorekeepers, and game managers during competition. The findings from this study are significant due to high levels of engagement during a SE season in which higher autonomy was provided to the students. An autonomy supportive climate has produced favorable results regarding student engagement and enjoyment (Hastie et al. 2014). In their examination of game performance and physical activity levels, Ward et al. (2019) discovered that performance was best when participants were part of a matched ability team. Through video observation the researchers noted that while higher skill players exceled in mixed ability grouping, lower skilled students suffered. With regards to activity levels, all students accrued lower levels of MVPA during mixed ability game play. Researchers indicated that lower skilled students received the ball less in mixed ability games and when they did, success rates were less. This study supports the notion that when placed on matched ability teams, one should see an increase in overall game play and MVPA. This supports the notion that in a high autonomy climate, students should have the opportunity to practice skills based on what they are confident in completing.

Even with this potential for enhanced learning, some believe that teachers and the pedagogical expertise they offer to learning environments are in danger of being replaced by digital technologies, which could provide health related content with relative ease (Gard 2014). In response to this view of digital technology in PE (Gard 2014; Lupton 2015; Williamson 2015) Casey et al. (2017) stated that 'there is significant potential for teachers to connect young people's uses of digital technology with their learning experiences in HPE (Health and Physical Education)' (p. 297). In sum, technology must be embraced and may serve a true educational purpose and enhance PE learning when used alongside quality practice. With understanding of the positive impact that MBI approaches can have on student learning, including technology within the structure of the model will further augment student motivation and success within PE in the 21st century.

One potential opportunity for utilizing technology in PE would be the use of heart rate monitors (HRMs). HRMs offer teachers an opportunity to provide students with feedback regarding their activity levels and overall physical fitness. This can occur through projecting heart rate data for students to view or sending home reports based on collected heart rate data. This data can provide parents with information about student outcomes in PE classes (Pascal et al., 2019). Research studies examining the impact of HRMs on the physical activity levels of upper elementary students have produced positive results (Ignico and Corson 2006; Nelson et al. 2011; Strand and Reeder 1993). In addition, HRMs represent a technological tool that can be understood and operated by elementary students making it developmentally appropriate for PE.

In their study to determine the effects of HRM training on fourth and fifth grade students one mile run performance Ignico and Corson (2006) attempted to motivate students through feedback and by providing evidence of HRM success. The researchers investigated students wearing HRMs compared to a control group that did not. Results from the study indicated that students wearing the HRMs performed better in the one-mile run. One of the earliest studies investigating HRMs was conducted to examine physical activity levels for traditional PE skill units (Strand and Reeder 1993). The researchers wanted to understand the intensity levels of middle school students participating in a variety of sport skills. Results indicated that heart rate is dependent on the activity or sport being taught. The teachers in the study were informed to teach their classes as they normally would. With purposeful instruction and available technology, teachers today could potentially improve upon these numbers by using HRM feedback. Regardless of the activity, students could learn how their health-related HR levels fluctuated during class which is a strong learning tool and motivator for students. Many monitors today will project active heart rate numbers onto a screen providing students with instant feedback. The feedback, coupled with intentional planning and possible competitiveness, provide students with motivation to be active and engaged in the activity.

While gender differences have been identified in many PE studies based on skills, attitudes, or performances with boys traditionally reporting high scores, the SE model consistently shows that gender differences are reduced (Hastie et al. 2009). However, when adding elements like technology within the models and the history of differences traditionally found in PE experiences, it is important to evaluate potential gender differences.

The chosen instructional approach, in addition to the use of technology measures has the potential to create a positive environment for learning. By incorporating SE, teachers can establish a learning environment that supports student autonomy through the choice of activity. In addition, students can work with their teams, or peers in class, to practice skills and potentially increase activity levels as a result of more movement in class and a higher level of skill engagement. It is the goal of this study to support these claims and strengthen the existing SE research. Therefore, the purpose of this study was to examine the effectiveness of student learning/performance through MBI and technology. Specifically, on the influence of using heart rate monitors in combination with the SE Model to impact MVPA and jump rope performance. This study was guided by the following questions: (1) To what extent did engaging in an HRM system influence 4th graders' jump rope skill learning and MVPA in PE? (2) To what extent did experiencing a SE model and HRM system simultaneously influence 4th graders' jump rope skill performance and MVPA in PE?

It is hypothesized that students receiving SE instruction and the use of the Polar cardio GX heart rate system will produce positive outcomes as compared to the traditional and technology inclusion only group. Specifically, students receiving SE instruction with technology feedback will have larger increases in jump performance and MVPA. Additionally, we hypothesize that gender differences are likely not going to be identified in the SE group as compared to the others as well. Jump rope was selected as the skill unit due to the opportunity for students to work individually, with a partner, and/or in a group. In addition, SE supports a high autonomy climate, thus the autonomy to choose could increase confidence in students and potentially result in higher engagement. Results from this research could help determine if this approach is conducive to increased student engagement and learning.

Materials & Methods

Participants

Following approval by the university's Institutional Review Board, informed consent was sought and obtained from all participants and their parents prior to data collection. The study consisted of 130 (61 Female, 69 Male) 4th grade students from three PE classes in a suburban school in the Southeastern portion of the U.S. The school enrolled 893 students of which approximately 56% received free school meals. Students had PE two days a week for 30 minutes each day. Students participated in a total of seven, 60-minute lessons. This number was chosen to potentially enhance the limited literature on shorter (less than 12 lessons) SE seasons. A random sample of approximately 45 students (24 female, 21 male) were asked to wear accelerometers (that is a light 1"x1"x0.5" activity monitoring device that was placed around students' waist) and 30 students (15 female, 15 male) were asked to wear HRMs, which were placed around the chest. The HRMs were used to display student data during class. Students wore the devices during school PE time for the duration of the study. Furthermore, students' height and weight were also measured to match students to their accelerometers. Accelerometer data were extracted after each lesson of instruction. Students also completed a pre-and-post performance test that consisted of completing as many jumps as possible in a time span of 30 seconds. Jumping rope is a fast paced, high aerobic activity which is best measured in a shorter duration of time.

Procedures

For this study, three randomly assigned classes were taught using one of the following instructional methods; (1) traditional (Trad)(46 students; 23 male, 23 female), (2) traditional with the use of the Polar HRM system (TPS)(41 students; 25 male, 16 female), and (3) SE using the Polar HRM system (SEPS)(43 students; 21 male, 22 female). The Trad and TPS groups were taught by their regular PE teacher. One of the researchers for this study, with 14 years of experience using the SE model, served as the lead teacher for the SEPS group. The Trad group had 15 students wear an accelerometer, while the TPS and SEPS groups had 15 students who wore the accelerometers and the HRM at the same time. All students in the study were unable to wear a device due to the high cost and limited supply of accelerometers that were available. Following the procedures of Chen et al. (2013), a random selection of those wearing the accelerometers was used with a priority on balanced grouping. These subgroups are then arranged as class-level representations for data analysis purposes.

The Trad approach consisted of the teacher introducing students to a short rope jump by providing the name of the jump, describing the jump, and a short demonstration. After the demonstration, students were given a short amount of time to practice the jump. Once completed, the teacher would proceed to the next jump on the list. This approach would continue for the time available in class. The teacher would attempt to introduce as many jumps as possible. In addition to individual jumps, the teacher also introduced to partner jumps and long rope jumps.

The TPS was similar to the first approach, but it included the Polar GX heart rate system. Selected students would wear the Polar device and their heart rate would be projected onto the wall for viewing. The purpose of this approach was to determine if receiving heart rate feedback would have an impact on student activity levels.

SEPS used SE as the instructional model and included the Polar GX heart rate system. While the Trad approach includes a teacher providing instruction and students doing activities, SE includes additional features to help meet the goal of the model. For this study, features of the SE were incorporated. For both TPS and SEPS, the teacher introduced students to the heart rate monitors and the projected information. In addition, daily reminders were given regarding the significance of their heart rate number.

To confirm the teachers' behavioral fidelity of instruction and adherence, a 10-item checklist with benchmarks indicating the instructional features of SE and a traditional approach was employed. Based on the checklist created by Pritchard et al. (2008), trained observers made decisions based on instruction being used (see Table 1). Three randomly selected lessons were selected for inspection by observers familiar with the instructional approach with 100% agreement being met.

Table 1. Sport Education Season Plan

Day	***Activity***	***Notes***	***Out of Class***
1	Intro-Jump Test, Teams/Roles Explain Skills	Forward- 30, Announce teams, Define student roles, Explain skills and introduce the posters, Practice 5s	Choose Mascot and bring to class (5 pts)
2	Protocols/Explain Score sheet/Practice Day 1	Go through the normal routine: Bring mascot, Warm Up, Practice short (5s, 10s & partner skills) and long rope	Bring in Team Photo to display next to their Team name (5 pts)
3	Practice Day 2, Test 1	Practice (10s, 15s & partner skills); Give students the opportunity to practice the testing procedure	All team members must wear their team colors (5 pts)
4	Practice Day 3, Test 2	Practice (15s, 25s & partner skills); 2nd opportunity to earn points for their team	Picture of you jumping rope (1 pt each)
5	Practice Day 4, Test 3	Practice all skills; 3rd opportunity to earn points for their team	Team will demonstrate a Long Rope routine (10 pts)
6	Practice Day 5, Long Rope Competition	Groups will attempt to complete 3 routines for team points	Jump 250 times (Signed index card by parent) (5 pts each)
7	Awards	Given to team with highest score for Daily Task, Testing, and Long Rope	

The Sport Education season

All students participated in a Jump Rope season that took place over seven lessons with a duration of 60-minutes each. Siedentop (1994) suggested that a SE season should be two to three times the typical amount of a PE unit. Parker and Curtner-Smith (2005) found that multi-activity teaching led to greater MVPA among middle school students compared to the SE model in a season of only 10 lessons of approximately 30-minutes. This study consisted of pre-service physical education teacher education students who were using the SE model for the first time. A SE unit can require significant time to include all features of the model (Hastie & Curtner-

Smith 2006). As a result, active learning time can be reduced in order for the model to be incorporated and followed. While the length of this study is shorter compared to most SE seasons, the intent was to determine if improvement of skill and physical activity can occur in a shorter duration of time. These findings should help enhance the already existing research on length of seasons.

The SEPS group followed a SE plan (See Table 2). On day one students were asked to pair up to complete a 30-second jump performance test in which they were challenged to complete as many jumps as possible. While they jumped, their partner would count their total completed jumps (verified by recording). After completing the test, students were introduced to SE, student roles, and skills that they would be learning. On day two, students were introduced to daily protocol. Their procedure would consist of entering the classroom and going to their team headquarters. After a warm-up, students would then be introduced to 2-3 new jump rope skills and given time to practice. After completing their practice, they were then allowed to travel around the room to practice different levels of short rope skills which were listed, and shown, on a variety of posters. The autonomy allowed students to choose what they wanted to work on and for how long.

Table 2. Jump Rope Scoresheet

5 Point			**10 Point**		
Jump Name	**Jumps**		**Jump Name**	**Jumps**	
Skier	**5**		Heel Touch	**10**	
Bell	**5**		1 Foot	**10**	
Twister	**5**		Jogger	**10**	
Penguin	**5**		Boxer	**10**	
Side Straddle	**5**		Side Straddle (Backwards)	**10**	
Straddle X	**5**		Straddle X (Backwards)	**10**	
Front Straddle	**5**		Front Straddle (Backwards)	**10**	
Rocker	**5**		Rocker (Backwards)	**10**	

15 Point			**20 Point**		
Jump Name	**Jumps**		**Jump Name**	**Jumps**	
Heel Touch (Forwards/Backwards)	**5**		Knee Lift	**15**	
1 Foot (F/B)	**5**		Can-Can	**15**	
Jogger (F/B)	**5**		Criss Cross	**15**	
Boxer (F/B)	**5**		Side Swing Cross	**15**	
Knee Lift	**10**		Backward Criss Cross	**10**	
Can-Can	**10**		Leg Under	**10**	
Criss Cross	**10**		Circle Jump (360)	**10**	
Side Swing Cross	**10**				

25 Point		**Partner Jumps**		
Jump Name	**Jumps**	**Jump Name**	**Jumps**	
Doubles	2	2-in-1 Rope – Face-to-Face (15pts)	10	
Doubles w/ Cross	1	2-in-1 Rope – Face-to-Face (Free Turns) (15pts)	8	
Doubles w/ Side Swing Cross	1	2-in-1 Rope – Side-by-Side (Alternate) (15pts)	5	
Triples	1	2-in-1 Rope – Side-by-Side (Full Turn) (15pts)	5	
		2-in-2 Ropes – Side-by-Side (15pts)	10	
		2-in-2 Ropes – Side-by-Side (20pts)	5	
		Two Wheel – Full Turn (20pts)	5	
		Two Wheel – Switching Places(20pts)	5	

The next phase of the season (Lessons 3-6) consisted of students involved in formal competition. A day during this phase consisted of students having time to practice jump rope skills and develop a plan for the competition. During a jump rope competition, each team would be paired with another team. The team competing first would choose a polyspot on which to stand. The other team (referees or officials) would sit on a spot directly in front of a member from the other team. The jumper would have seven minutes to accumulate as many points as possible. In order to earn points, the jumper was required to inform the official of which jump they were attempting. The official would then notify the player when the jump had been successfully completed. At that point, the jumper would proceed to their next jump. Point values for jumps ranged from 5 to 25. When the time period ended, the jumper and official would switch roles. At the conclusion of the competition, each jumper would receive their scoresheet. They would then join their other team members to tally their points for a grand total to be given to the researcher. Day six consisted of a long rope challenge. For this challenge students were given four minutes to successfully complete each challenge. If the challenge was completed within the time frame, they earned points for their team.

The final phase consisted of the post-30 second jump performance test and the awards ceremony. The post-test was completed to determine improvement in students jumping ability. The test and procedures were the same as the pre-test.

Data Collection

All lessons of the season were recorded on a Canon digital video recorder mounted on a tripod. In order to capture all students, the camera was placed in the corner of the gym. The location prevented interference with the teacher, or the activity. A cordless microphone was also used to capture all communications during lessons. Recording the lessons also allowed researchers to review footage for data that was missed or needed to be re-evaluated.

Students completed a pre-and-post 30-second jump performance test. Students would attempt to complete as many jumps as possible while a partner would count the jumps that were successful. Jumps were considered successful if the jumper maintained two hands on the jump rope, swung the rope from back to front over the head passing their eyes, the jumper got both feet over the jump, and the rope continued to move into the next cycle. The purpose of the test in this study was to serve as a short-term maximum performance score related to skill performance and consistency. At the end of each day accelerometer data was downloaded to the researcher's computer. The randomized subsample that wore the accelerometers were used as the class level representations of MVPA for each session (Chen et al. 2013). The heart rate data was downloaded and shared with parents similar to the study done by Pascal et al. (2019). It was used to help motivate students during their PE class.

Data analysis

Initially all data were screened for input accuracy, missing data, normality, and for any potential outliers. Descriptive statistics and mean scores for each variable by group and by sex and group were calculated. In addition, weekly MVPA means for the subsample wearing accelerometers and HR monitors was calculated by instructional group and by gender.

Next, two sets of analysis of variance (ANOVA) were conducted to test the effects of the intervention on the jump rope performance test amongst all groups as well as to test potential differences in percentage of MVPA over the educational unit between the three intervention groups. Major assumptions of the ANOVA models were tested including tests for data normality and potential outliers, homogeneity of variance (Box*M*), and intraclass correlations (ICC). First, to test the pre/post jump rope performance scores a 3 x 2 x 2 (group x time x sex) repeated measures ANOVA (RM-ANOVA) was used to calculate main effects and interactions among the independent variables (group, time, and sex) by the dependent variables (pre/post jump rope performance scores). Potential changes for individuals within the group over time were estimated as well as differences between the groups over time, and by gender. Using the Pillai's Trace criterion is recommended for interpretation when the sample size of each cell is relatively small, when unequal samples are being compared, and when assumptions of homogeneity of variance are violated (Tabachnick and Fidell 2014). Any significant interactions were followed up using Bonferroni-adjusted pairwise comparisons to see where group differences occurred (Tabachnick and Fidell 2014). Within-subject effects were interpreted using the Huynh-Feldt adjusted test score, which is recommended when cell sizes are uneven and when assumptions of sphericity are violated which is common in repeated measures analysis (Tabachnick and Fidell 2014).

The second ANOVA tested potential differences in time in MVPA (dependent variable) by sex and intervention group (independent variables). First, each individual participants' percentage of time in MVPA over the six class period data collection points was averaged together to represent typical percentage of time spent in MVPA across the unit in each of their respective intervention groups. From there, the average time spent in MVPA for students who wore HR monitors was calculated into each individual student's unit mean time (6 data points: 15 students per intervention group). Both within group and across group interactions were tested by treatment and sex. All main effects were also evaluated using post hoc pairwise comparison to evaluate where differences may have occurred. Final adjusted mean scores and plots were used to probe interactions and partial eta squared (η_p^2) was used to determine effect size.

Results

Preliminary analysis

Preliminary results for jump rope performances pre/post intervention by group and sex can be found on Table 3. Overall, male jump scores at the pre-test mark (39.25) were higher than the females (34.68). However, both groups showed improvement over time, regardless of interventions, performing a mean number of 45.67 (+6.42) and 42.26 (+7.58) jumps for males and females, respectively. On average student performance also increased in each intervention group from pre to post performance test, with the larger increases coming in the

TPS (+8.80) and SEPS (+8.40) groups. Evaluating the mean score changes by sex shows that both males and females improved on their performance in each of the three intervention groups over the unit with the largest increases for males in the TPS group (+8.09) and in the SEPS group for females (+10.56).

Table 3. Jump Rope Performance Mean Scores (30-second max) Pre-and-Post Intervention.

Category	Trad	TPS	SEPS
Performance			
Overall	43.71	32.27	45.41
Pre	41.81	27.87	41.21
Post	45.60	36.67	49.60
Male			
Overall	46.28	34.50	46.59
Pre	43.80	30.46	43.50
Post	48.75	38.55	49.69
Female			
Overall	41.14	30.05	44.22
Pre	39.82	25.29	38.94
Post	42.46	34.81	49.50

Note. TRAD= Traditional Instruction Group; TPS= Traditional with Polar System; SEPS= Sport Education with Polar System.

When evaluating time in MVPA (%), students achieved an adequate to high amount of activity on average across six lessons in the Trad (51.74%), TPS (45.15%), and SEPS (61.01%) intervention groups (break down by sex found on Figure 1). Both male and female students achieved their highest average percentage of MVPA time in the SEPS group.

When evaluating the trajectory of MVPA time across lessons on average (Figure 2), both the Trad and SEPS groups trended upward and then back down over time whereas the TPS group showed a slight decrease in time but then levelled back off toward the end. Interestingly, females reached higher levels of MVPA time compared to boys, on average, in the TPS group.

Figure 2. Overall MVPA time (%) means for students and by sex in each intervention group.

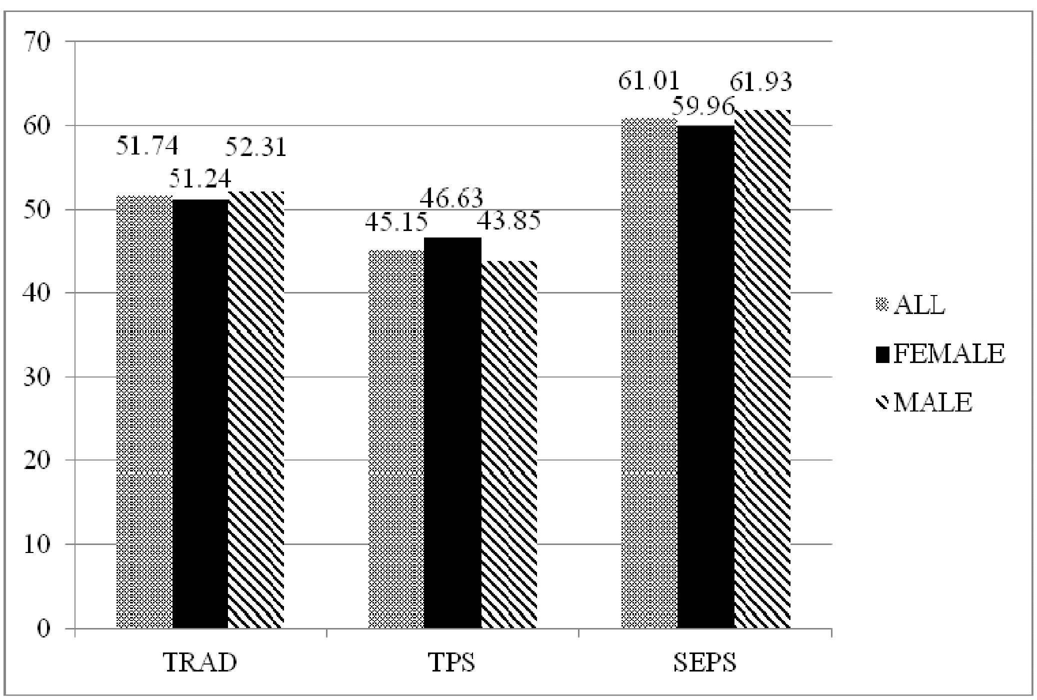
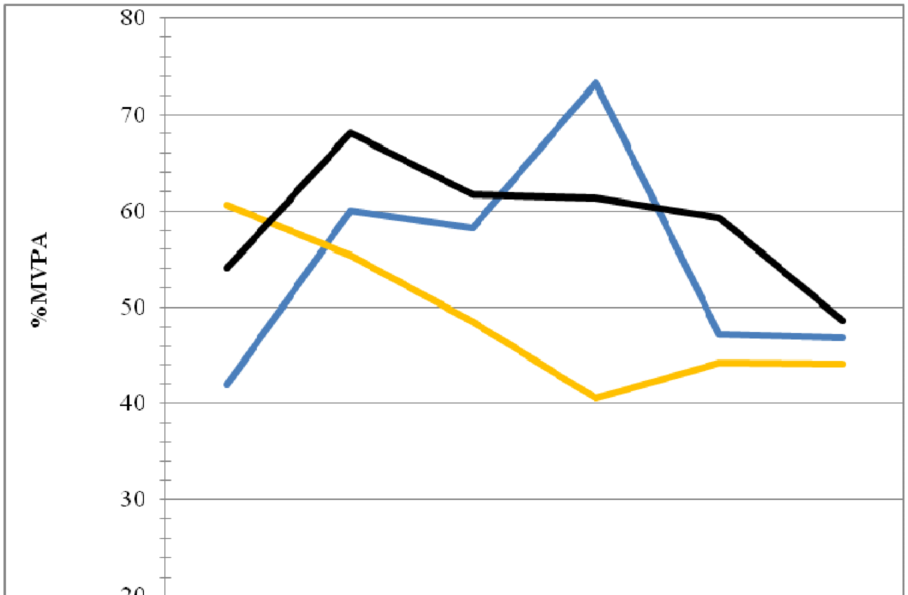


Figure 3. Weekly trajectories of mean time (%) in MVPA by week for each intervention group.



	1	2	3	4	5	6
TRAD	41.98	60.02	58.28	73.38	47.18	46.83
TPS	60.64	55.44	48.56	40.57	44.17	44.14
SEPS	54.13	68.06	61.74	61.33	59.36	48.62

Main analysis

Analysis of mean scores found no outliers amongst the three groups and follow up scatterplot evaluations showed balanced distributions and linearity across dependent variables. Also, the ICCs between the three groups for the pre/post jump performance tests were calculated to test for similarities in scores and potential nesting within classes. As anticipated, the pre-test performance scores violated the independence assumption (ICC= .18) scoring above the recommended .10 or less scoring criteria (Huitema et al. 1999). However, the post-test performance ICC score (.09) met an acceptable criteria level, which suggested that scores were likely not nested within the class following the intervention and can be analyzed at the individual level.

The violation at the pre-test scores is likely explained by the uniform instruction and traditional teaching that students had received before the intervention took place including the different instructional strategies that were implemented. Thus, given the focus of this study on the evaluation of dependent variables following the intervention, researchers moved forward with analysis with confidence. Lastly, in model analysis, the variance of homogeneity assumption (Box*M*= 66.93, *p*= .001) was violated, which is common for complex models as it is sensitive to sample and uneven cell sizes (Tabachnick and Fidell 2014) thus Pillai's Trace criterion was used for data interpretation. Additionally, the Bonferroni approach was used for post-hoc comparisons given that homogeneity of variance was not violated in the parceled cells used for follow-up comparisons (Levene's test, *p*-value greater than .10).

To evaluate skill performance on the jump rope, test a 3x2x2 RM-ANOVA was tested and found within-subject differences on performance by time ($F(2, 104)= 28.987$, $p= < .001$, $\eta_p^2= .23$) as well as a between-group differences by intervention group ($F(3, 104)= 5.442$, $p= .006$, $\eta_p^2= .10$), however no effects were found by sex. When comparing means for differences in performance scores over time, all students significantly scored higher on the post jump performance tests as compared to the pre-text performance ($p <.001$) regardless of group or sex. Additionally, Bonferroni-corrected pairwise comparison revealed that TRAD and TPS groups ($p= .01$) were significantly different as well as TPS and SEPS ($p= .005$). In summary, the effect sizes (η_p^2) for individuals pre/post and across intervention groups were moderate to small, respectively and should be interpreted with caution given the relatively small sample size and short intervention timeline.

Lastly, ANOVA results testing group differences in time spent in MVPA (%) across the unit between the three groups revealed significant differences between the three groups ($F(2, 44)= 14.866$, $p= < .001$, $\eta_p^2= .43$), but no differences based on sex. Post hoc adjusted-mean pairwise comparisons showed that the TRAD group was significantly different compared to the SEPS group ($p= .009$) and the TPS group was different from the SEPS group ($p< .001$) as well. When evaluating the post hoc pairwise adjusted mean scores, the results showed that overtime the SEPS group had more time on average than the TRAD (-9.27%) and TPS (-15.91%) groups across the unit. Given the effect size, these findings over a 6-lesson unit are quite significant.

Discussion

To explore the potential differences between instructional methods and the use of technology feedback, this study examined the effects of traditional and SE model instruction, in combination with the use of the Polar cardio GX heart rate system, on student activity levels and jump rope performance. Results from this research show that 4th grade students were more likely to both, (1) increase in their 30-second jump rope performance tests, and (2) time spent in MVPA when trained within the SE model and given opportunities to track target heart rate than compared to a traditional instructional approach for teaching a Jump Rope unit or a traditional delivery with the use of HRMs. However, it is important to note that regardless of instruction, or the use of HRMs, student activity levels were adequate to high and jump performance improvement did occur in all intervention groups. Results did show statistically significant differences in amount of student improvement favoring the use of the SE model with technology feedback in terms of jump test performance and MVPA for students.

In addition to the overall higher MVPA, the increases in jump performance scores are likely a reflection of previous findings that show overall, upper elementary students tend to find the tasks enjoyable and are willing to participate (Layne and Hastie 2012). Interestingly, boys scored higher overall in jump performance than girls, while the girls performance increases over time were slightly higher than the boys. Although, no statistical differences were found by sex, it was important to note that the largest improvements in jump test performance for girls was in the SEPS group whereas the largest improvements for boys was in TPS group. Previous research shows that female students often report lower skill ability, perceived self-competence, and can often feel marginalized in PE (Hastie et al. 2009). It is likely that when teachers utilize the SE model and they develop a sense of team, community, and give students roles and responsibilities, that female students will feel more connected to their classmates and engaged in the activity as opposed to when traditional methods are used. One paradox for boys scores was found as they were to have less time in MVPA overall than girls in the TPS group, but at the same time showed the greatest increase in the jump rope performance test. One explanation is that the TPS boys group reported the lowest pre-test scores and a novel yet attainable task like jump rope was easy for lowered skilled students to improve in as opposed to students who were already scoring at their highest potential from the onset of the unit. In addition, boys may have achieved less MVPA in the TPS group because physical activity levels may be associated with higher jump rope performance. Future research should investigate the correlation with activity levels and overall performance in a variety of sport and activity contexts for all gender groups.

The between intervention groups and within pre/post jump rope performance test differences highlight the need for quality PE instructional models such as SE as well as the need for training students to use technology to aid in learning as opposed to simply using technology to use it (Hill and Valdez-Garcia 2020). The SE model provides a template for incorporating the use of technology. For instance, within teams' students could use an iPad for watching skill demonstrations, recording one another to evaluate performance, or to simply record notes on performance. Another use would be for record keeping. Instead of traditional paper and pen technique, technology allows the teacher instant statistics with minimal management time. Ultimately, today's student enjoys the use of technology with any school related task. Interest levels and student enjoyment may increase with this simple change. Today there is a push for evaluating the use of technology and associated benefits in PE (Casey et al. 2017). The addition of technology appears to be an untapped resource within SE and may help inform individual and group progress as well as motivate students to improve while they are tracking real time performance. The lack of significant differences among boys and girls within the SE model also further support evidence that the SE model reduces gender bias and promotes increases in female student performance and activity time, which supports previous research (Hastie et al., 2009). SE by design creates a sense of togetherness among students. The affiliation feature of SE allows students of mixed ability and sex to work together towards common goals. Moreover, students likely appreciate the opportunity to collaborate with peers, reducing the isolation or lack of confidence that may be common during skill practice and competition (Carlson and Hastie, 1997). This sense of community created using the affiliation assumption of the SE structure can enhance relatedness, satisfaction, and subsequent student enjoyment (Perlman 2010, 2012). Perlman (2015) indicated that an autonomy-supportive environment like the one used when implementing the SE model resulted in increased motivation and support for relatedness. In the present study, students were encouraged to explore all jumps and practice with their peers during the SE focused lessons. These opportunities for autonomy and inclusion likely prompted student enjoyment for task participation as opposed to working in isolation and being governed by a direct teaching strategy.

Lastly, significant differences were found between SEPS and both the TRAD and TPS models in terms of time spent in MVPA across the unit. These findings align and support previous work that indicated the student-centered nature and group learning aspects of the SE model can facilitate greater amounts of PA in class (Ward et al. 2017). Similarly, students in the present study had a significant amount of time for free practice. A striking difference between a traditional and SE jump rope lesson is the amount of movement by students. In a traditional lesson, students are given a demonstration of a jump and then given time to practice the jump. Typically, students stay in their area and movement is minimal. In comparison, the SE group was given time to move around the gym to identify jumps located on posters that were located on classroom walls. After identifying a jump task to practice, students were allowed to find an open location to practice the skill. In addition, students could practice partner and long rope jumps using the same format. Similar to the findings from Ward et al. (2017), the high autonomy approach may have led to higher activity levels for students in the SEPS group. The SE model can provide change for teachers who struggle with creating movement opportunities.

Limitations

While findings from this study were beneficial, it was not without limitations. It is recommended, to maximize the benefits of the season, to conduct a season of longer duration (Siedentop et al. 2019; Hastie et al. 2009). This format can provide students the time and opportunity to practice skills and potentially increase learning. Due to the amount of available time, only seven 60-minute lessons were conducted. While results were positive, more time could have provided increased opportunities for students. Another limitation was the limited number of available accelerometers. Funds were available to purchase a total of 15 accelerometers which resulted in over half of the participants not being able to wear one for data collection. During the study, students expressed disappointment in not having one to wear. This prevented the research team from having an extended data set for analysis. Lastly, the 30-second jump rope performance test has limitations as many factors outside of skill ability may impact a student's scores (e.g., BMI, physical fitness, physical irregularity), thus this score may not be an indicator of skill level and other objective observations like skill cue checklists and rubrics may be essential to measure true skill level in jumping rope and other skills of interest.

Future research considerations

Future research should focus on instruction and the use of technology in all PE instruction. These findings can provide further explanation of how to produce positive change in physical activity and skill performance regardless of grade level. In addition, with the ever-evolving improvement in technological features, research on technology in PE should be ongoing. Even with the favorable results, some may consider the technology implemented outdated. While the process for publishing research findings can take time, researchers should use previous research formats to re-test new technologies for PE. Finally, it would be beneficial to analyze the combination of student autonomy and social growth within the SE model. The features of the model provide students with opportunity to work freely as well as within a group. An analysis of these features in addition to student learning and feedback via technology use could provide important results.

Conclusion/Practical Application

This study showed that while all instructional interventions increased performance and MVPA, the SE model produced the most favorable results in 4th grade students. The SE model allowed for students to have increased autonomy and the opportunity to guide their learning through student choice. This freedom led to increased MVPA and exploration of jumps to discover appropriate challenges according to their ability. In addition, projecting heart rates increased student interest and enhanced the learning environment. Incorporating technology within PE needs continual examination to determine most effective usage with students. Overall, combining the central tenets of the model with current technological features, teachers can enhance the learning environment to create continual opportunities for students to stay engaged and thus maximize learning.

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